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Evaluation of Airborne Remote Sensing Tools for GEM Monitoring

Project Number:	02584
Submitted under:	Innovative Tools and Strategies to Improve Monitoring; page 31 FY02 Invitation
Restoration Category:	Monitoring; GEM Transition
Proposer:	PI, Evelyn D. Brown, UAF SFOS IMS co-P.I. James H. Churnside, NOAA Environmental Technology Laboratory, Boulder CO
Lead Trustee Agency:	ADFG
Cooperating Agency:	NOAA
Alaska Sea Life Center:	No
Duration:	1st year of 3-year project
Cost FY02:	$78,600
Cost FY03:	$280,000
Geographic Area:	Spill Region (Prince William Sound, N. Gulf of Alaska, Kodiak, Lower Cook Inlet
Injured Resources:	Potential survey species include sea birds (common murre, marbled murrelet, pigeon guillemot) and fish (Pacific herring, pink salmon, sockeye salmon)

ABSTRACT

The main objective of this study is an evaluation of airborne remote sensing tools for EVOS GEM monitoring including a biological/ecological interpretation of the data collected. The instrument package consists of 1) a pulsed lidar to map subsurface biological features day to a maximum of 50 m, 2) an infrared radiometer to map SST day (similar to AVHRR), 3) two 3-chip digital video systems to map ocean color (chlorophyll), birds, mammals, surface fish schools, and ocean frontal structure, and 4) an infrared digital video to map birds and mammals at night. We will use shipboard and buoy data for validation and interpretation of remote sensed data.

INTRODUCTION

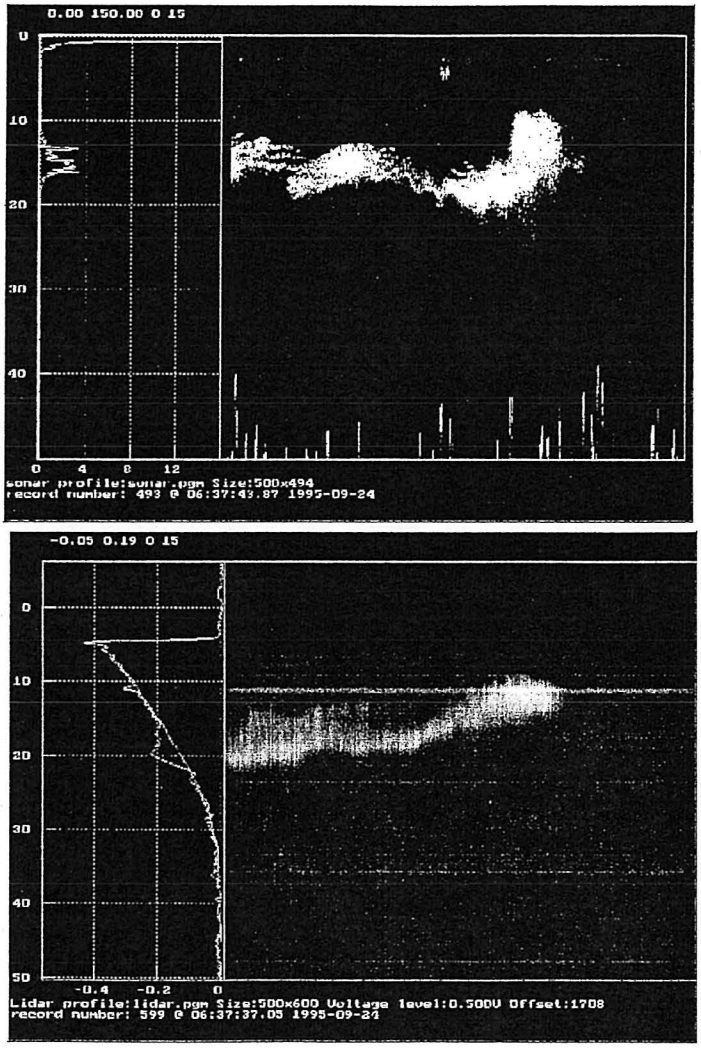
Biological assessment and ecological study of marine pelagic resources pose severe challenges from high cost and logistical difficulty to an inability to adequately address issues of spatial and temporal scale. Ship surveys in Alaska are severely limited by storm activity, are extremely costly, and research vessels are often "overbooked," often scheduled a year in advance. In addition, ships and acoustics have depth limitations, missing shallow, nearshore regions or the near surface. Ship avoidance behavior, by fish and their predators, affects results and sampling nets disturb biological features from their natural orientations. Finally, the slow speed of ship travel precludes understanding of short term or ephemeral events and cannot provide a synoptic view of the study region over short time scales. Biological relationships shift diurnally and with the tides; storm events restructure ocean fronts along with the biological structure that attracts fish and their predators, and predator-prey associations are often spatially patchy and short-lived. Data from satellites shows promise in helping to answer some of these problems, but frequent cloud cover is a problem in Alaska. The result of all of these issues is an increasing high-speed, cost-effective data collection tools that can document structure, in real time, without disturbance and that can be used to "fill-in" satellite data on cloudy days.

Airborne remote sensing and visual survey methods can meet many of these needs. The cost is less than 10% of a ship survey per survey kilometer and depth penetration has been improved to more than 3 times the visual range with the use of lidar (described here) The synoptic views aerial surveys provide are more appropriately coupled with satellite images in temporal scale than ship board results and data from airborne remote sensing instruments can be used to interpret and expand missing or low resolution from satellite data. Biological features are observed in "real space and time" without complications from ship avoidance behavior and disturbance of biological structure (as with net sampling). This instrument shows particular promise for the field of marine ecology in determining predator-prey relationships, capturing ephemeral biological events, and defining spatial and temporal scale. Accuracy of remote sensed data is improved by adaptive or "response-type" ship sampling. Using adaptive ship sampling and new technology in underwater digital video and plankton recorders, the overall cost of obtaining the information required could dramatically decrease.

Airborne lidar (light detecting and ranging) is a tool that shows promise for marine research. One form of lidar produces short pulses of green laser light, which pass through the water surface, reflect off fish and particles in the water, and returned to a receiver on the instrument. The strength of the returning pulse separates fish targets from small particles and the elapsed time indicates the range or depth of the object. When coupled on single platform with other instruments, such as multi-spectral imagers, infrared and/or microwave radiometers, and infrared cameras, physical and biological parameters can be collected simultaneously. Surface and subsurface features, such as zooplankton layers, fish schools, large individual fish, marine mammals, sea birds, oceanic fronts, sea surface temperature and salinity, and chlorophyll blooms are recorded to depths where light signals are attenuated.

The use of lidar and multi-spectral imagers are not new to ocean science. Squire and Krumboltz (1981) were among the first to experiment with optical lasers and other remote sensing devices for the purposes of fish surveys. Gauldie (1996) provided a review of lidar applications to fisheries management, mainly concerned with obtaining fish abundance and distribution

information. Krekova et al. (1994) provided a numerical evaluation of remote sensing fish schools with lasers; however, lidar applications are not limited to schooling fishes. Development of airborne lidar fisheries applications was greatly enhanced by Dr. James Churnside and his research team from the National Oceanic and Atmospheric Administration (NOAA) Environmental Technology Laboratory (ETL). They constructed and tested the Fish Lidar Oceanic Experimental (FLOE) system from off-the-shelf components and developed several signal processing techniques to discriminate between returns from fish and from small particles in the water (Churnside et al., in press). The FLOE system has been used off the coast of California to survey anchovies, sardines (Churnside et al. 1997; Hunter and Churnside, 1998; Lo et al. 1999) and more recently squid as well as sardines off the coast of Spain (Churnside et al., in press) and Pacific herring off the coast of Washington State. Comparisons of lidar to acoustic data has been very encouraging (Figure 1).

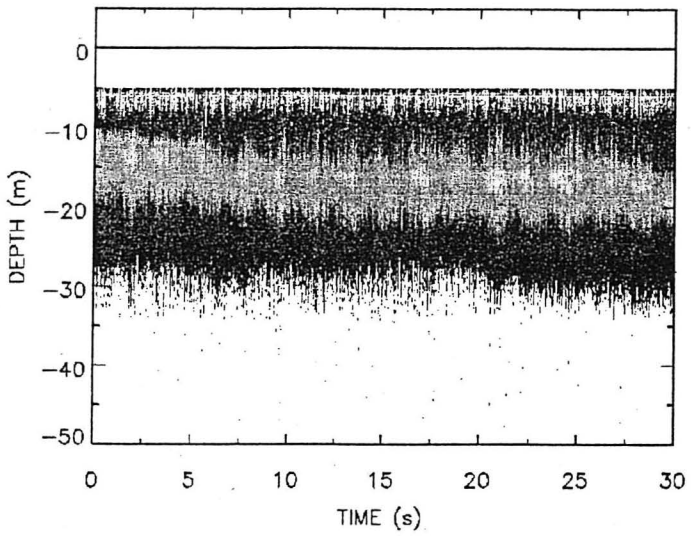


A.

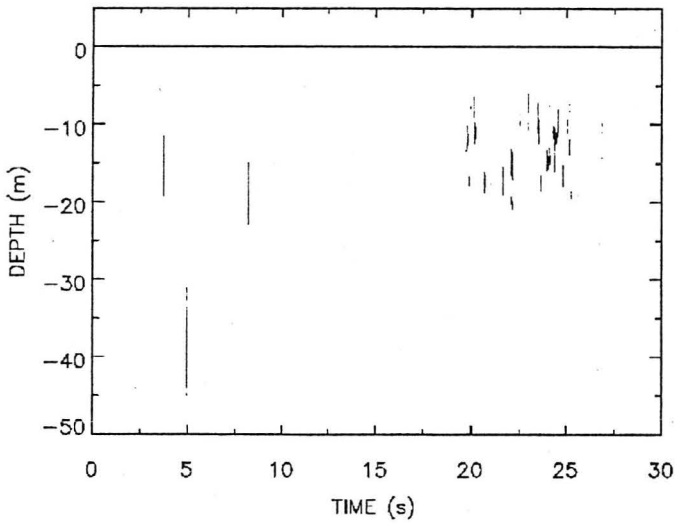
B.

Figure 1. A comparison of signal reflection from a school of anchovy by shipboard acoustics (A) and by lidar (B; post-processed image). The images were collected synoptically (Churnside et al. 1997; http://www1.etl.noaa.gov/lidar/index.html).

Airborne lidar has also been used to detect subsurface oceanic scattering layers (Hoge et al. 1988) as well as zooplankton layers and marine mammals (Figure 2).



A.



B.

Figure 2. Examples of plotted lidar output taken at approximately 200 m in altitude at 225 knots airspeed where time here represents linear space; zooplankton imbedded with scattered fish targets (A) and dolphins (B) are shown. Each image is 30 s of data and about 900 shots from the laser; traveling at 75 m/s, this is about 2.5 km.

Last summer (2000) the FLOE system was coupled with a digital imager and field tested in the North Pacific. Flown at 1000-ft altitude, the measured swath was about 5 m during the day and 7 m at night. The imager was a high-resolution video camera equipped with a tunable spectral filter capable of capturing 10 different bandwidths within the visual range and an adjustable focal length as well as frame-capture rate. The swath width of the imager is altitude and focal length dependent but ranged from 150-200 m at 1000 ft. altitude. Both instruments were mounted side-

by-side and angled down-looking at about a 10-degree angle from a camera port and window port in a twin-engine aircraft (Figure 3 and 4). Data from each instrument was stored electronically and processed later with custom software. The lidar data signal processing and output is similar to acoustic data. Flights were coordinated with three ongoing marine research programs with varying objectives. Surveys were flown in British Columbia, northern southeast Alaska, in Prince William Sound, Alaska, and over the continental shelf in the Gulf of Alaska. Surveying at 120 knots, 222 km was surveyed per hour. Features captured using the lidar included plankton and euphasid/amphipod layers, fish schools (Figure 5), larger individual predators, and fine detail of biological structural changes at ocean fronts. The penetration depth was 15-30 m in inside waters (non-silty) and up to 50 m in outside waters over the continental shelf. Penetration was much better at night due to an increased field of view with no background light interference. The imager captured sea bird and mammal configurations, fish schools (Figure 6), and changes in ocean color/front structure (Figure 7). Both data types are binned in cells with a 2-D array of image data underlain with a 3-D array of lidar data. A 3-D geo-referenced visualization is produced that can be analyzed using spatial statistical methods with linked GIS and spatial statistics software. We are in the process of completing analysis of the data from this study. However, the processing steps are listed here in methods since we propose to follow similar steps.

Figure 3. Aircraft used for the lidar/imager surveys in the North Pacific.

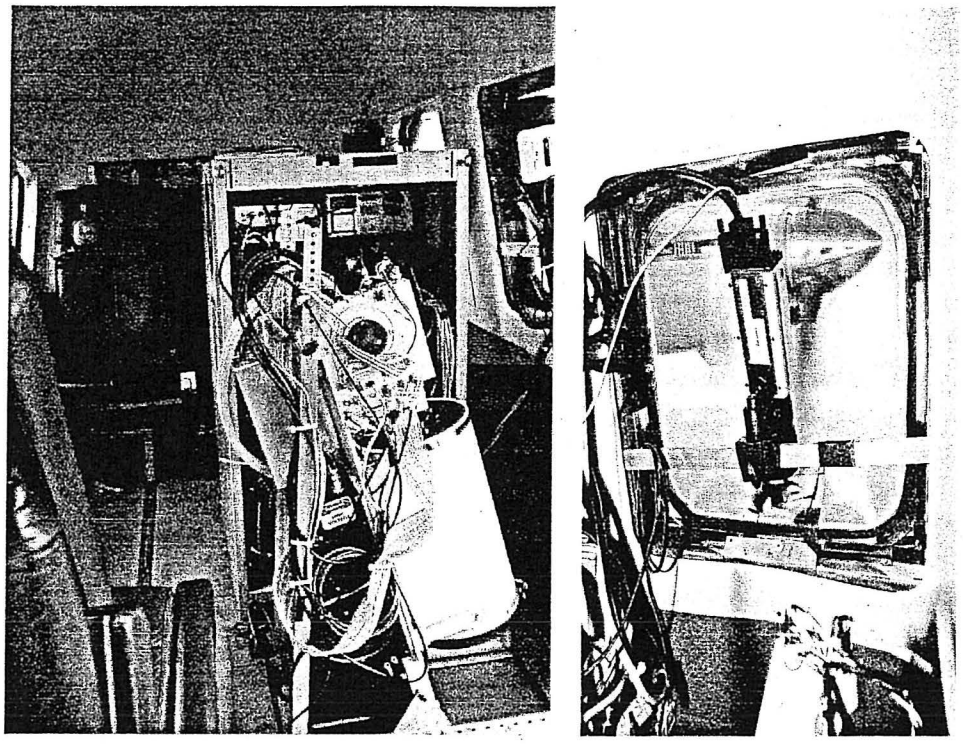


Figure 4. The photograph on the left is the NOAA-ETL fish lidar (telescope in the fore view with the hardware rack behind) mounted in the survey aircraft used in the summer of 2000. The photograph on the right shows the digital imager mounted in the window.

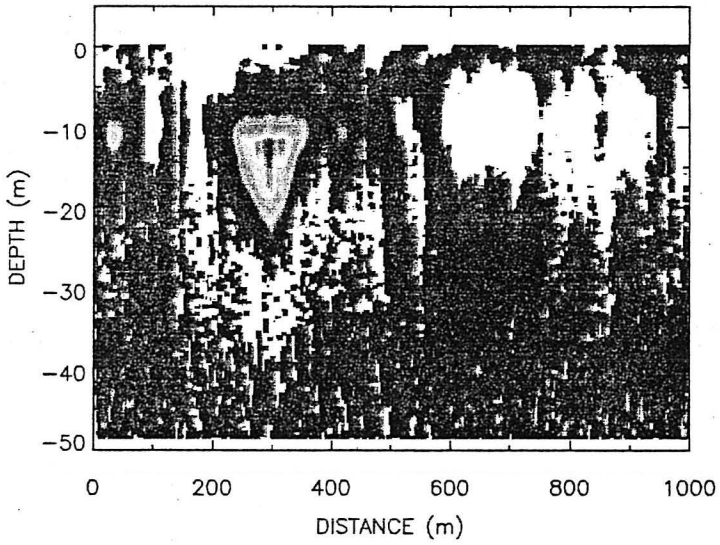


Figure 5. A raw data file output (displayed by shot number or distance with the background signal removed) of a fish schools in the Gulf of Alaska (attenuation depth here was approximately 40 m).

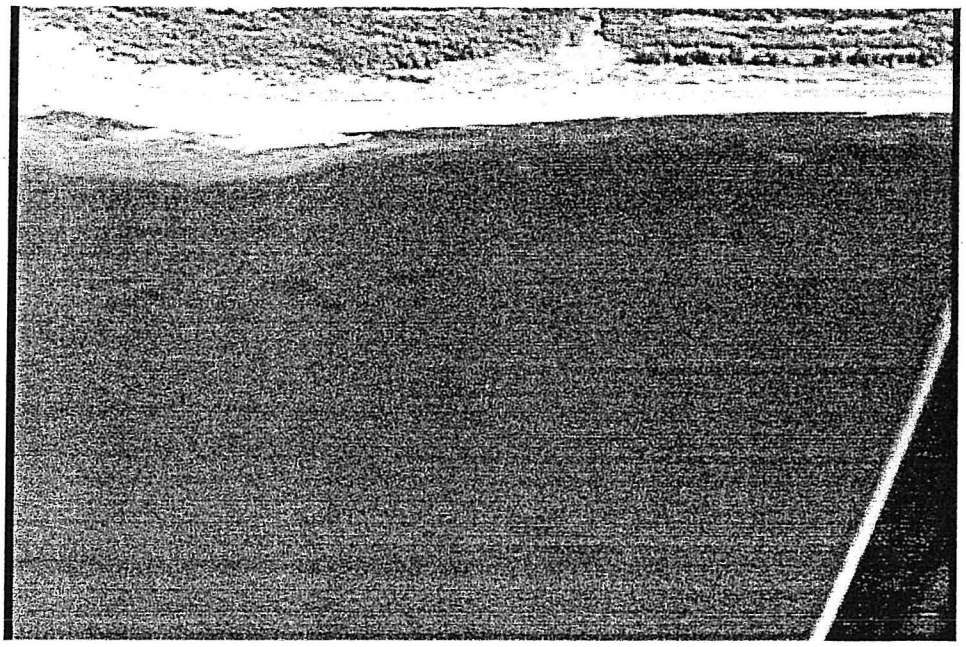


Figure 6. Near-surface fish schools (sand lance) captured by the digital imager (Airborne Technologies)

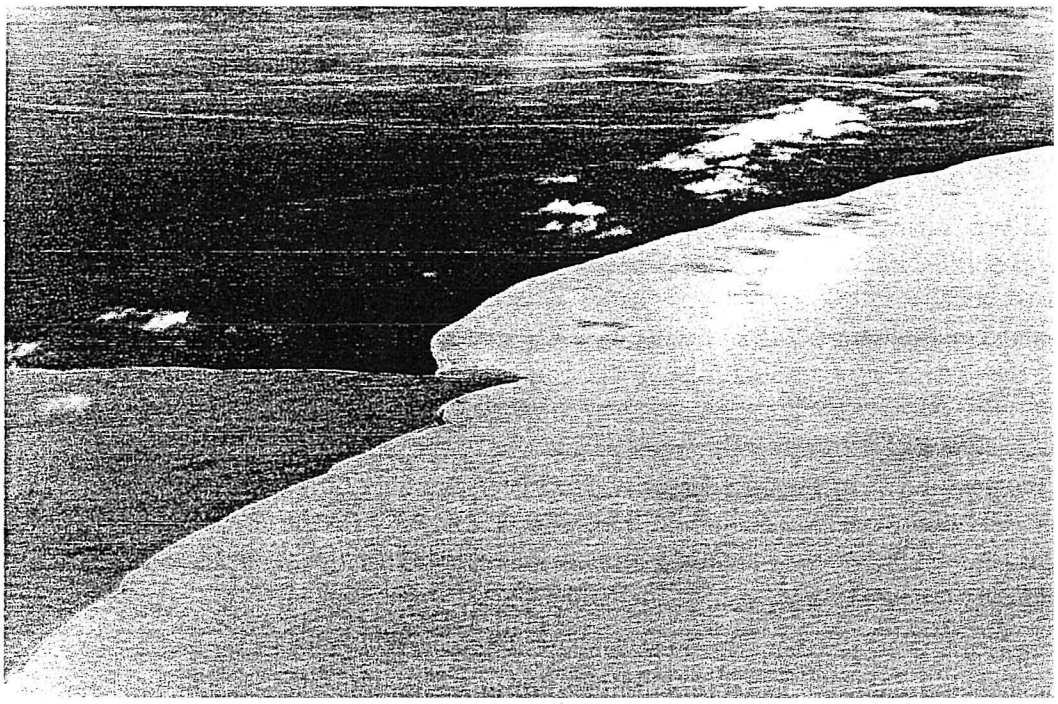


Figure 7. Image of oceanic regions captured with the imager; the binned lidar data is imbedded within this structure for analysis (Airborne Technologies, Inc.).

Following the encouraging results of the NPMR pilot study, we now propose to evaluate the potential use of these tools for GEM monitoring. The evaluation for this project will require

cooperation with other researchers. Working with an ongoing, and separately funded ship-board research program (GLOBEC), we will survey onshore to offshore transects overlapping and expanding the GLOBEC ship tracks. We may also exchange information with other EVOS and non-EVOS researchers working in the same area (see list below) for validation, interpretation and assessment of the usefulness of our data to their respective programs. For this project, we propose to work with a single cruise, most likely in mid- to late-July. However, if the evaluation is positive, we propose to increase the temporal strata and survey other critical times periods in future years. In the case that future surveys are not funded and due to the late start-up data proposed, we will require close-out funds to complete analysis and report-writing in FY03. However, the reporting costs will be significantly reduced from the estimate provided for FY03.

As part of the evaluation, we will fuse the data from the various instruments, add ship-board data from GLOBEC (monitoring and process studies), and perform an ecological interpretation of the biological structure spatial structure (e.g. size and interrelationships of features such as zoo-plankton patches and fish schools, proximity to fronts, short term scale of predator-prey events or frontal structures). We will also evaluate how the data suite (instrument data only or combination instrument/ship/buoy) addresses the complex research hypotheses and questions posed in preliminary drafts of GEM. A publication will be produced concerning the evaluation and interpretation. Earlier this year, we solicited various researchers working in the spill-impacted region for interest in the types of data we could provide to their respective studies. We received several replies including

1) Arthur Kettle/Dave Roseneau, USFWS, seabirds at the Barren Island; would like to know more about the distribution of forage fish, primary and secondary production, and physics of the seabird foraging region;

2) Kathy Kuletz, USFWS, murrelets in PWS; would like us to perform overflights in her nearshore survey areas and provide information on available prey

3) Dave Irons, USFWS, kittiwakes and other seabirds in PWS and NGOA; would like better information on availability and ecology of prey species for seabirds

3) Bruce Wright and Lee Hulbert, NMFS, sharks in PWS and N GOA; would like improved information about the distribution and ecology of salmon and sleeper sharks

There may be others. We will try to overfly areas of interest to these researchers to aid in the determination of the usefulness of the data to them. However, we may be able to coordinate with a small number in 2001 due to the limited flight hour allocation. As with the aerial survey program conducted for APEX, we will produce binned, interpreted data in an archive that will be available to cooperating researchers to use for their own purposes.

NEED FOR THE PROJECT

A. Statement of Problem

There is a need to identify cost-effective research tools for monitoring marine ecology in the EVOS spill region as a part of the GEM program. The data required to address the complex

ecological questions posed by GEM are diverse. The settlement monies are finite and the GEM effort should include tools that are efficient, have adequate spatial coverage, and provide information for multiple research questions and objectives. Distributions and ecological relationships of several of the injured species will likely be captured by the instruments including common murres, marbled and Kittlitz's murrelets, Pacific herring, pink salmon (high seas juveniles), sea otters, sockeye salmon (high seas juveniles), harbor seals, killer whales, and human activities in the areas surveyed.

B. Rationale/Link to Restoration

Prior to the formal initiation of the GEM plan, a full evaluation of potential monitoring tools would facilitate informed decision-making and planning. This proof of concept project enhances readiness to implement GEM by providing an evaluation of a potential suite of tools. Given the list of potential cooperating researchers and diversity of data delivered, there are likely several links to other restoration efforts that have not been identified at this point.

C. Location

For this evaluation, we propose to work in Prince William Sound and the adjacent northern Gulf of Alaska, with transect extensions to the west along the Outer Kenai Peninsula. As we will operate out of Anchorage, we may transect lower Cook Inlet to the Barren Islands, on the way to transects further east for logistical reasons.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

There will likely be very little physical or direct interaction with spill community residents because we will most likely operate out of Anchorage (to keep field costs down). However, we are interested in posting interpreted visualizations on a web site easily accessed by residents. We are interested in providing the information to local schools for educational purposes and can provide simplified verbal interpretations with the visualizations. As our program (airborne remote sensing instrumentation and marine ecological research) is expanding (from other funding), we would like to encourage potential graduate students from the spill region to participate in proposed studies on both Masters and PhD levels. We will be offering opportunities to obtain multi-disciplinary degrees in a combination of 2 or 3 of the following disciplines: engineering, computer science, physics (optics), marine ecology, oceanography, wildlife biology, and fisheries. We feel that participation by local students is an optimal vehicle for information transfer to rural areas.

PROJECT DESIGN

A. Objectives

The objectives for this project are:

1. Determine the types of information that can be collected from remote sensing instrumentation and the limitations of the collection.
2. Interpret the information collected in an ecological sense;

a. Describe general distribution patterns of plankton, fish, and predators
b. Determine the spatial relationships of the biological features to one another
c. Describe ocean structure in terms of chlorophyll, SST-SSS, and ocean fronts.
d. Determine how the biological structure is related to the ocean structure

3 Evaluate the extent of data collected and cost-effectiveness per unit area

4 Evaluate the limitations and usefulness of the interpretation in relation to GEM questions.

B. Methods

The hypothesis for this project is:

Data from airborne remote sensing instrumentation can be used to define spatial and temporal variability of zooplankton, fish, and predator distributions, interrelationships between the three, ocean structure, and relationships between biological distribution and ocean structure.

The instrument package consists of 1) a lidar using pulsed green laser light to map subsurface biological features day to a maximum of 50 m, 2) an infrared radiometer to map SST day (similar to AVHRR satellite data), 3) a 3-chip digital color video set up to map ocean color (chlorophyll), 4) a digital color video set up to capture ocean fronts, near-surface fish schools, and seabird or mammal aggregations, 5) a telescoping video set up to acquire high resolution (6 cm) images of non-white seabirds and mammals for species identification, and 6) an infrared digital video to map birds and mammals at night.

The instrument package and settings vary from day to night. The daytime configuration consists of the lidar, infrared radiometer, and all three digital videos. The nighttime configuration consists of the lidar, radiometer and infrared camera. Due to the cost of processing, we may not operate all videos continuously, instead collecting data only in areas of interest.

Table 1. NOAA-ETL FLOE System Specifications

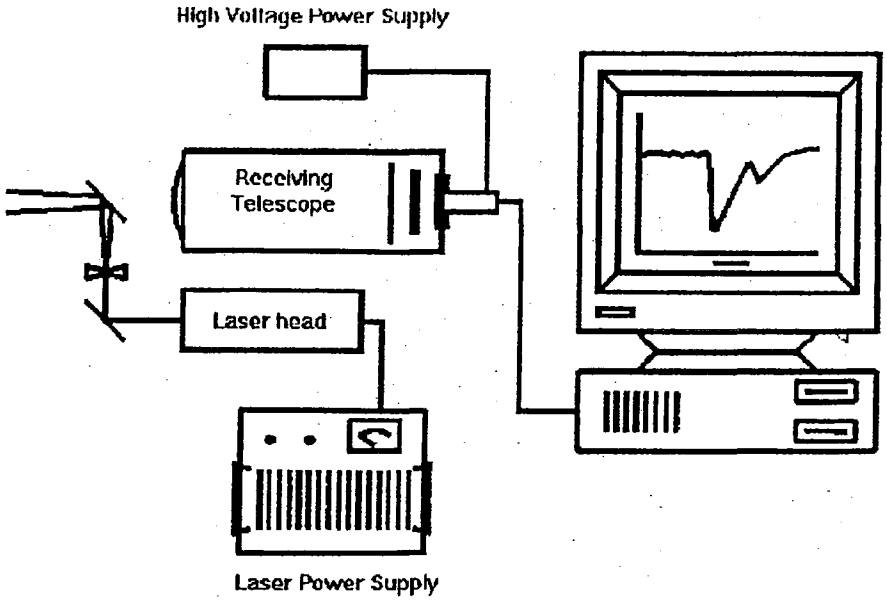
TRANSMITTER		RECEIVER	
Wavelength	532 nm	Aperture diameter	17 cm
Pulse length	15 nsec	Field of view	63 mrad
Pulse energy	100 mJ	Optical bandwidth	10 nm
Pulse repetition rate	30 Hz	Electronic bandwidth	100 MHz
Beam divergence	62 mrad	Sample rate	1 GHz

We will use the NOAA FLOE system (Table 1) for this project in 2002. The FLOE system is simple without scanning or imaging capabilities (Figure 8). The laser is a frequency-doubled, Q-switched YAG laser, linearly polarized parallel to the plane of incidence. A negative lens in front of the laser increases the beam divergence. The laser is mounted next to the receiver telescope and the diverged beam is directed by one mirror to a second mirror mounted to the back of the telescope secondary. The laser beam is directed toward the water coaxial with the telescope. The lidar receiver is a simple refractor that uses a condensing lens to focus the returned signal onto a

photomultiplier tube (PMT) detector. An interference filter reduces the contamination of the lidar signal by background light. A rotating polarizer is used to make measurements of the parallel- and cross-polarized returns. The PMT output is passed through a logarithmic amplifier to reduce the dynamic range of the signal. This signal is routed to an analog-to-digital converter (ADC) in a personal computer where it is digitized and saved to the computer hard disk. In other cases, two ADC boards with different gains are used to increase the dynamic range of the receiver. The maximum range and sensitivity of the lidar system is highly dependent on the clarity of the water, but fish can be detected to depths of 30-50 m below the sea surface in clear waters. We have proposed to build a beta version of FLOE; MEL (Marine Ecological Laser) will be modular, smaller, and have greater penetration capabilities. Beyond 2002, we would likely deploy MEL replacing FLOE. Lidar data processing is discussed below.

We will also use the NOAA ETL infrared radiometer. Radiometers are passive instruments that receive energy signals that are naturally emitted from objects within the instrument's viewing angle. A radiometer antenna pointed downward and receives infrared emissions from the ocean surface the beam. It monitors thermal emissions near the wavelength of 11 microns and the IR brightness temperature is approximately equal to the physical temperature of the ocean surface. The IR brightness temperature is calibrated in the laboratory prior to and following field data collection.

Ocean color and chlorophyll concentration will be estimated using a commercial 3-chip color video, also provided by NOAA. The first step is to synthesize the wavelength bands used by one of the satellite ocean color instruments, such as SeaWIFS or MODIS. Because we are synthesizing these bands from combinations of the wider bands in the video, either or both can be obtained from the same data set. Once we have the bands, we filter the digitized video images through each of the bands in the computer. This produces an estimate of what the satellite instrument would have seen, except, of course, for the distortions introduced by the atmosphere in the satellite images. At this point, we can use the algorithms developed for the satellite instruments for ocean color, chlorophyll concentration, and suspended sediment load. These values can be compared directly with the satellite products, although the spatial scale of the aircraft images is much smaller.



Block Diagram Fish Lidar System

Figure 8.Block diagram for the lidar system

The other color digital cameras are high resolution and can be fitted with tunable, multi-spectral filters and telescoping lens. The real power of this data is the software used to process the images. Within the custom software (developed by private industry partner), the image data is binned (flexible size), geocoded at the center, and normalized color pixel values are assigned to each bin (to detect ocean structure). Manual and shape recognition algorithms are used to extract counts of animals in each bin. Based on similar pixel values, fish school perimeters, surface areas and color density (potentially related to fish density) are extracted for each bin.

As in the NPMR pilot study (see Introduction), we will mount the instruments side by side to either look through a hole in the belly of the aircraft or through a window. Although the swath widths differ between instruments, we will insure they overlap via setting viewing angles for the instruments.

We will base our flight plan around the GLOBEC research vessel schedule and transecting plan as well as other coordinating projects. We will fly a total of approximately 25 hrs; flying at approximately 140 knots, we will cover approximately 6500 km of ocean transects. The day-to-day schedule is relatively flexible due to weather, altered ship courses (due to weather), and other logistical concerns. Our goal will be to maximize synoptic observations with ground survey programs. We will overfly at least one continuously recording oceanographic buoy for each flight. The ship survey or buoy provides 1) a temperature array used to compare temperature profile to surface temperature, 2) light attenuation from PAR or Photosynthetically Active Radiation used to check background correction estimated for lidar data, and 3) chlorophyll concentrations from a fluormeter (for ocean color calibration measurements). We will also derive biological validation measurements from the ground programs from interpreted acoustic data, zooplankton tows, net captures of fish, and visual sightings of birds and mammals. Finally, we

will use ship-board data to obtain sub-surface oceanographic structure (especially salinity, pycnoclines, location/size of fronts, and information of stratification) used to frame our spatial observations ecologically.

The majority of personnel time allocated within this project is for signal processing and analysis. The ratio, summed over all the instruments data produced, is well over 3:1 processing to collection time (a standard for acoustic data). However, processing algorithms are well established for the radiometer and ocean color video. The imaging video and lidar data is significantly more time-intensive.

Processing steps are illustrated from data collected during the pilot study. The laser fires 30 times per second and new files are produced every 66 seconds to limit size. Each file is a 2000 (no. of shots) by 1,000 (0.109 m depth intervals) array and represents approximately 5 km of lineal space. The data in Figure 9 represents the echo from one laser pulse on the afternoon of August 22 in Prince William Sound. Figure 9a shows the raw detector echo with distance form the plane. Clearly, the strongest echo was from the surface of the sea. The lidar signal decays exponentially with depth in the water. Signals were visible down to 30 m below the sea surface. Figure 9b shows the signal in terms of the linear detector current. In Figure 9b, the vertical axis of the plot has been shifted to highlight the signal from just below the sea surface. Figure 9c shows the background signal for the data set of individual laser pulses. This profile represents the median of the 2000 profiles. Figure 9d shows the perturbations in an individual profile (number 400 of the 2000) relative to the background plotted in Figure 9c. In the context of the other measurements made that day it is possible to interpret the echoes in Figure 9d. The echoes centering at 10 m below the sea surface (range 5-15 m) appeared commonly over distances of several km in the lidar and were spotted with spikes of increased signal return. The locations and depths matched plankton and juvenile high seas salmon catches from the ship data. The echoes at 20 m below the surface were much patchier. Net catches of capelin (form large schools) matched these echo locations and depths. The relative target signal (Figure 9d) used to detect targets is a radiometric measure. Specifically it is calculated as the ratio of the difference between the individual profile (Figure 9b) and the median water signal (Figure 9c) divided by that same median water signal. The median signal is small and sensitive to noise at depths of 30 m and over (for this file) and thus the detection of targets near the maximum range is not very robust. This is of particular concern for studies in the Gulf of Alaska where the water in some areas can be considerably more turbid than in the coastal waters of California. However, in Alaskan waters, most of the primary and secondary production along with predatory activity takes place in the upper 20m during the summer when the water column is stratified. Thus, the lidar measurements provide the potential to yield real-time high-resolution snapshots of biological distribution in the upper level of the ocean.

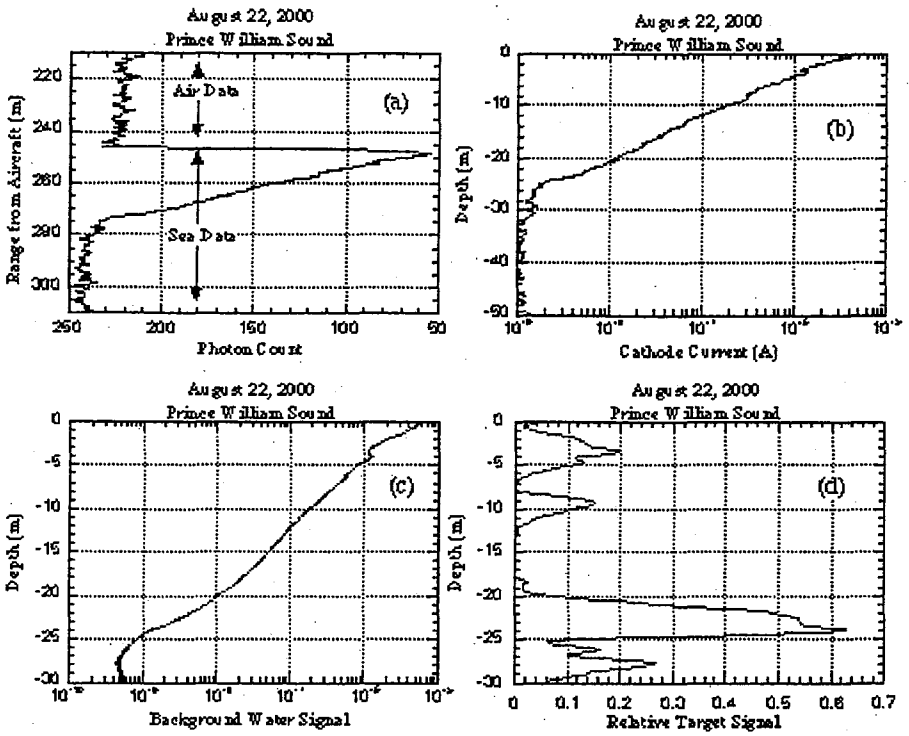


Figure 9. Fish lidar data from 22 August 2000. See text for details.

As part of the pilot study, we made improvements to the existing software (originally written in IDL) in the step-wise signal processing algorithms including:

1) automating the calculation of background signal which tends to change as different bodies of water are transected,
2) automating the identification and downloading of arrays containing potential targets to be linked to validation and target strength information,
3) automating the identification of potential problematic arrays, especially those containing targets near the attenuation depth with amplified noise, and

The two-stage program is written in Visual Basic. The first stage follows the processing steps outlined above summarizing files as 1-D meta-file data for easy viewing and interpretation (see Figure 10). Sequences of files can thus be selected according to "feature grouping" for more detailed analysis. The second stage program allows you to select the file sequences and process the raw data files according to specified bins sizes with appropriate threshold levels and attenuation depths. The data used for analysis is thereby greatly reduced. The output from the programs can be dumped via the dynamic links to Visual Basic, available in most MS Windows software for further processing, visualization and analysis. We will likely use ArcView to overlay validation data in order to identify lidar signal; we will use acoustic density information where available to scale lidar backscatter values to biomass, however, overlap may not be 100%. In the case of non-overlap, we will infer identification and density if from the closest validated sighting and represent the uncertainty in the reporting. Output files can also be created in a commonly used format for viewing on acoustic processing software in a form familiar to many

oceanographers and fishery biologists. This was done to assess the utility of building on existing acoustic software versus creating entirely custom software for the lidar system.

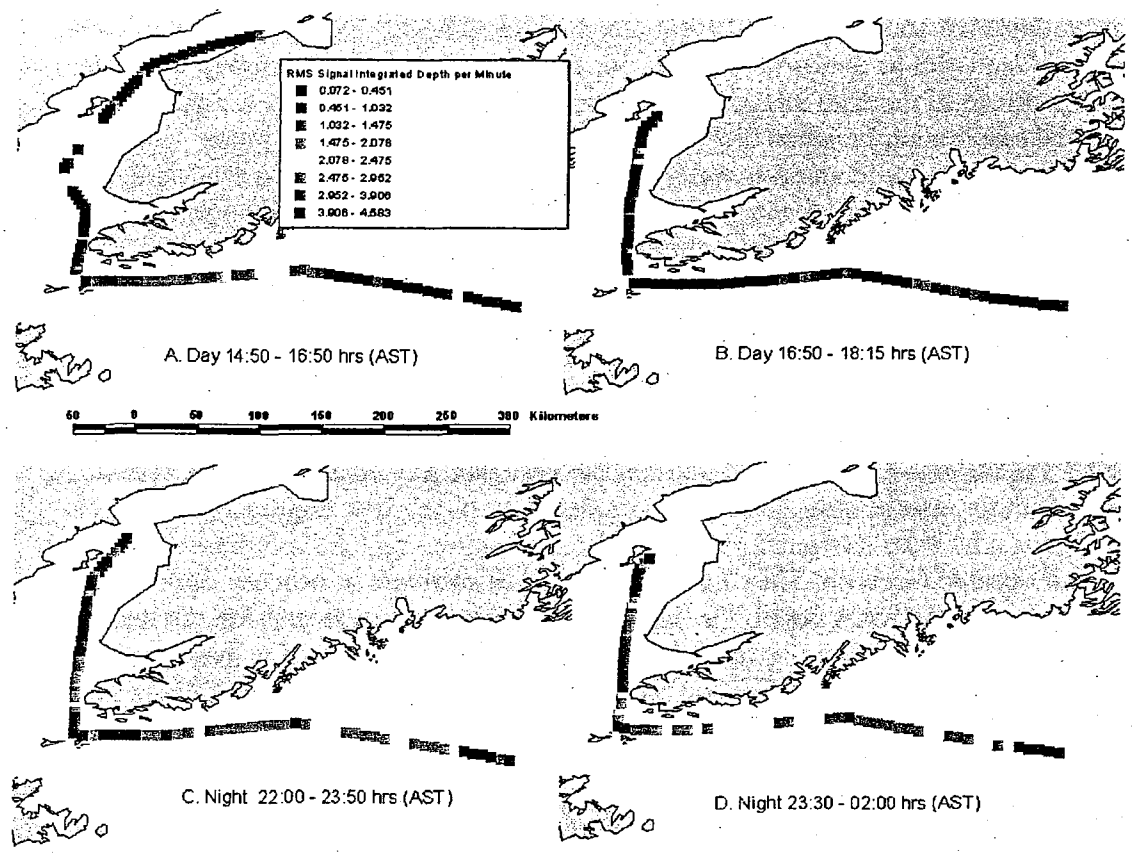


Figure 10. A view of the meta data or file summary along a single survey near the lower Cook Inlet and Outer Kenai coast. Each square is a single file representing about 4.5 km and the Root Mean Square signal integrated over all depths and shots is show as 10^{-4} volts. The left and right hand figures show short term variability collected on the trip out (left) and return (right). The top and bottom figures contrast day and night.

A general treatment of remote sensed and other aerial data is provided in Hunter and Churnside (1995). However detailed statistical modeling of lidar results was explored by Lo et al. (2000), in relation to aerial census of anchovy off the coast of California. They provided methods 1) to estimate the number of transects needed to minimize abundance estimates, 2) to determine the effects of signal to noise ration (SNR) with attenuation (or depth) on the probability of detection, 3) to estimate the maximum detection depth (z_{max}) based on threshold to noise ratio (TNR) and SNR, 4) to predict the probability of detection based on water mass characteristics, and 5) comparisons of estimates to other methods. The maximum detection depth is a function of the size of the organism or aggregation (i.e. school). For organisms residing partly below the maximum detection depth, acoustic data is combined with lidar data to produce a subsurface correction factor. Lo et al. (2000) suggest the application of line transect theory applied in the vertical along transect plane (rather than horizontal) to estimate abundance, estimation and detection error. For organisms above the maximum detection depth, we can assume 100% detection along the survey track. Finally, Lo et al. recommend the further development of signal

processing algorithms to automate the SNR, TNR, z_{max}. Several of these algorithms have been developed under the NPMR pilot study and will be applied to this study. We will use the models developed by Lo et al. to interpret the data collect for this project.

Once we have identified and quantified (normalized signal strength; Figure 9d), we will rely mainly on spatial statistics to describe distributions and interrelational parameters. Potential stochastic descriptions of the data include comparison of spatial variability via variograms, indices of spatial association between distributions (e.g. Moran's or Geary's index; Cliff and Ord 1981; Geary 1954), kridging to smooth and expand estimated distribution patterns, and nearest neighbor or distance statistics to quantify interrelationships. This statistical interpretation will be included in the publication produced as part of this project.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The project is a cooperative effort between the UAF and NOAA. Currently, the NOAA Environmental Technology Laboratory possesses the only publicly accessible lidar system, as well as a suite of other instruments. The lab is populated by physicists, engineers, and highly trained technicians who have designed and built a host of remote sensing instruments used for atmospheric and oceanic research. They have also designed software to process signals. Therefore, the role of the NOAA co-PI, Dr. James. Churnside, will be to provide the lidar, radiometer, and ocean color video. Personnel from his lab will also mount the instruments in the plane, perform maintenance and repairs, and handle the raw data. The role of UAF is to provide the biological expertise needed for survey design, links to external data (from ships and buoys), signal interpretation, and spatial analysis. Data processing tasks and the evaluation/reporting will be a joint effort.

SCHEDULE

A. Measurable Project Tasks for FY02

January 14-23:	Attend EVOS workshop and present pilot study results if desired
March 15-17:	Develop survey design and flight plan; attend scientific planning meeting (project members and coordinating researchers)
July 1:	Instrumentation preparation and calibration completed
July 15 - August 15:	Complete field data collection
September 1:	Validation data collation initiated
October 1:	Signal processing completed

B. Project Milestones and Endpoints

FY02

October 1:	Objective 1; preliminary identification of features capture

FY03

December 15:	Objective 1; identity of capture features validated/limitations of data determined
April 15:	Objective 2; spatial analysis completed

April 30:	Objective 3; evaluation of cost-effectiveness of information Objective 4; evaluate usefulness and limitation for GEM
May 31:	Manuscript draft submitted; final report completed
August 31:	Manuscript revised and finalized

C. Completion Date

August 31, 2003, FY03, is the estimated completion data for this project.

PUBLICATIONS AND REPORTS

No publications are planned for FY02. The project has a late start-up data with data collection proposed near the end of FY02. Therefore, all reporting and publication production will occur in FY03.

PROFESSIONAL CONFERENCES

Other than the EVOS workshop and scientific planning meeting, we have no plans to present the results formally in FY02.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

We have other proposal submitted that address instrumentation development, software development, surveys in other locations in Alaska (Kodiak, SE Alaska, Aleutian Chain, Bering Sea), links to satellite data, and target strength work. These proposals include additional co-investigators from agencies, academic organizations and private industry. Sources of funding for these proposals include NSF (Major Research Instrumentation Program, Biocomplexity Program, Small Business Innovative Research Program), CIFAR (UAF-NMFS cooperative program), NMFS, NESDIS, and the Sea Life Center. Surveys under several of these programs (CIFAR and NMFS) are complimentary to the work proposed for GEM and data collection methods are identical.

We will coordinate with the GLOBEC monitoring research program (TomWeingarter, chief scientist; Ken Coyle, acoustician/zooplankton, Russ Hopcroft, zooplankton, Lew Haldorson, fisheries data, and Bob Day from ABL for bird and mammal data) during the late summer cruise. We will also coordinate with GLOBEC process studies occurring at the same time in 2002, specifically with NMFS ABL focusing on juvenile high seas salmon (Jack Helle, Ed Farley) and the zooplankton research (Russ Hopcroft, UAF). We coordinated with them during the pilot study in 2000 and will continue that relationship. In 2000 the NMFS group was operating under the Ocean Carrying Capacity Research program managed by Jack Helle. The other potential coordinating researchers are (repeated from introduction):

1) Arthur Kettle/Dave Roseneau, USFWS, seabirds at the Barren Island; would like to know more about the distribution of forage fish, primary and secondary production, and physics of the seabird foraging region;

2) Kathy Kuletz, USFWS, murrelets in PWS; would like us to perform overflights in her nearshore survey areas and provide information on available prey

3) Dave Irons, USFWS, kittiwakes and other seabirds in PWS and NGOA; would like better information on availability and ecology of prey species for seabirds

3) Bruce Wright and Lee Hulbert, NMFS, sharks in PWS and N GOA; would like improved information about the distribution and ecology of salmon and sleeper sharks

PROPOSED PRINCIPAL INVESTIGATORS

Evelyn D. Brown
University of Alaska, Institute of Marine Science
PO Box 757220
Fairbanks, AK
phone: (907)474-5801
fax: (907)474-1943
email: ebrown@ims.uaf.edu

Responsibility: Oversee the UAF signal processing tasks, signal validation, biological interpretation, statistical analysis and report writing

James H. Churnside
NOAA Environmental Technology Laboratory, R/E/ET1
325 Broadway
Boulder, CO 80303
phone: (303)497-6744
fax: (303)497-3577
email: jchurnside@etl.noaa.gov

Responsibility: Provide instruments for the study, oversee the NOAA signal processing tasks, instrument calibration, assist in interpretation or processing algorithm improvements, and assist with signal analysis and report writing.

PRINCIPAL INVESTIGATORS

James H. Churnside

Education

Ph.D.	Department of Applied Physics and Electronic Science Oregon Graduate Center (now Oregon Graduate Institute), Beaverton, Oregon 1978
B.S.	Physics, Mathematics and Computer Science Whitworth College, Spokane, Washington 1974

Experience

1991 to present	Chief, Ocean Remote Sensing Division NOAA Environmental Technology Lab., Boulder, Colorado
1985 to 1991	Physicist NOAA Wave Propagation Lab., Boulder, Colorado
1979 to	Member of the Technical Staff

1985 The Aerospace Corporation, Los Angeles, California

Most Recent Journal Publications (of 54)

E. R. Westwater, Y. Han, J. B. Snider, J. H. Churnside, J. A. Shaw, M. J. Falls, C. N. Long, T. P. Ackerman, K. S. Gage, E. Ecklund, and A. Riddle, "Ground-Based Remote Sensor Observations during PROBE in the Tropical Western Pacific," Bull. Am. Meteor. Soc. 80, 257-270 (1999).

C. M. R. Platt, S. A. Young, P. J. Manson, G. R. Patterson, S. C. Marsden, R. T. Austin, and J. H. Churnside, "The Optical Properties of Equatorial Cirrus from Observations in the ARM Pilot Radiation Observation Experiment," J. Atmos. Sci. 55, 1977-1996 (1998).

J.H. Churnside, V.V. Tatarskii, and J.J. Wilson, Oceanographic Lidar Attenuation Coefficients and Signal Fluctuations Measured from a Ship in the Southern California Bight,@ Appl. Opt. 37, 3105-3112 (1998).

J.H. Churnside, J.J. Wilson, and V.V. Tatarskii, Lidar Profiles of Fish Schools,@ Appl. Opt. 36, 6011-6020 (1997).

J.A. Shaw and J.H. Churnside, Scanning-Laser Glint Measurements of Sea-Surface Slope Statistics,@ Appl. Opt. 36, 4202-4213 (1997).

J.A. Shaw and J.H. Churnside, Fractal Laser Glints from the Ocean Surface,@ J. Opt. Soc. Am. A 14, 1144-1150 (1997).

Evelyn D. Brown

Education:

B.S.	Zoology and Chemistry, University of Utah, Salt Lake City, 1977
M.S.	Fisheries Biology and Aquacultural Engineering, Oregon State University, Corvallis, OR, 1980
Current	PhD candidate in Fisheries at University of Alaska, Fairbanks (completion expected in the spring of 2001)

Experience:

Research Associate, University of Alaska, Fairbanks, 1995 to the present;

Herring and Fisheries Research Biologist, Alaska Department of Fish and Game, Cordova, Alaska from 1985 to 1995;

Principal Investigator, Injury to Prince William Sound Herring from the *Exxon Valdez* Oil Spill, NRDA FS 11, 1989-1992.

Fisheries Biologist, Florida Department of Natural Resources, St. Petersberg, Florida, 1987-1988; hydroacoustics.

Field Experience:

Aerial surveys; P.I. and primary surveyor, single and twin engine aircraft; 1988-present; techniques include lidar (laser sensing), digital imager (color video and Compact Airborne Spectrographic Imager or CASI), and visual surveys

Shipboard surveys; skiffs, commercial fishing and research vessels (30-110 ft); P.I. on 2, participated in over 12; last decade

Research SCUBA dive master; PI for several studies of nearshore fish spawning and egg survival projects

Operational experience scientific and shipboard downlooking acoustics, side-scan sonars, net sonars, GPS, and computerized navigation

Selected Publications:

Brown, E.D. In prep. A conceptual model of Pacific herring, *Clupea pallasi*: ecology and factors affecting year-class survival in Prince William Sound, Alaska. PhD Dissertation, University of Alaska Fairbanks, Fairbanks, Alaska. (Final Report to the *Exxon Valdez* Oil Spill Trustee Council and submitted to Fisheries Research).

Brown, E.D. In prep. Effect of herring egg distribution and ecology on year-class strength and adult distribution. . PhD Dissertation, University of Alaska Fairbanks, Fairbanks, Alaska. (Final Report to the *Exxon Valdez* Oil Spill Trustee Council and submitted to Fisheries Research).

Brown, E. D., G.A. Borstad, and B.L. Norcross. In final revision. Estimating forage fish and seabird distribution and abundance using aerial surveys: survey design and uncertainty. (Fisheries Research).

Brown, E.D. and B.L. Norcross. In press. Effect of herring egg distribution and ecology on year-class strength and adult distribution: preliminary results, Page 00 in International Symposium on Herring, 2000, University of Alaska Sea Grant AK-SG-01-00.

Brown, E.D. and B.L. Norcross. In press. Effect of herring egg distribution and ecology on year-class strength and adult distribution: preliminary results *in* International Symposium on Herring, 2000, University of Alaska Sea Grant, Report 00:00.

Norcross, B.L., E.D. Brown, R.J. Foy, M. Frandsen, S. Gay, T.C. Kline Jr., D.M. Mason, E.V. Patrick, A.J. Paul and K.D.E. Stokesbury. In press. A synthesis of the life history and ecology of juvenile Pacific herring in Prince William Sound, Alaska. Fish. Oceanog. 00:00

Stokesbury, K. D. E., J. Kirsch, E. D. Brown, G. L. Thomas, B. L. Norcross. 2000. Spatial distributions of Pacific herring, *Clupea pallasi,* and walleye pollock, *Theragra chalcogramma,* in Prince William Sound, Alaska. Fish. Bull. 98:400-409.

Purcell, J.E., E.D. Brown, K.D.E. Stokesbury, and L.H. Haldorson. 2000. Aggregations of the jellyfish *Aurelia labiata*: abundance, distribution, association with age-0 walleye pollock, and behaviors promoting aggregation in Prince William Sound, Alaska, USA. Mar. Ecol. Prog. Ser. 195: 145-158.

Brown, E.D., S. Vaughan, and B.L. Norcross. 1999. Annual and seasonal spatial variability of herring, other forage fish, and seabirds in relation to oceanographic regimes in Prince William Sound, Alaska *in* Ecosystem Approaches for Fisheries Management, University of Alaska Sea Grant, AK-SG-99-01, Fairbanks, Alaska.

OTHER KEY PERSONNEL

Kevin Abnett is a software engineer at the Geophysical Institute at UAF. Kevin will be responsible for software/programming adjustments needed to signal processing algorithms and for providing the processed data in coordination with an unnamed engineering/programming technician.

Tim Veenstra, Airborne Technologies Inc., will be contracted to provide the aircraft and video imaging equipment. He will complete all image processing tasks, quantification of targets or pixel valuation, and delivery of binned, geocoded image data to the PIs.

LITERATURE CITED

Churnside, J.H., J.J. Wilson, and V.V. Tatarskii. 1997. Lidar profiles of fish schools. Applied Optic 36(24): 6011-6020.

Churnside, J. H., V. V. Tatarskii, and J. J. Wilson. 1998. Oceanic attenuation coefficients and signal fluctuations measured from a ship in the Southern California Bight, Applied Optics 37: 3105-3112.

Churnside, J.H., J.J. Wilson, and V.V. Tatarskii. In press. An airborne lidar for fisheries applications. Applied Optic 0: 00.

Cliff, A.D. and J.K. Ord. 1981. Spatial processes: models and applications. Pion Limited, London.

Gauldie, R.W., S.K. Sharma, and C.E. Helsley. 1996. LIDAR applications to fisheries monitoring problems. Can. J. Fish. Aq. Sci. 53: 1459-1468.

Geary, R.C. 1954. The contiguity ratio and statistical mapping. The Incorporated Statistician 5: 115-145.

Hoge, F.E., R.E. Berry, and R.N. Swift. 1986. Active-passive airborne ocean color measurement. 1: Instrumentation. Applied Optics 25: 39-47.

Hunter, J.R. and J.M. Churnside. 1995. Airborne fishery assessment technology: a NOAA workshop report. NOAA Southwest Fisheries Science Center Administrative Report, La Jolla, California, LJ-95-02. 71 pp.

Hunter, J.R. and J.H. Churnside. 1998. An evaluation of the potential use of airborne lidar for inventorying epipelagic fish schools. Extended abstract, page 43 in American Fisheries Society 128th Annual Meeting Abstracts, Hartford, Conn.

Krekova, M.M., G.M. Krekov, I.V. Samkhvalov, and V.S. Shamanaev. 1994. Numerical evaluation of the possibilities of remote laser sensing of fish schools. Applied Optics 33(24): 5715-5720.

Lo, N.C.H., J.R. Hunter, J.H. Churnside. 1999. Modeling properties of airborne lidar surveys for epipelagic fish. Administrative Report No. LJ-99-01, NMFS, Southwest Fisheries Science Center, La Jolla, CA (in submission process for formal publication).

Squire Jr., J.L. and H. Krumboltz. 1981. Profiling pelagic fish schools using airborne optical lasers and other remote sensing techniques. Mar. Tech. Soc. J. 15(4): 27-31.

Revision 7-6-01
approved tc 12-11-01

Evaluation of Airborne Remote Sensing Tools for GEM Monitoring

02584

Submitted under: Innovative Tools and Strategies to Improve Monitoring; page 31 FY02 Invitation

Restoration Category: Monitoring; GEM Transition

Proposer: PI, Evelyn D. Brown, UAF/SFOS/IMS
co-P.I. James H. Churnside, NOAA Environmental Technology Laboratory, Boulder CO

Lead Trustee Agency: ADFG

Cooperating Agency: NOAA

Alaska Sea Life Center: No

Duration: 1st year 3-year project

Cost FY02: $74,435 ($15,000-NOAA; $59,435-UAF)

Cost FY03: $240K

Geographic Area: Spill Region (Prince William Sound, N. Gulf of Alaska, Kodiak, Lower Cook Inlet

Injured Resources: Potential survey species include sea birds (common murre, marbled murrelet, pigeon guillemot) and fish (Pacific herring, pink salmon, sockeye salmon)

ABSTRACT

The main objective of this study is an evaluation of airborne remote sensing tools for EVOS GEM monitoring including a biological/ecological interpretation of the data collected. The instrument package consists of 1) a pulsed lidar to map subsurface biological features day to a maximum of 50 m, 2) an infrared radiometer to map SST day (similar to AVHRR), 3) two 3-chip digital video systems to map ocean color (chlorophyll), birds, mammals, surface fish schools, and ocean frontal structure., and 4) an infrared digital video to map birds and mammals at night. We will use ship board and buoy data for validation and interpretation of remote sensed data.

Prep

REVISIONS TO ORIGINAL PROPOSAL

In response to the EVOS review and reviewer comments, we have made some revisions to this proposal. Changes have been made to reduce the scope and clarify the objectives of the proposal. The objective to evaluate airborne remote sensing for GEM monitoring remains. The instrument package will remain the same since there would be no cost Savings realized, but rather potential loss of valuable information. Because there are fixed costs associated with separate data analysis (for this project), reporting, as well as instrument staging and logistical costs, the only areas for cost reduction are field data collection, student support and some processing. We have therefore removed the graduate student support, reduced flight hours by half, reduced field travel costs, and reduced data processing costs.

In the original proposal, the objectives were too broad. In response, we have revised the objectives as follows:

1. Using remote sensing instrumentation, sample waters in the GOA and PWS to obtain a single synoptic view of the marine system in the upper 50 m of the water column.
2. Collect information on biological distributions of zooplankton, fish and other large invertebrates synoptic with surface information on ocean color, ocean fronts and seabird and mammal configurations.
3. Describe general distribution patterns using shipboard data for interpretation.
4. Determine spatial relationships of the biological features to one another and to ocean structure observed.
5. Evaluate the extent of data collected and cost-effectiveness per unit area.
6. Evaluate the limitations and usefulness of the interpretation in relation to GEM questions.

We will make every effort to synchronize flights with ongoing ship research programs including the list of projects in the original proposal. However, given the limitations in flight hours and logistical difficulties in scheduling overlapping field programs, we only guarantee overlap with GLOBEC. The justification for this priority is the need to maximize validations of the data types collected from airborne instruments. GLOBEC is collecting a diverse array of oceanographic and biological information and can therefore best provide the type of validation needed.

We will focus the EVOS surveys in the northern GOA and PWS. Although we are collecting very similar and comparable information in Kodiak, the survey costs in that region are covered by the NMFS project. However, we can include in the analysis for EVOS, a comparison of GOA and PWS to Kodiak ecosystem structure. We plan to survey in the GOA for 3-4 days depending on the number of hours flown per day and weather.

We are also involved in several other projects with objectives ranging from instrument and software development to large field sampling programs. We are tasked with comparing marine ecosystem structure in sea lion foraging habitat around Kodiak Island

and in SE Alaska for NMFS. We are tightly coordinated with existing or new ship programs. We can, therefore, keep the cost of the aircraft and data processing down since we will piggyback the EVOS surveys to this work. Otherwise, it would be difficult to obtain a suitable aircraft cost-effectively for the number of survey days involved. There are no developmental costs included in this proposal; all software development, instrument acquisition and repair, and new mounting/hardware systems are covered under other projects with funding from NSF and the North Pacific Marine Research Fund. We will use the software developed under the other programs to process and interpret the EVOS GEM data. We have an instrument development proposal pending with NSF that would result in construction of a modular and improved lidar system. If completed, the new instrument would be deployed for the EVOS GEM work at no extra cost. We have purchased a gated video for the lidar system that will allow us to obtain snapshots of biological structure at 0.1 m depth intervals. These pictures will be very useful in allocating signal return to large and small objects and evaluating the quality of signal data collected. This video was not included in the original EVOS proposal, but will be deployed for the EVOS GEM surveys at no extra cost.

Finally, a response is needed in reference to the reviewer's comments about the PI qualifications. A multi-disciplinary team has been working on airborne remote sensing development and surveys in Alaska. The two PIs from this project are part of that team. Here is a listing of the personnel involved:

UAF	
Evelyn Brown:	Fisheries and Marine Ecology, Airborne Surveys, Spatial Analysis
Richard Collins:	Electrical Engineer, Optics and Research Lidar (not included in this proposal)
Kevin Abnett:	Software Engineer, Signal Processing (limited support in this proposal)
NOAA	
James Churnside:	Physicist, Optics, and Instrumentation Development
James Wilson:	Electrical Engineer, Instrumentation Maintenance
Private Industry:	
Tim Veenstra:	Aircraft Charter and Configuration, Imaging Services
Pat Simpson:	Acoustic Integration (with airborne data), Software Development (not included in this proposal)

Revision 7
approved TC 12-14-01

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002	PROPOSED FY 2002 TRUSTEE AGENCIES TOTALS ADEC	ADF&G	ADNR	USFS	DOI	NOAA
				$63.6				$15.0
Personnel	$0.0	$10.5						
Travel	$0.0	$2.8						
Contractual	$0.0	$59.4						
Commodities	$0.0	$0.1						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$72.8	Estimated					
General Administration	$0.0	$5.8	FY 2003					
Project Total	$0.0	$78.6	$280.0					
Full-time Equivalents (FTE)	0.0	0.3						
			Dollar amounts are shown in thousands of dollars.					
Other Resources	$0.0	$0.0	$0.0					

Comments:

(Caution. Use this blank form carefully. It is designed with ADFG only as contractor with UAF only and with NOAA as Co-PI.)

FY02

Prepared: April 2001

Project Number: 02584 Revision
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Lead Agency: ADF&G

FORM 2A
MULTI-TRUSTEE AGENCY SUMMARY

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel		$0.0
Travel		$0.0
Contractual		$59.4
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$59.4
General Administration		$4.2
Project Total	$0.0	$63.6
Full-time Equivalents (FTE)		0.2
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
Estimated FY 2003					
$240.0					

Dollar amounts are shown in thousands of dollars.

Comments:
Summary sheet for contractual (RSA) with UAF
FTE and Estimated FY 2003 is for UAF

FY02

Prepared: April 2001

Project Number: 02584 Revision
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Agency: ADF&G

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel		$10.5
Travel		$2.8
Contractual		$0.0
Commodities		$0.1
Equipment		$0.0
Subtotal	$0.0	$13.4
General Administration		$1.6
Project Total	$0.0	$15.0
Full-time Equivalents (FTE)		0.1
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
Estimated FY 2003					
$40.0					

Dollar amounts are shown in thousands of dollars.

Comments:
The lidar equipment and other remote sensing instruments, potentially including an infrared radiometer and digital 3-chip color video (set up to collect ocean color), are being provided at no cost to the project. This represents a substantial savings over having to rent or purchase this equipment. Personnel time involved with processing costs is also being provided in-kind. This represents an approximate 50% match of the total personnel time.

FY02

Prepared: April 2001

Project Number: 02584 Revision
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Agency: NOAA Environmental Technology Laboratory

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2002
James Churnside	Supervisory Physicist	ZP 5	0.3	20.0		6.0
James Wilson	Electronics Engineer	ZP 4	0.3	15.0		4.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.6	35.0	0.0	
					Personnel Total	$10.5

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2002
RT Denver to Anchorage - Field Data Collection	1.8	1	5	0.2	2.8
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$2.8

FY02

Prepared: April 2001

Project Number: 02584 Revision
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Agency: NOAA Environmental Technology Laboratory

FORM 3B
Personnel
& Travel
DETAIL

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed FY 2002
Description	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$0.0

Commodities Costs:	Proposed FY 2002
Description	
misc. (water filter for laser, dry nitrogen for laser, data recording media, etc.	0.1
Commodities Total	$0.1

FY02

Prepared: April 2001

Project Number: 02584 Revision
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Agency: NOAA Environmental Technology Laboratory

FORM 3B
Contractual & Commodities DETAIL

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2002
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
NOAA Fish Lidar	1	NOAA

FY02

Prepared: April 2001

Project Number: 02584 Revision
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Agency: NOAA Environmental Technology Laboratory

FORM 3B
Equipment
DETAIL

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002	LONG RANGE FUNDING REQUIREMENTS
Personnel		$18.1	
Travel		$4.1	
Contractual		$25.2	
Commodities		$0.1	
Equipment		$0.0	
Subtotal	$0.0	$47.5	Estimated FY 2003
Indirect		$11.9	
Project Total	$0.0	$59.4	$240.0
Full-time Equivalents (FTE)		0.2	
			Dollar amounts are shown in thousands of dollars.
Other Resources			

Comments:
Summary for UAF portion of this budget; carried forward as contractual from ADF&G

The indirect rate is 25% TDC, as negotiated by the *Exxon Valdez* Oil Spill Trustee Council with the University of Alaska.

FY02

Prepared: April 2001

Project Number: 02584 Revision
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Name: Evelyn Brown, University of Alaska Fairbanks

FORM 4A
Non-Trustee
SUMMARY

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Personnel Costs:			Months Budgeted	Monthly Costs	Overtime	Proposed FY 2002
Name	Position Description					
Evelyn Brown	Research Associate		1.5	6.7		10.0
Engineer/Programmer	Engineer/Programmer		1.3	6.4		8.1
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	2.8	13.1	0.0	
					Personnel Total	$18.1

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 2002
Description					
Field testing R/T Fairbanks-Anchorage (Brown)	0.5	2	10	0.1	2.0
					0.0
EVOS workshop and research planning (Fairbanks-Anchorage) (Brown)	3.0	1	4	0.2	0.9
					0.0
Scientific Meeting (GLOBEC/PICES) (Brown)	0.6	1	4	0.2	1.2
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$4.1

FY02

Prepared: April 2001

Project Number: 02584 Revision
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Name: Evelyn Brown, University of Alaska Fairbanks

FORM 4B
Personnel
& Travel
DETAIL

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed FY 2002
Description	
communications	0.1
Aerial Survey Contract (aircraft and imaging services)	25.0
Copy/Reproduction	0.1
Contractual Total	$25.2

Commodities Costs:	Proposed FY 2002
Description	
Data Storage/Hardware/Printer supplies/repair	0.1
Commodities Total	$0.1

FY02

Prepared: April 2001

Project Number: 02584 Revision
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Name: Evelyn Brown, University of Alaska Fairbanks

FORM 4B
Contractual & Commodities
DETAIL

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2002
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	

FY02

Project Number: 02584 Revision
Project Title: Evaluation of Airborne Remote Sensing Tools for GEM Monitoring
Name: Evelyn Brown, University of Alaska Fairbanks

FORM 4B
Equipment
DETAIL

Received 11-15-01
approved TC 12-11-01

Lingering Oil: Bioavailability and Effects to Prey and Predators

Project Number:	02585
Restoration Category:	Research and Monitoring
Proposers:	
Part I: NOAA- ABL	Stanley Rice, Jeff W. Short, Mandy Lindeberg; NMFS, Auke Bay Laboratory; ABL Program Manager: Dr. Stan Rice
Part II: DOI-USGS:	Jim Bodkin, Brenda Ballachey, Paul Snyder, Dan Esler; DOI Program Manager: Dede Bohn
Lead Trustee Agency:	NOAA
Cooperating Agencies:	DOI-USGS
Alaska Sea Life Center:	Yes
Duration:	1st year of a 2 year project
FY02 FY03	296.4K Part I (NOAA): 201.6 K Part II (USGS): 94.8 K 30K (Estimated: closeout)
Geographic Area:	Prince William Sound, Gulf of Alaska
Injured Resource/Service:	Intertidal, Sediments, Sea Otters, Harlequin Ducks

ABSTRACT

About 20 acres of contaminated beach were found in 2001 surveys of western PWS conducted by Auke Bay Laboratories (ABL). This estimate was more than twice the estimate following the 1993 shoreline assessment surveys. Sea otters and harlequin ducks have not recovered, raising concerns that continued exposure may be affecting their survival. This study is an outgrowth of ABL surveys in 2001 and USGS studies of impacts to sea otters and harlequin ducks. Biochemical assays and mortality patterns are consistent with continuing oil exposures, but linkages between oil persistence studies and impact studies have not been attempted to date. This study will attempt to identify a greater degree of linkage between oil persistence, exposure and effects by choosing a common set of sites at which to assess oil persistence and biological effects on sea otters and harlequin ducks. The emphasis will be on bioavailability, and impact to sea otters and harlequin ducks, but some effort will be expended on bioavailability and exposure of prey species living in oil patches. ABL will lead studies of oil bioavailability and impacts to prey species; DOI-USGS will lead studies directly on sea otters and harlequin ducks.

GENERAL INTRODUCTION

In summer 2001, the shoreline assessment project found about 20 acres of beach in Prince William Sound that were still contaminated with oil. This 20 acre estimate of oil contaminated beaches was more than twice the estimate coming from the surveys in 1993 (1993 surveys covered more beaches, but dug far fewer holes) (Gibeaut and Piper, 1998a and b). Most of the oil found in 2001 was classified as "light", but was still readily located, and easily observed. Some of the subsurface pits (20) were classified as heavily oiled. Oil saturated all of the interstitial spaces, and was extremely repugnant. These "worst case" pits exhibited an oil mixture that resembled the oil a few weeks after the spill- highly odiferous, lightly weathered, very fluid. Most of the subsurface oil was found at a lower tide height than expected (between zero and 6 ft), in contrast to the surface oil which was found mostly at the highest levels of the beach. This is significant, because the pits with the most oil were found low in the intertidal zone, closest to the zone of biological production.

Recovery of sea otters and harlequin ducks in the North Knight Island area has not occurred, with both species showing evidence of injury in 2001). Oil exposure has been suspected as a factor constraining recovery, particularly in consideration of elevated levels of cytochrome P4501A (P450), a biomarker of aromatic hydrocarbon exposure, in otters and ducks from oiled areas (Ballachey et al. 2001b, Trust et al. 2000). Higher mortality rates have been demonstrated for sea otters (Monson et al. 2000) and harlequin ducks (Esler et al. 2000) residing in oiled areas of western PWS, but without confirming bioavailability and identifying exposure pathways, it has not been clear that lingering oil was responsible. Presence of oil was not a measure of bioavailability. Earlier studies showing significant oil concentrations in contaminated mussel beds were suggestive, but there was never an exhaustive survey of mussel beds to determine their distribution and significance, and assumptions were made that they were not widespread and likely did not present a large risk to predator species. The survey in 2001 indicates relatively more oil lower down on the beach, near the biological zone, and raises the possibility that oil deposits at high impact sites may be limiting recovery of sea otters and harlequin ducks.

Field studies in 2002 will focus on two primary questions:

(1) Is the lingering oil bioavailable? And, (2) is it still causing impacts? Auke Bay Laboratory (ABL) will lead studies on oil bioavailability, and will modify their surveys to overlap with impact sites relevant to sea otters and harlequin ducks (and control areas). DOI-USGS will focus their impact studies on aea otters and harlequin ducks at the same suite of sites. Bioavailability studies will look at the mobilization of oil out of oil patches, into the water and into prey species. This suite of studies should permit extensive interpretation of the data by having answers to questions of bioavailability within a site, within a bay, within a region, and impacts at a very site specific level (within an oil patch, within a bay, within a region), and will include impact studies on both prey and predators.

The two research groups are submitting a joint proposal to investigate bioavailability and

impacts, but will operate independently. Both groups have shared data and selected sites worthy of further study so that the oil persistence/bioavailability data can be compared to the exposure and impact data gathered on the two predator species. The following project proposal has been divided into two sections: Part I, led by ABL, which will focus on bioavailability of oil from oil patches and transport to prey species; and Part II, led by DOI-USGS, which will focus on the impacts to sea otters and harlequin ducks. Upon completion of the data collection and analyses, researchers from the two groups will work together to interpret results and prepare a final report.

PART I: Bioavailability of PAH from oil patches and impacts to prey species (NOAA-ABL)

ABSTRACT

Presence of oil indicates but does not prove that the oil is potentially bioavailable. The extensive beach surveys conducted in western PWS in 2001 estimate that about 20 acres of upper intertidal beach remain contaminated, and lend support to the hypothesis that lingering oil can still cause injury to invertebrates near the oil patch as well as to the predators feeding in the area. This half of the project, led by ABL, will focus on determination of bioavailability of oil within an oil patch, within a bay, and possibly within a region of the spill. Further, prey species (mussels, other invertebrates, and crescent gunnels living in the oil patches) will be assessed for contamination (bioavailability of PAH) and also for impacts. This half of the project should aid interpretation of the impact studies on sea otters and harlequin ducks conducted by DOI-USGS as there will be a high overlap of impact and control sites between the two study components.

INTRODUCTION

In summer 2001, the shoreline assessment project identified about 20 acres of beach in Prince William Sound that were still contaminated with oil, and changed our perception of how much oil remains and where on the beach it is located.Further, it has elevated the possibility that the lingering oil may be causing continuing injury in some species, including sea otters and harlequin ducks. Oil was found at 58% of the 91 sites assessed; 6775 randomly stratified sampling pits were assessed to have the linear equivalent of 7.8 km of oil contaminated beach. This 20 acre estimate of oil contaminated beaches was more than twice the estimate coming from surveys in 1993 (1993 surveys covered more beaches, but dug far fewer holes) (Gibeaut, and Piper, 1998a, b). Most of the oil found in 2001 was classified as "light", but was still readily located and observed. All the pits used in the assessment were dug by hand, and all the initial classifications were made from visual observations. Over a period of about 100 days, 91 sites were visited, each site picked randomly from a population of sites judged to be heavily or moderately oiled in one of the surveys from 1989-1993.

In addition to the area estimated to remain contaminated, several other important points are evident. (1) Surface oil was not a good indicator of subsurface oil at that specific pit. In other words, surface oil, which was found predominantly high in the intertidal beach areas, was not a good predictor of subsurface oil, which was found predominantly much lower in the intertidal zone. (2) Some of the subsurface pits (n = 20) were classified as heavily oiled. In these pits, oil saturated all of the interstitial spaces, and was extremely repugnant. These "worst case" pits exhibited an oil mixture that resembled the oil a few weeks after the spill- highly odiferous, lightly weathered, very fluid. (3) Subsurface oil was also found at a lower tide height than expected (between zero and 6 ft), in contrast to the surface oil which was found mostly at the highest levels of the beach. This is significant, because the pits with the most oil were found low in the intertidal zone, closest to the zone of biological production, and indicate that our estimates

are conservative at best.

The lingering oil has survived two summers of intense clean-up by Exxon (1989,1990), 12 winters of storms, and 12 years of tides (Brodersen et al., 1999; O'Clair et al., 1996). Oiling levels have certainly declined during this time period, but the remaining oil would appear to be relatively stable and not very vulnerable to further degradation and weathering (Hayes and Michel, 1998 and 1999). This begs the question- is it bioavailable, and is it still causing impacts? In the mid 1990's, similar concerns grew out of some studies on oiled mussel beds (Babcock et al., 1998; Carls et al., 2000). A few oiled mussel beds had been located, and were thought to remain oiled because they were not cleaned in 1989 or 1990, but their impacts were presumed to be relatively insignificant because their total areas were not large (less than an acre). It was curious that oil remained and that it was not heavily weathered, but the volumes from the specific sites were thought to be too small to be damaging on a wide scale. The surveys in 2001, which were not exhaustive surveys of the lower intertidal zones, raise the question that there may be more mussel beds that remain contaminated, and that possible entry into the food chain may not be restricted to the lingering oil targeted in the 2001 surveys. The distribution, quantity and significance of oiled mussel beds remains unknown, and probably deserves further attention in outlying years.

Sea otter and harlequin duck studies in 1996-98 continued to show long term effects: elevated P450s (Ballachey et al. 2001, Trust et al. 2000), and abnormal mortality patterns Monson et al. 2000, Bodkin et al. in press, Esler et al. 2000)). In the heavily oiled area of northern Knight Island (including Herring Bay and Bay of Isles), sea otter abundance remains well below pre-spill levels (Dean et al. 2000). . The population size of harlequin ducks before the spill was not accurately known, but the winter mortality rates in oiled areas are significantly higher than in non-oiled areas of the sound. Studies of both sea otters in 2001 found further evidence of continued exposure, based on blood chemistries and liver examinations (sea otters) and P450 levels (harlequin ducks). This generates concern that the lingering oil is indeed bioavailable and at concentrations sufficient to have impacts on predator species.

This half of the project will attempt to determine if oil is bioavailable in areas where sea otters and harlequin ducks are doing poorly, and compare results from oiled areas to nonoiled areas where they are doing well. Bioavailability of PAH in prey species, and their damage, will be assessed at very specific oil patch sites, and at control sites within the impacted bays as well as regional control sites. These data should permit a better evaluation of lingering oil as a potential cause of the continuing injury in sea otters and harlequin ducks, as there will now be a high degree of overlap, geographically and chronologically, between the study sites looking at PAH bioavailability/prey damage and assessment of effects on the predators.

NEED FOR THE PROJECT

A. Statement of Problem

After 12 years, significant oil remains in and on the beaches of Prince William Sound, but its presence is not proof that the oil is bioavailable to prey and predators. The amount of oil found in 2001 was surprising (more than twice the estimate coming from 1993 surveys), as was the location on the beach (lower intertidal zone). Significant impacts to sea otters and harlequin ducks in the oiled area persist, including lower survival rates in oiled areas than in unoiled areas, for both species. We do not know if the persistent oil is bioavailable to otters and harlequin ducks, and if it is, if it has toxic impacts as the data suggest.

B. Rationale

Studies of persistence/ bioavailability will be coordinated with further studies of impacts to sea otters and harlequin ducks. The study sites will be modified from the existing studies so that there is greater overlap- bioavailability studies and impact studies will be compared at the same sites where otters and ducks have adequate numbers for study (Montague Island as a control site; Green Island, Bay of Isles, Herring Bay, Northwest Bay as impact sites). The bioavailability studies will be led by the Auke Bay Laboratory, and the impact studies on sea otters and harlequin ducks will be led by USGS.

C. Location

All study sites and sampling will be conducted within Prince William Sound. For some of the "effects" studies, Cordova harbor will be used as a "positive" oil control and samples of mussels or fish will be collected there. All other sites will range from Montague Island (control area) to Green Island and northern Knight Island (see Figure 1).

COMMUNITY INVOLVEMENT

Charters to support the research will be solicited from the spill impacted area. Further, some labor support for some of the field operations may be solicited from the Native villages.

A. Objectives

1. Determine if the oil remaining is bioavailable:
    a. From beach sites judged to be heavily oiled from the 2001 surveys

2. Determine if the oil remaining is still causing impacts:
    a. To mussels, as determined by DNA damage to hemolymph cells
    b. To intertertidal fish (crescent gunnels) living in or near subsurface oil deposits

B. Methods

General sampling strategy for bioavailability and prey impacts:

Bioavailability of PAH and prey impacts will be assessed at a suite of sites that overlap with the harlequin duck and sea otter studies. There are several sampling components to the study:

Bioavailability of PAH: The key question of bioavailability will be assessed in several different ways and scales. Plastic strips (sensitive, cheap to analyze) will be the primary sample medium for assessment, and will be supplemented by mussel and prey samples. Plastic strips will be placed above and below the beach surface at several points in a beach relative to an oil patch. See the sampling diagram with a beach layout (Figure 2).

Bioavailability to mussels and mussel beds: Mussels and strips sample slightly differently; mussels can pick up more PAH in droplets than strips. Using combinations of mussels and strips, we will have better capabilities of interpreting the data. Mussels are not ubiquitous in oil patches; for this reason, there will be some use of caged mussels to supplement collections from resident mussels. Mussel beds within the sample sites will also be targeted if they are oiled, to see if bioavailability and impacts are the same as oil patches without mussels. Mussel beds from the earlier mussel bed studies will not be targeted in this study (for budget reasons) because we need the present sample sites to have overlap with the 2001 surveys and the otter/duck studies. The probability of detecting released oil is not great after 12 years of tides and weathering. For this reason, we have adopted the general strategy of targeting beaches with high quantities of oil remaining, and have put many sampling devices in a spread of locations and depths to increase our probabilities for capturing minimal releases of oil. The strips are the most sensitive sampling device we know of.

Design and structure:
Regional Controls: Montague island area will serve as a regional control. Two independent sites on Montague may be used for some of the sampling.

Within Bay Control sites: Several bays will be sampled in an oil patch, but also at some distance within the bay away from the sampled patch. This will allow interpretation on the scope of some of the signals (PAH in resident mussels; P450 in crescent gunnels) to determine how site specific the signal is.

Positive Control: Some analyses require a "positive" control for the methods and field collections. If there were no measurement of DNA damage in mussels or P450 impacts in crescent gunnels, the methods would be in question; positive controls (Cordova harbor) will prevent this interpretation glitch. Table 1 lays out the sampling design by site, sample type, sub-location, and sample quantities.

Statistics: In addition to the complement of retrieved samples for analyses, an additional 10% will be added as duplicates. This will be spread across the sample sites and strata, and will permit accuracy measurements.

Sampling Periods (Seasonal): Two seasons will be sampled where practical; winter when storm violence may be more likely to cause the release of subsurface oil, and impacts may be the greatest; plus summer when extensive sampling is more favorable and practical. There is risk of loss of the sampling devices, so about twice as many will be deployed as will be analyzed. This extra deployment has little impact on costs, but ensures a sampling scheme without holes. These extra deployment numbers are not shown in table 1. There will be "over-sampling", particularly of strips and prey, and some analyses will be contingent on primary analyses, to be run later in the current year, or possibly into next year under a different proposal.

Sampling Locations: The following sites will be used (figure 1)

Montague Island	a control site; two different areas may be sampled
Green Island	otter impact site with known oil; otters are present in numbers
Bay of Isles	impacted site with marginal numbers of recovering otters
Northwest Bay	impacted site; worst case site for bioavailability studies
Herring Bay	impacted sites; worst case site for bioavailability studies
Cordova harbor	impacted "positive" control site

*Oiled mussel beds will also be sampled from a subset of these.

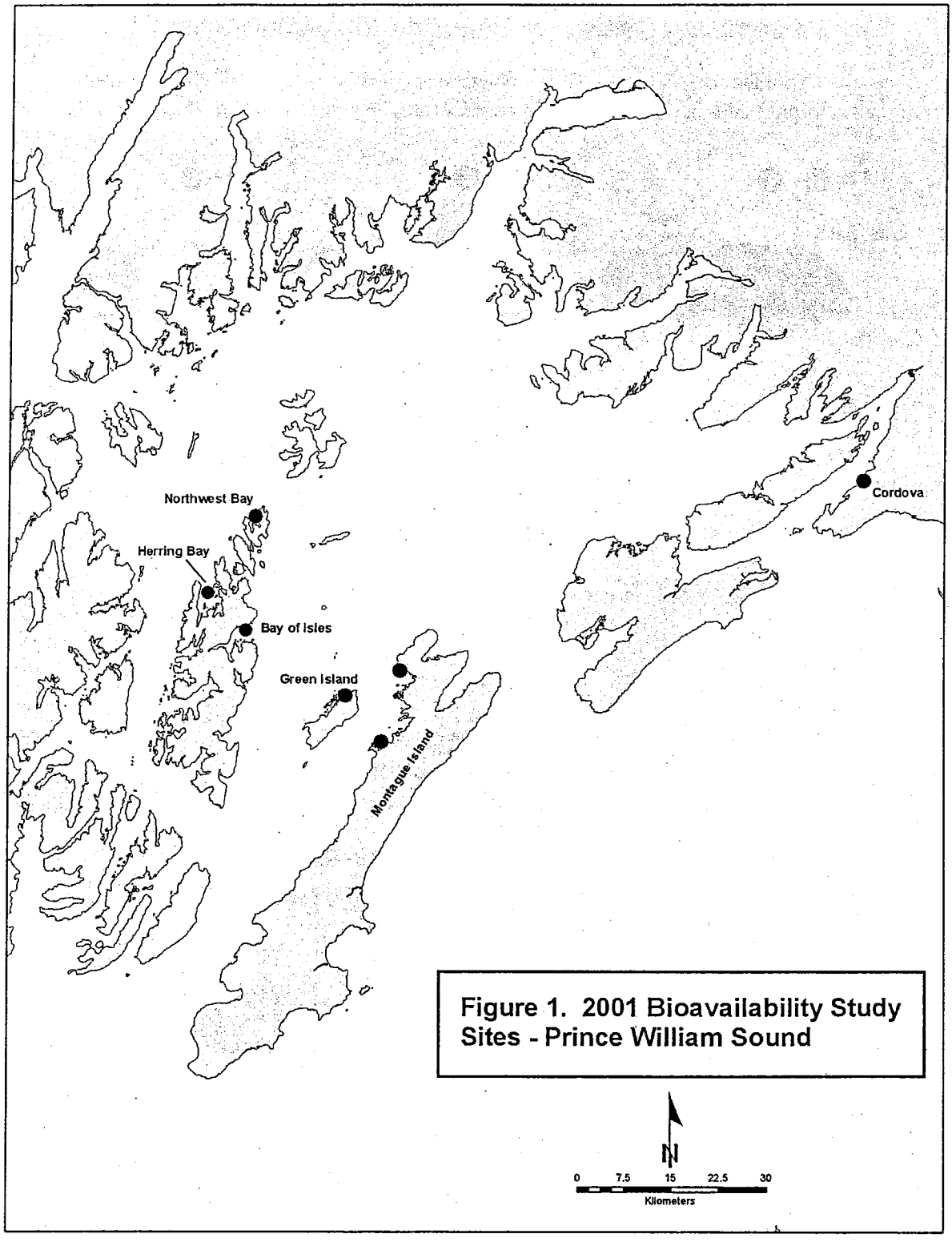
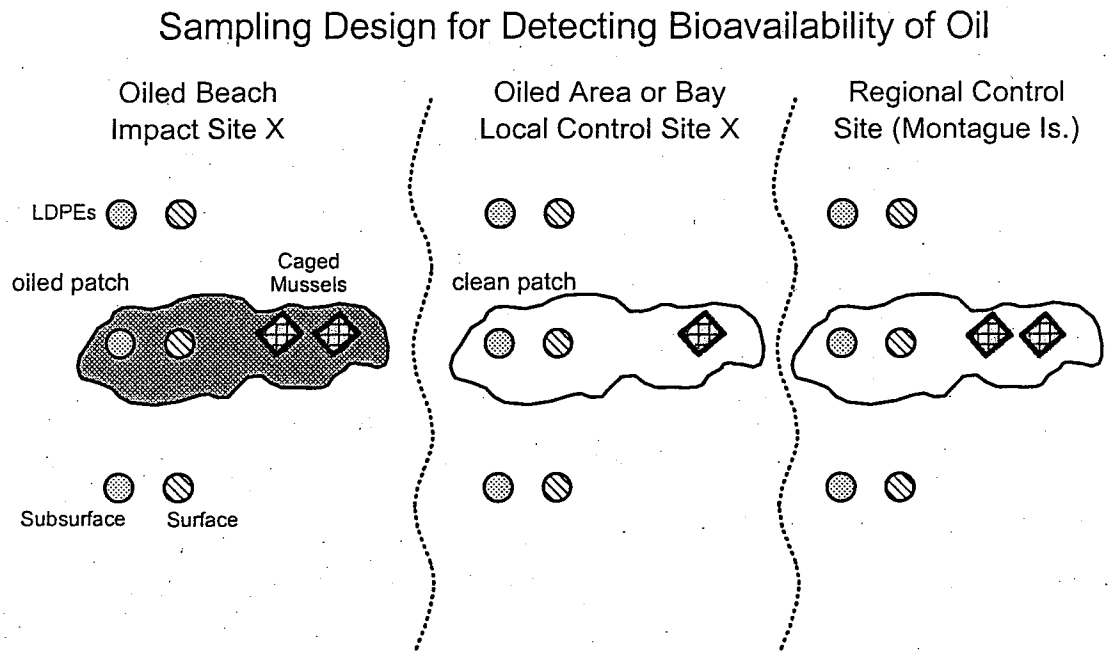


Figure 1. 2001 Bioavailability Study Sites - Prince William Sound



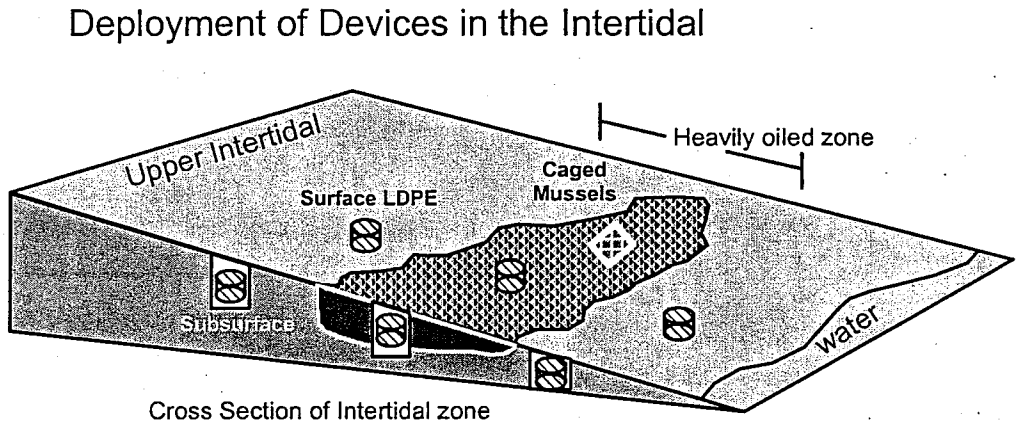


Figure2.Samplingdesignforbioavailabilityofoilanddeploymentof LDPEs.

Table 1. Numbers and types of samples analyzed at different sites to determine bioavailability

	LDPE (strips)			
	Heavy Oil Patch		Mussel Beds	
Site	Oiled Patch	Local Control	Oiled	Local Control
Cordova (positive Controla)	6			
Montague Is. (area control)		6		6
Green Is.	6	6		
Bay of Isles	6	6	6	6
Herring Bay	6	6	6	6
Northwest Bay	6	6		
subtotal = 90	30	30	12	18

Grand Total (winter/summer + 10% QC) = 200

*1/2 of the strips are subsurface and 1/2 are at the beach surface

*Deployment of LDPEs doubled to ensure recovery

	Bioavailability to Mussels			
	Caged		Resident	
Site	Oiled Patch	Local Control	Oiled	Local Control
Cordova (positive Controla)	2		2	
Montague Is. (area control)		2		2
Green Is.	2	1		
Bay of Isles	2	1	2	2
Herring Bay	2	1	2	2
Northwest Bay	2	1		
subtotal = 28	10	6	6	6

Grand Total (winter/summer + 10% QC) = 40

* all samples are at the beach surface

	Impacts - DNA Damage Assessment			
	Mussels (Comet)		Gunnels (P450)	
Site	Oiled Patch	Local Control	Oiled	Local Control
Cordova (positive Controla)	20		20	
Montague Is. (area control)		20		20
Green Is.	20	20	20	20
Bay of Isles	20	20	20	20
Herring Bay	20	20	20	20
Northwest Bay	20	20	20	20
subtotal = 28	100	100	100	100
	200 x 2 (w/s)		200	

* 20 = # of individuals; Gunnels = 1 sampling period (summer)

Specific Methods: Sampling strategy for bioavailability and prey impacts:

A. Determine bioavailability of PAH at heavily oiled 2001 survey sites.

1. To determine if PAHs are available, plastic strips (low density polyethylene devices or LDPEs) will be deployed at each of the sites (See figure 1) in a sampling pattern designed to capture any flow dynamic that is possible (see figure 2). Strips will be deployed above and below the beach surface in protective perforated containers. Some strips will be deployed higher on the beach from an oil patch, some within the oil patch, and some below the oil patch. At some distance away from the oil patch, a similar sampling scheme will be deployed to determine if PAH are available on a broader scale than just in the immediate vicinity of a specific oil patch. Likewise, regional controls will determine if there is more PAH available at even a larger scale. These deployments will be made in both the winter and in the summer. Oiled patches discovered and mapped during the 2001 survey will be relocated (patches found in lower zones near the biological active zones will be targeted) and LDPEs placed in close proximity. This array of LDPEs will be replicated to ensure retrieval of sufficient numbers 30 days later, and to allow for the 10% replicate analyses required for statistical evaluation of accuracy. See table 1 for numbers analyzed by site, compared to other measurements.

2. Mussels will also be sampled for bioavailability of PAH. Mussels will be used in addition to strips because they tend to sample oil droplets more efficiently than strips, and comparative analyses will allow for greater interpretation of the results. Mussels are often not available at some of the oiled sites, and caged mussels may be used for that sampling. See table 1 for numbers analyzed by site, compared to other measurements

3. Some prey animals will be sampled in addition to resident mussels to see if PAH are bioavailable in these species. Over-sampling will be the strategy; selected samples for analyses will be based on results from strips, and collections from other sites. Only the high impact areas will be analyzed initially; other samples will be archived and further analyses will be proposed if PAH are found in the mussels from the high impact sites. A minimum of 20 samples will be analyzed by GC-MS (Short et al., 1996).

4. A limited number of sediment samples will be collected during both sampling periods within the oiled patches to determine the condition of the oil and whether PAH composition matches weathered *Exxon Valdez* oil (EVO) (Short and Heintz, 1997). These samples will be analyzed by GC-MS (Short et al., 1996). These samples will be needed for interpretation and only a few need to be analyzed.

B. Determine DNA damage to resident mussels from oiled and unoiled patches via single cell gel electrophoresis (comet analysis).

DNA damage in mussels, measured by the comet analysis, has evolved as a monitoring tool for PAH and other contaminants in polluted harbors (Steinert et al., 1998). It is a very sensitive technique, is relatively inexpensive, and requires relatively few cells. DNA damage is repairable, hence sample collection and preservation at the site is a requirement.

Specific methods:
20 mussels will be sampled from each specific sampling location; hemolymph samples will be taken on site, cryopreserved in liquid nitrogen, and returned to the lab for storage (-70 C) and assay of DNA damage. A "positive" control will be used (Cordova harbor) to verify that the sample collection and methods are working. A minimum of twenty five cells will be utilized to determine the extent of damage at the individual level. Impacted sites will be compared to control sites within the bay (e.g., bed rock mussels with no underlying oil bed), and to regional controls (Montague Island). Samples will be analyzed blind. 200 mussels will be analyzed from winter, and 200 from summer collections. Comet analyses will be contracted out to Dr. Robert Thomas of California State University at Chico. See table 1 for numbers and sites compared to other measurements.

C. Determine if crescent gunnels living in oil patches are exposed to oil (P450) and compare to collected specimens from other sites that are either nearby (same bay) or distant (regional controls)

Crescent gunnels live under rocks in the intertidal zone at low tide and are the only vertebrate that resides within an oil patch (Peden and Hughes, 1984). If a vertebrate can show exposure and damage, crescent gunnels would appear to be the species with the highest probability. Earlier work has shown that gunnels collected from the spill zone had higher P450 values (Woodin and Stegeman, 1993), but interpretations were hampered by the lack of collections from known oil patches. This project would collect animals from within oiled patches, from nearby unoiled patches within the same bay, and from regional controls. Damage to organs evaluated histopathologically would not be conducted this fiscal year (because of costs), but the tissue blocks would be retained and would be proposed for future funding if there are significant differences in P450 responses from the different sites.

Specific methods:
20 crescent gunnels will be sampled, dissected, and preserved appropriately on site. Gunnels collected from impacted sites will be compared to control sites within the bay system of the impact site, and to regional controls (Montague Island, and also a "positive" control from Cordova Harbor). Organs (including liver, kidney and gills) will be dissected out, preserved, and subsequently processed into blocks and slides for P450 antibody staining. A total of 200 fish will be analyzed. Samples will be analyzed blind. All analyses will be contracted to Dr. Gary Marty of University of California Davis. This study will be done only in the summer. . Sampling sites for gunnels will be the same as they are for the mussels (see table 1).

Interpretive model for bioavailability studies

The following rationale outlines how we will interpret the bioavailability of lingering EVO :

PAH are bioavialable if:

- The LDPE tested positive for PAHs in the surface deployments.
- The LDPE strips are positive in subsurface deployments outside the oil patches.
- The bioavailability is more significant if the control sites within a bay test positive.
- The bioavailability is more questionable if the regional control sites have significant positive PAH results.
- The deployments are suspect if lab and field blanks test positive.
- The methods are suspect if the positive control of Cordova Harbor is NOT positive.

Further analyses to strengthen case:

- The multiple impact sites test positive.
- PAHs are present in mussels and/or prey.
- P450 present in Crescent Gunnels; comets are above normal in oiled areas.
- P450 and comet assays are suspect if the samples from Cordova Harbor are not positive.

SCHEDULE for Bioavailability and prey impact studies

A. Measurable Project Tasks for FY02 (October 1, 2000 – September 30, 2002)

FY02: All field collections and measurements will be completed in the FY 02 funding cycle. All chemical analyses, blood work, P450 analyses, etc will be initiated in FY 02.

FY03: Close out of the FY 02 is anticipated for both agencies. Further work would be dependent on results, and would be applied for as an independent proposal. Some chemical analyses may spill into FY 03, but all data analyses will be completed by Jan 2003. Final reports would be due May 15, 2003.

B. Project Milestones and Endpoints

Winter field work: Deployments about Feb 1, 2002, with a pick-up cruise a month later (Bioavailability, mussel impacts, prey collections).

Summer field work: Deployments about mid June, followed by a pick-up cruise in July (Bioavailability, mussel impacts, fish impacts).

C. Completion Date

Field work completed by Aug of 2002.
Chemical analyses completed by November 2002.

P450 analyses completed by November 2002. Comet tests completed by October 2002.

Final report by May 15, 2003

PUBLICATIONS AND REPORTS

Several specific papers on bioavailability, and impacts are expected. At some point, one or more synthesis papers combining bioavailability and impact data across disciplines is expected but is beyond the scope of the project at this time.

PROFESSIONAL CONFERENCES

The EVOS Trustee meetings will be attended by the principle investigators.

NORMAL AGENCY MANAGEMENT

None of these projects are part of normal agency management activities.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project is related to the close-out of the Shoreline assessment project, and will use the information generated from that study for specific site selections. Likewise, the sea otter and harlequin duck work is an outgrowth of projects funded in FY 01 or FY 02, and will utilize information from those projects. Further, there has been coordination between the two agency component parts in development of the proposal, to ensure geographical overlap and relationship.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

N/A

PROPOSED PRINCIPAL INVESTIGATORS

Stanley D. Rice
Auke Bay Laboratory, Alaska Fisheries Science Center
National Marine Fisheries Service, NOAA

11305 Glacier Highway, Juneau, Alaska 99801-8626
Phone: (907) 789-6020
FAX: (907) 789-6094
e-mail: jeep.rice@noaa.gov

Jeffrey W. Short
Auke Bay Laboratory, Alaska Fisheries Science Center
National Marine Fisheries Service, NOAA
11305 Glacier Highway, Juneau, Alaska 99801-8626
Phone: (907) 789-6065
FAX: (907) 789-6094
e-mail: jeff.short@noaa.gov

Mandy R. Lindeberg
Auke Bay Laboratory, Alaska Fisheries Science Center
National Marine Fisheries Service, NOAA
11305 Glacier Highway, Juneau, Alaska 99801-8626
Phone: (907) 789-6616
FAX: (907) 789-6094
e-mail: mandy.lindeberg@noaa.gov

PRINCIPAL INVESTIGATORS

Stanley D. Rice
GM-14 Physiologist

Received BA (1966) and MA (1968) in Biology from Chico State University, and PhD (1971) in Comparative Physiology from Kent State University. Employed at Auke Bay Fisheries Laboratory since 1971 as a research physiologist, task leader and Habitat Program Manager since 1986. Rice has researched oil effects problems since 1971, and has published over 115 papers, including over 75 on oil effects. Studies have ranged from field to lab tests, behavioral to physiological to biochemical studies, from salmonids to invertebrates to larvae to meiofauna. Rice has conducted and managed soft funded projects since 1974, including the Auke Bay Laboratory *Exxon Valdez* damage assessment studies since 1989. Activities since the oil spill have included leadership and management of up to 10 damage assessment projects, field work in PWS, direct research effort in some studies. Quality assurance of all studies, particularly the biological impacts research has been the continuing focus through the restoration years. Principle investigator in subtidal sediment studies, pink salmon effects studies, and in the SCAT surveys of 2001. In addition, Rice has lead the effort on use of LDPE research by the Auke Bay Lab.

Jeffrey W. Short

Research Chemist

Education: M.S. (Physical Chemistry). 1989- Present: Established and managed the hydrocarbon analysis facility at ABL to analyze hydrocarbon samples generated by the *Exxon Valdez* NRDA effort. Responsible for quality control and data interpretation of all data hydrocarbon data produced by ABL labs. Principle investigator of several EVOS projects through the damage assessment and restoration years, paarticularly those studies involved in tracking oil (subtidal sediments), tracking the Hydrocarbon Data Base, several specific projects (Pristane; Coal as a background source), and most importanly, principle investigator of the large shoreline assessment project (SCAT) in FY 2001. Many publications.

Mandy R. Lindeberg
Fisheries Research Biologist

B.S. Marine Biology. 1990- present: Mandy has been involved in *Exxon Valdez* oil spill research for the last 11 years. Her research includes studies on intertidal invertebrates and seaweeds, mussel populations, and a co-principal investigator of spot shrimp populations in Prince William Sound. She was the field chief of the intensive PWS oiled shoreline survey during 2001. Her responsibilities include quality control of field and laboratory sample processing, data analysis, graphics, and proposal/report preparation.

OTHER KEY PERSONNEL

Chemists Marie Larsen, Larry Holland, Josefina Lunasin will participate in the chemical analyses of the samples. Contractors Dr. Robert E. Thomas and Dr. Gary Marty will participate at the principle investigator level on analyses for DNA damage in mussels and P450 response in crescent gunnels.

LITERATURE CITED

See combined "Literature Cited" section for Parts I & II.

Summary of ABL Budget:

Support Logistics: Vessel Charter			
Winter deployment cruise:	9 days,	9 K	
Pickup cruise:	8 days,	7 K	
Summer deployment cruise:	7 days,	7 K	
Pickup cruise	7 days,	7 K	
		Subtotal vessel	30 K
Materials and supplies:			
Strips, collectors,		4 K	
Nitrogen, shipping logistics		2 K	
Misc field gear		3 K	
Comet supplies		2 K	
			11 K
Contracts:			
Comet analyses:		5 K	
P450, Histopath processing, analyses		30.2 K	
Soft Labor:		12 K	
			47.2 K
Travel:			
2 Trips: Calif to PWS- R. Thomas (winter, summer)		2.6 K	
1 Trip: Calif to PWS- G Marty (summer)		1.2 K	
ABL- to PWS	4 deployment	1.6 K	
	4 pick up	1.6 K	
	4 deployment	2.0 K	
	4 pick up	2.0 K	
3 trips: ANC to Trustee meetings		1.6 K	
			12.6 K
Analytical costs: 200 strips at $ 200 per strip		40 K	
caged mussels: 32 at $500 ea		16 K	
resident mussel: 24 at $500 ea		12 K	
sediments: 6 samples at $500 ea		3 K	
prey samples 20 at $500 ea		10 K	
			81 K
Labor: Lindeberg, field party chief		12.5 K	
		Subtotal	194.3 K
		Plus overhead	7.3 K
		Total:	**201.6 K**

PART II: Impacts to Sea Otters and Harlequin Ducks (DOI - USGS)

ABSTRACT

Sea otters and harlequin ducks have not fully recovered from the EVOS, based on demographic, physiological and biochemical differences between populations in oiled and unoiled areas. To explore links between residual oil and the lack of population recovery, we propose to capture sea otters in areas known to have relatively high quantities of residual oil, and collect blood and liver samples. These areas will overlap with the study sites described in Part I of this DPD, to be sampled for bioavailability of lingering oil in intertidal areas. Exposure of sea otters to hydrocarbons will be measured by the cytochrome P450 biomarker (in blood and liver) and liver function will be assessed by gross and histologic examination, and by serum enzymes. Harlequin ducks are already being captured in oiled areas as part of another project (02423). However, included in this proposal are components for (1) histopathology of sea duck liver biopsies, collected from Barrow's goldeneyes in 1996 and from harlequin ducks in 2001 and 2002. Results of this study will be interpreted in conjunction with data collected by NOAA-ABL scientists, on the bioavailability of oil in shoreline areas of western PWS.

INTRODUCTION

Through 2001, studies have shown a lack of recovery for sea otters (*Enhydra lutris*) and harlequin ducks (*Histrionicus histrionicus*) in oiled areas of western PWS, and several lines of evidence strongly implicate continuing exposure to oil as a primary factor limiting recovery (Bodkin et al. in press; Esler et al. in press). Both species feed on invertebrates in the nearshore ecosystem, and potentially could be exposed to oil either through their prey or directly, in sediments or in the water column. Major research findings in 1995-2001 include: (1) lower survival rates for sea otters and harlequin ducks in oiled areas (Monson et al. 2000, Esler et al. 2000), (2) elevated levels of cytochrome P450 1A (CYP1A), a biomarker of hydrocarbon exposure (Ballachey et al. 2001b, Trust et al. 2000, Esler, pers. comm.), and (3) diseased livers in sea otters from the oiled area in 2001 (USGS unpub. data). The discovery in summer 2001 of greater amounts of residual EVOS oil on beaches (NOAA-ABL, unpubl. data) substantiates concerns that exposure in nearshore areas persists, and that residual hydrocarbons are constraining recovery of sea otters and harlequin ducks in areas of PWS that were heavily oiled in 1989.

Sea otters and harlequin ducks are subject to continuing study in 2002, as part of Project 02423. For harlequin ducks, ongoing work consists of (1) capture of wild birds for survival rate studies (radiotelemetry) and tissue sampling for CYP1A assays, and (2) controlled studies of oil exposure on physiology and behavior of harlequin ducks held at the SeaLife Center in Seward. For sea otters, ongoing studies include (1) collection of carcass remains off beaches, to estimate ages and survival rates, and (2) surveys of abundance. Sea otters in heavily oiled areas were

captured in July 2001, as part of Projects 01423 and 01534, but no further capture of sea otters was proposed for 2002. However, the observation of diseased livers in 4 of 15 sea otters caught in 2001 at northern Knight Island, in conjunction with elevated serum enzymes indicative of liver dysfunction, has generated additional concern about the effect of residual oil on health of both sea otters and harlequin ducks residing in areas of western PWS where beach sediments are known to retain oil.

Based on new findings from summer 2001, we propose to capture sea otters in waters adjacent to known areas of residual oil, to assess oil exposure (using the CYP1A biomarker) and liver function (by gross examination, biopsies for histopathological examination, and serum chemistries). For harlequin ducks, similar work is already underway as part of Project 02423; however, we propose to expand the harlequin duck studies with histopathological examinations of liver biopsies from wild-caught and captive birds. Additionally, we propose to do histology on archived liver biopsies collected in 1996 from Barrow's goldeneyes in oiled and unoiled areas of western PWS. We will coordinate capture locations for sea otters and harlequin with NOAA-ABL researchers who are examining bioavailability of lingering oil (see Part I of this DPD).

NEED FOR THE PROJECT

A. Statement of Problem

Sea otters and harlequin ducks occupy an invertebrate-consuming trophic level in the nearshore and are conspicuous components of the nearshore ecosystem. Previous restoration projects (95025-99025; 99423-02423) have examined the status of recovery of sea otters and harlequin ducks. Results to date clearly suggest that complete recovery has not occurred for sea otters or harlequin ducks, and implicate continuing exposure to oil as a limiting factor.

The lack of recovery of sea otters is based on an aggregate of findings. The sea otter population in western PWS (WPWS) suffered heavy losses in 1989, with estimates of sea otter mortality due to the spill ranging from 750 to 2,650 individuals (Garshelis 1997, Garrott et al. 1993). Surveys of abundance, conducted 1993-2000, have shown a significant increasing trend in the overall WPWS sea otter population. In contrast to the western Sound, sea otter numbers at northern Knight Island (where oiling of beaches was heavy) remain below pre-spill estimates and do not show a significant increasing trend (Figure 1; Bodkin et al. in press; Dean et al. 2000; USGS unpubl. data). Survey results are consistent with other observations of sea otters in western PWS,

which suggest that the population in the most heavily oiled areas has not yet recovered. Carcass collections and modeling efforts based on age-at-death data through 1998 (Monson et al. 2000) indicate post-spill survival rates of sea otters in WPWS have been lower than pre-spill rates, even for animals born after 1989. From 1996-98, measurement of the CYP1A biomarker in sea otters showed elevated levels at Knight Island (Fig. 2), indicating recent exposure to aromatic hydrocarbons (Ballachey et al. 2001b, Bodkin et al. in press); analyses of samples from 2001 are pending. Serum chemistries of sea otters in the western Sound show elevations of enzymes indicative of liver disease, most notably gamma-glutamyl transferase (GGT) (Ballachey et al. 2001a, USGS unpubl. data). During the period 1992-2001, over 30% of the sea otters in the oiled area had a moderate to severe increase in serum GGT levels, compared to less than 10% in the unoiled area. In July 2001, livers of sea otters in oiled and unoiled areas of WPWS were examined directly, by endoscopy, and biopsied for histopathology. Observations of the livers, and histology results, confirm that there is a higher incidence of microscopic and biochemical abnormalities in sea otters from the oiled area (USGS unpubl. data). In some cases, damage to the liver appears sufficient to impair survival of those individual otters.

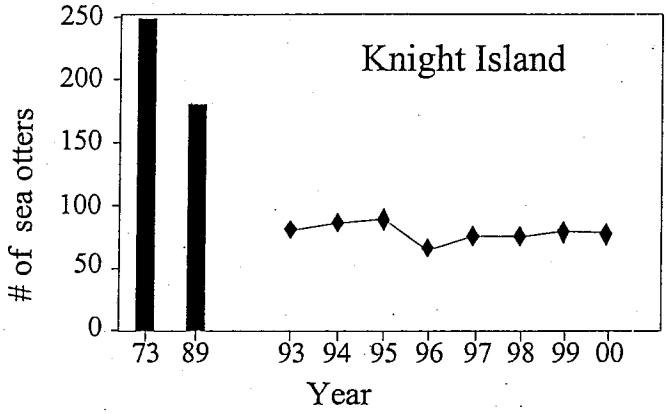


Figure 1. Estimated sea otter abundance at northern Knight Island.

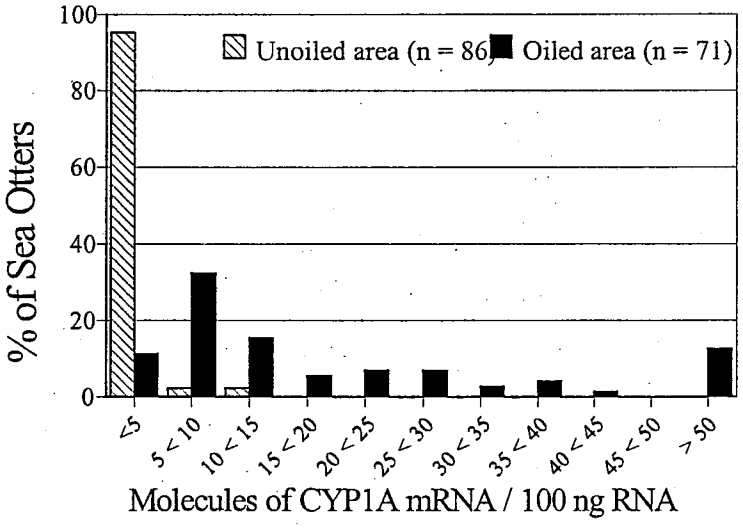


Figure 2. Measurement of cytochrome P4501A induction (RT-PCR technique) in sea otters in WPWS, 1996-98.

To further investigate links between continuing oil exposure and toxic effects on sea otters, we propose to capture sea otters in summer 2002 in areas of western PWS which are known to have relatively high concentrations of residual EVOS oil, and which will be monitored in 2002 to determine the bioavailability of that oil. We will evaluate induction of the CYP1A biomarker and liver function in these otters, and relate our findings to results on bioavailability of oil along adjacent shorelines. These studies will provide unique and valuable information on long-term

chronic effects of the oil spill on sea otters and aid in projecting recovery time for the sea otter population in PWS.

Recent studies (/025, /427, and /423) suggest that harlequin duck populations also continue to suffer deleterious effects from the oil spill. In 1996-98, sea ducks (harlequins and goldeneyes) had higher CYP1A levels in oiled areas than in unoiled (Trust et al. 2000), and in 2000, harlequin duck samples continued to show elevated CYP1A (D. Esler, pers. comm.) indicating that hydrocarbon exposure is continuing. In addition, harlequins in oiled areas have lower survival than their counterparts in the unoiled area. This difference was demonstrated over the course of 3 winters (1995-98) and again in the winter of 2000-2001 (Figure 3; Esler et al. 2000, Esler et al. in press, , D. Esler pers. comm.). Continued study of harlequin ducks is underway as part of Project 02423, and thus we are not proposing additional capture of harlequins as part of this project. However, given the liver pathologies observed in sea otters in summer 2001, we propose to do histopathology on (1) archived liver biopsies collected from Barrow's goldeneyes in oiled and unoiled areas in 1996 (Trust et al. 2000), (2) liver biopsies collected from wild-caught harlequins in oiled and unoiled areas in the fall of 2001, and (3) liver biopsies collected in spring 2002 from harlequin ducks held in captivity at the SLC and exposed to oil (the latter two groups are part of studies under 02423).

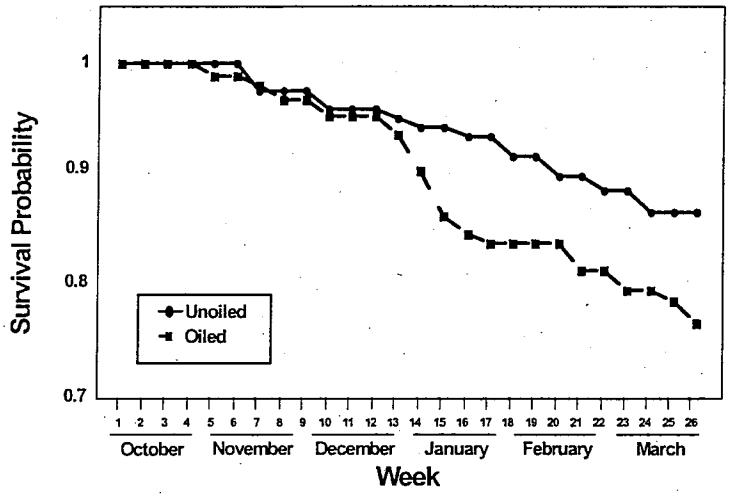


Figure 3. Survival probabilities of harlequin ducks, 1995-98.

B. Rationale/Link to Restoration

Sea otter and harlequin duck restoration requires assessments of population recovery status and definition of impediments to recovery. The proposed work will complement an ongoing study of continuing injury to sea otter and harlequin duck populations (Project 02423), by identifying the extent to which residual oil is bioavailable and examining individual animals from those same areas for evidence of exposure and toxic effects of hydrocarbons on the liver.

C. Location

Studies will be conducted in PWS. Specific study sites for the sea otter components will be northern Knight Island, Green Island, and the Port Chalmers/Stockdale area at Montague Island. Harlequin duck study sites, as described in Project 02423, are Montague Island, Green Island, Knight Island, Crafton Island, Main Bay, and Foul Bay. Captive harlequin duck studies (02423) are at the Alaska SeaLife Center in Seward. Communities affected by the project include Chenega, Whittier, Cordova and Seward.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

PROJECT DESIGN

A. Objectives

1. Assess liver function and incidence of liver abnormalities in sea otters from oiled and unoiled areas.

2. Monitor CYP1A induction in sea otters in oiled and unoiled areas, as an indicator of ongoing aromatic hydrocarbon exposure.

3. Assess incidence of liver abnormalities in harlequin ducks from oiled and unoiled areas.

4. Relate CYP1A and liver findings to residual oil concentrations in capture areas.

B. Methods

Sea Otters. In summer 2002, we will capture sea otters in oiled and unoiled areas of PWS. We will capture up to 40 otters in oiled areas (Knight Island and Green Island) and up to 10 otters in unoiled areas (Montague Island). Liver and blood samples were recently collected from sea otters in the Monterey harbor area of California (non-EVOS study); these will be used as alternate reference samples for liver histopathology and CYP1A assays.

Capture and handling methods will be similar to those employed previously (Bodkin et al. 1999). Sea otters will be sedated, body measurements taken, a tooth collected for age determination, and a blood sample taken by jugular venipuncture. Each otter will be tagged with two color-coded, numbered flipper tags. Liver biopsies will be taken by endoscopy procedures, as conducted in summer 2001. Following reversal, sea otters will be released in the same vicinity as captured.

In Project /025, the RT-PCR assay (quantitative reverse transcriptase PCR assay; Snyder et al. 2000, Vanden Heuvel et al. 1993, 1994) was adapted to measure CYP1A levels in sea otters. This assay quantifies the messenger RNA (m-RNA) that codes for the CYP1A protein. Results of the assay are reported as the molecules of mRNA per 100 ng of RNA. We will conduct the assay on both peripheral blood mononuclear cells and a liver biopsy. The peripheral blood lymphocytes will be isolated in the field by a ficoll gradient technique, cryopreserved in liquid nitrogen and shipped to Purdue University for analyses. In addition, duplicate slides of whole blood will be made for hematology, and blood from each otter will be processed to obtain serum, which will be frozen and later submitted for serology analysis.

Histopathology on the liver samples will be done using standard procedures, at the School of Veterinary Medicine, Purdue University.

Harlequin Ducks

An extensive study of harlequin ducks is ongoing under Project /423. Liver biopsies will be collected as feasible from individual birds in that study, at the time of surgeries to implant radiotransmitters for survival studies. In addition, liver biopsies were collected from Barrow's goldeneyes in 1996 and archived. Histopathology on the liver samples will be done using standard procedures, at the School of Veterinary Medicine, Purdue University.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The overall project is a joint effort with NOAA-ABL. USGS-BRD personnel will be responsible for directing and conducting sea otter and harlequin duck studies. A contract will be established with Purdue University for histopathology of liver samples and for CYP1A assays on sea otter tissues. ABL personnel will conduct studies on oil bioavailability as described in Part I of this DPD.

SCHEDULE

A. Measurable Project Tasks for FY02

Sea Otters

December-March:	Coordinate and plan sea otter capture. Obtain/update marine mammal permits.
July:	Capture of sea otters in WPWS; sample blood and liver for CYP1A and histopathology.

Harlequin Ducks

November:	Capture harlequin ducks for field studies of survival and CYP1A induction (Project 02423); biopsy livers for histopathology (new element).
March:	Surgically biopsy livers of captive birds at SLC for histopathology.

B. Project Milestones and Endpoints

Sea Otters

FY02:	July 2002: Capture of sea otters, sampling of blood and liver. Fall/winter 2002/03: Sample analyses

Harlequin Ducks

FY02:	Liver biopsies will be collected in Nov. 2001 and March 2002, in conjunction with activities under Project 02423. Histopathology will be completed by September 2002.

C. Completion Date

All sample collection will be completed in FY02; laboratory analyses will be completed by December 2002, and project close-out will occur in FY03. A final report will be submitted by May 15, 2003.

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.

PROPOSED PRINCIPAL INVESTIGATORS

James Bodkin
USGS - Alaska Science Center
1011 E. Tudor Rd., MS 701
Anchorage, Alaska 99503
PHONE: (907) 786-3550
FAX: (907) 786-3636
james_bodkin@usgs.gov

Brenda Ballachey
USGS - Alaska Science Center
1011 E. Tudor Rd., MS 701
Anchorage, Alaska 99503
PHONE: (907) 786-3512
FAX: (907) 786-3636
brenda_ballachey@usgs.gov or bballach@nucleus.com

Paul Snyder
Veterinary Pathobiology Department
1243 Veterinary Pathology Building
School of Veterinary Medicine
Purdue University
West Lafayette, IN 47907-1243
765-494-9676 (Office)
765-496-3520 (Lab)
765-494-9830 (Fax)
pws@vet.purdue.edu

Dan Esler
Centre for Wildlife Ecology
Simon Fraser University
c/o Canadian Wildlife Service
5421 Robertson Road, RR1
Delta, BC V4K 3N2
(604) 940-4652
FAX: (604) 946-7022
email: desler@sfu.ca

PRINCIPAL INVESTIGATOR QUALIFICATIONS

Jim Bodkin, Research Wildlife Biologist, and team leader for coastal ecosystem in Alaska for the Alaska Biological Science Center of USGS, Biological Resources Division. He has over 20 peer-reviewed scientific publications and directs an active coastal marine research program. He has studied and published on sea otter foraging ecology and community structuring since 1988 and has been principal investigator for sea otter survey methods development. He earned a M.S. from California State Polytechnic University in 1986.

Brenda Ballachey is a Research Physiologist at the Alaska Biological Science Center of USGS, Biological Resources Division. She was Project Leader for sea otter NRDA studies from 1990 through 1996, and has been involved in all aspects of post-spill research on sea otters, including the Nearshore Vertebrate Predator (NVP) project, with primary responsibilities for examining effects of residual oil on biomarkers and health of sea otters and other NVP study species. She

received her M.S. in 1980 at Colorado State University, and Ph.D. in 1985 Oregon State University. She has authored or coauthored over 25 peer-reviewed publications.

Dr. Paul Snyder is an Associate Professor of Pathology and Immunotoxicology and Director of the Clinical Immunology Laboratory of the Department of Veterinary Pathobiology, Purdue University. He is also a Diplomate of the American College of Veterinary Pathologists. His research interests are in the area of mechanism-based studies on the pathology and immunology of xenobiotics on biological systems. He has been a PI on the Nearshore Vertebrate Predator project since 1995.

Dan Esler is a Research Wildlife Biologist with the Alaska Biological Science Center, USGS Biological Resources Division. He has conducted waterfowl research in arctic and subarctic regions of Alaska and Russia for the past 11 years. Since 1995 he has served as project leader for harlequin duck studies as part of the EVOSTC-sponsored Nearshore Vertebrate Predator project. He earned a M.S. from Texas A & M University in 1988 and is currently enrolled as a doctoral candidate at Oregon State University. He has authored over 20 peer-reviewed journal publications and numerous reports and presentations addressing research and issues in waterbird conservation.

OTHER KEY PERSONNEL

George Esslinger, Kim Kloecker and Daniel Monson of the USGS Alaska Biological Science Center will assist with all aspects of logistics for the sea otter capture and sample collection. Dr. Mike Murray, Staff veterinarian at the Monterey Bay Aquarium, will be contracted to provide expertise in endoscopy procedures.

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Revision -01
Approved TC 12-11-01

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002	PROPOSED FY 2002 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
							$94.8	$201.6
Personnel	$0.0	$28.7						
Travel	$0.0	$17.4						
Contractual	$0.0	$139.2						
Commodities	$0.0	$97.0						
Equipment	$0.0	$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$282.3			Estimated FY 2003	Estimated FY 2004		
General Administration	$0.0	$14.1						
Project Total	$0.0	$296.4			$30.0	$0.0		
Full-time Equivalents (FTE)	0.0	0.5						
	Dollar amounts are shown in thousands of dollars.							
Other Resources	$0.0	$0.0			$0.0	$0.0		

Comments:
The Auke Bay Laboratory will lead the intertidal contamination/impact studies; USGS will lead the Otter/Duck impact studies.

FY02

Prepared: 11/15/2001

Project Number: 02585
Project Title: Lingering Oil: Bioavailability and Effects
Lead Agency: NOAA- Auke Bay Laboratory

FORM 2A
MULTI-TRUSTEE AGENCY SUMMARY

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel		$12.5
Travel		$12.6
Contractual		$77.2
Commodities		$92.0
Equipment		$0.0
Subtotal	$0.0	$194.3
General Administration		$7.3
Project Total	$0.0	$201.6
Full-time Equivalents (FTE)		0.2
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

		Estimated FY 2003	Estimated FY 2004		
		$15.0			

Dollar amounts are shown in thousands of dollars.

Comments:

Supervision and participation by J. Rice and J. Short contributed.

FY02

Prepared: 11/15/2001

Project Number: 02585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: NOAA - Auke Bay Laboratory

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2002
Jeep Rice	Habitat Program Manager	GM-15	0.0			0.0
Jeff Short	Research Chemist	GS-14	0.0			0.0
Mandy Lindeberg	Fisheries Research Biologist	GS-11	2.5	5.0		12.5
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
Subtotal			2.5	5.0	0.0	
					Personnel Total	$12.5

Travel Costs:		Ticket	Round	Total	Daily	Proposed
Description		Price	Trips	Days	Per Diem	FY 2002
EVOS Workshop - Jan. 2002		0.4	3	2	0.2	1.6
Winter Sampling						0.0
deployment	Juneau/Cordova	0.3	4	2	0.2	1.6
						0.0
pick up	Juneau/Cordova	0.3	4	2	0.2	1.6
	California/Cordova	1.0	1	2	0.2	1.4
						0.0
Summer Sampling						0.0
deployment	Juneau/Cordova	0.4	4	2	0.2	2.0
pick up	Juneau/Cordova	0.4	4	2	0.2	2.0
	California/Cordova	1.0	2	2	0.2	2.4
						0.0
					Travel Total	$12.6

FY02

Prepared: 11/15/2001

Project Number: 02585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: NOAA- Auke Bay Laboratory

FORM 3B
Personnel
& Travel
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Contractual Costs:			Proposed FY 2002
Description			
Vessles Charters			
winter deployment	9 days	9K	
winter pick up	8 days	7K	
summer deployment	7 days	7K	
summer pick up	7 days	7K	30.0
Temporary labor (NOAA) - field and lab support			12.0
Dr. Robert Thomas California State University at Chico	Comet Analyses		5.0
Gary D. Marty, DVM, Ph.D. Diplomate, American College of Veterinary Pathologists, Fish pathology Services	P450, Histopath processing, analyses		30.2
When a non-trustee organization is used, the form 4A is required.		**Contractual Total**	$77.2

Commodities Costs:		Proposed FY 2002
Description		
Materials and supplies:		
Strips, collectors		4.0
Nitrogen, shipping logistics		2.0
Misc. field gear		3.0
comet supplies		2.0
Analytical costs:		
strips = $200/strip x 200		40.0
caged mussels = $500 ea. x 32		16.0
resident mussels = $500 ea. x 24		12.0
sediments = $500 ea. x 6		3.0
prey = $500 ea x 20		10.0
	Commodities Total	$92.0

FY02

Prepared: 11/15/2001

Project Number: 02585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: NOAA- Auke Bay Laboratory

FORM 3B
Contractual & Commodities DETAIL

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2002
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency
NOAA/NMFS- Auke Bay Laboratory		
Computer/Software		
HPLC		
GCMS		

FY02

Prepared: 11/15/2001

Project Number: 02585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: NOAA- Auke Bay Laboratory

FORM 3B
Equipment
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel		$16.2
Travel		$4.8
Contractual		$62.0
Commodities		$5.0
Equipment		$0.0
Subtotal	$0.0	$88.0
General Administration		$6.8
Project Total	$0.0	$94.8
Full-time Equivalents (FTE)		0.3
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

		Estimated FY 2003	Estimated FY 2004		
		$15.0			

Dollar amounts are shown in thousands of dollars.

Comments:

No costs are included for NEPA compliance, technical review session attendance, restoration attendance, report writing, publications, professional conferences, or community involvement. USGS is contributing approximately six person months of salary towards this project.

FY02

Prepared: 11/15/2001

Project Number: 02585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: DOI/USGS - Sea Otters and Harlequin Ducks

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 2002
Research scientist	Wildlife Biologist	GS 12/04	1.0	7.0		7.0
Capture personnel	Biologist	GS 9	2.0	4.6		9.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
Subtotal			3.0	11.6	0.0	
					Personnel Total	$16.2

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2002
Airfare & per diem, IN - AK RT (Snyder); CA-AK RT (Murray, Hatfield)	1.0	3	9	0.2	4.8
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$4.8

FY02

Prepared: 11/15/2001

Project Number: 02585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: DOI/USGS - Sea Otters and Harlequin Ducks

FORM 3B
Personnel
& Travel
DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Contractual Costs: Description	Proposed FY 2002
Assays of blood and liver for cytochrome P450 1A 50@$200	10.0
Assays of liver, histopathology - 50 SO and 90 HD - 140 @$30	4.2
Overhead to Purdue - 5K	5.0
Charter vessel for captures - 20 days @1.8k/day	36.0
M. Murray contract 20 days @ .25K/day	5.0
Quest Laboratories, blood assays 50@ $35	1.8
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$62.0

Commodities Costs: Description	Proposed FY 2002
Veterinary supplies	1.5
fuel and miscellaneous supplies	3.5
Commodities Total	$5.0

FY02

Prepared: 11/15/2001

Project Number: 02585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: DOI/USGS - Sea Otters and Harlequin Ducks

FORM 3B
Contractual & Commodities DETAIL

2002 EXXON VALDEZ TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2002
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

FY02

Prepared: 11/15/2001

Project Number: 02585
Project Title: Lingering Oil: Bioavailability and Effects
Agency: DOI/USGS - Sea Otters and Harlequin Ducks

FORM 3B
Equipment
DETAIL

Scientific Support Services- Planning for EVOS Synthesis
Year 1, Cost Summary
Prepared by
Applied Marine Sciences, Inc.

02600
Approved TC
12-11-01

Task & Personnel	Total Hours	Rate	Cost	Total
SYNTHESIS				
Robert Spies	500	$119.31	$59,655.00	
Diane Stafford	57	$29.78	$1,697.46	
Sue Chase	49	$55.73	$2,730.77	
Deborah Florer	76	$42.41	$3,223.16	
Contract Writers	200	$100.00	$20,000.00	
Subtotal			$87,306.39	$87,306
Other Direct Costs				
Travel			9,880.00	
Shipping/Communications			1,500.00	
Miscellaneous			1,200.00	
Graphics			12,000.00	
Total Direct Costs				**$24,580**
Total Labor and Direct				$111,886
Gen. and Admin. Overhead	6.40%		$7,160.73	
Fee (5%)			$5,952.36	
TOTAL COST				**$125,000**

+ 8.8 GA

$133.8

TOTALS

FY 02 : $133.8

FY 03 : $212.0

FY 04 $184.8

$530.6

Revision 12/28/01
Approved 12 - -01

A synthesis of the ecological findings from the EVOS Damage Assessment and Restoration Programs, 1989-2001

Project Number: 02600

Restoration Category: Monitoring, Research

Proposer: Robert B. Spies, EVOS Chief Scientist, and collaborators

Lead Trustee Agency: Not known

Cooperating agencies: None

Alaska SeaLife Center: No

Duration: 1st year, 3 year project

Cost FY 02: $1338K

Cost FY 03: $212.0

Cost FY 04: $184.8

Geographic Area: No field work

Injured Resource/Service: All resources

ABSTRACT

This project will synthesize the significant results from 12 years of post-spill study in the EVOS damage assessment and restoration programs as they relate to anthropogenic and natural forcing factors influencing the northern Gulf of Alaska ecosystem. The results of the work will be incorporated into a series of interrelated manuscripts that will be submitted for publication as an integrated synthesis in book form. This effort will be one of the major products of the EVOS restoration program and help set the foundation for the Gulf Ecosystem Monitoring Program.

Introduction

The effort being proposed is a synthesis of the main scientific findings from the EVOS Restoration Program, with an emphasis on what new has been learned about the affected ecosystem, particularly the variability in this ecosystem in response to the spill and to natural factors. It will be based mainly on the products of the scientific studies following the spill and will cover the period of 1989 to 2001, with reference of course to literature covering earlier ecosystem responses and significant findings from non-EVOSTC studies. Publications, final reports and data will be evaluated to determine what can learned about human and natural forcing factors in the spill area ecosystem.

Need for the Project

A. *Statement of the problem*--The proposed long-term monitoring and research program for the northern Gulf of Alaska (GEM) is best put in place on a solid foundation from previous intensive work in the ecosystem affected by *the Exxon Valdez* Oil Spill. With over 300 separate research projects addressing all major ecosystem components for 12 years, and many simultaneous studies that potentially captured large-scale variability in various ways, and with major ecosystem studies now completed but with minimal interaction between them, the foundation has been laid in the damage assessment and restoration programs for a comprehensive synthesis. And, with at least some GEM activities due to start in FY 2003 and to expand slowly over the first 5 years of the program, the time for a synthesis is in FY 2002-2004.

One of the primary needs for this synthesis includes an update of the current conceptual model of ecosystem forcing that is contained in the Gulf Ecosystem Monitoring Program Plan; GEM 2001 (www.oilspill.state.ak.us).

Since the occurrence of the spill much has been learned about long-term ecological change in the north Pacific, both due to human activities and due to climate variability. The efforts to ascribe ecological change to particular causes over the last 12 years have been focused on various aspects of the ecosystem and have produced over 300 publications by Trustee Council scientists and an almost equal number form Exxon-sponsored studies. Recent analyses of multiple biological and physical data sets indicate that large-scale climate-induced shifts occurred in the North Pacific in 1977 and 1989 (Hare and Mantua, 2000). These changes, particularly the change in mid-1970s corresponded with profound changes in the production of some fish stocks (Francis et al., 1998). Both of these shifts likely had consequences that interacted in unique ways with the massive damage from the *Exxon Valdez* oil spill and the subsequent recovery of the ecosystem.

B. Rationale/link to Restoration--

Beginning in 2003 a new phase of the restoration process will start, long-term monitoring supported by the Restoration Reserve. This effort, the Gulf Ecosystem Monitoring Program (GEM) has as one of its main goals detection of natural and anthropogenic change in the ecosystem. The program will be based on a conceptual model that describes how the ecosystem works and how it varies with external forcing factors, both natural and human. The program is being designed so that this model will change as our knowledge of the Gulf of Alaska matures and deepens. Ecological insight that can inform this conceptual model will be especially useful in the next several years. The National Research Council (NRC) is conducting a review of the proposed program and plan. One of their main recommendations is to build GEM on a good understanding of what has been learned from the last 12 years. In order to do this, the NRC and many scientists familiar with the Restoration Program have suggested that a comprehensive scientific synthesis be performed, with special emphasis on what has been learned from EVOSTC research.

C. Location

There is no field work being proposed for this project. The outcome of this study should contribute substantially to GEM and eventually to a better understanding of the ecosystem on which the coastal communities of the northern Gulf of Alaska depend.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

We will interact with regional communities and subsistence users principally in two ways. First, In the first year of the project all of the community facilitators, and the Chugach Regional Resource Commission will be contacted during the information gathering phase of the project. They will be invited to contribute to the synthesis. Secondly, during the completion of the work a multimedia display will be developed to explain the findings of the study in understandable terms and presentations made at those communities that wish to participate.

PROJECT DESIGN

A. Objectives

The project has the following objectives for FY 2002:

1. Gather, organize and start to read and evaluate the relevant reports, publications and other modes of information about the changes in the affected ecosystem between 1989 and 2002.

2. Gather any relevant publications and historical data sets and evaluate them in order to understand ecosystem changes that occurred before the spill.

3. Produce an outline of the integrated synthesis during a meeting of the P.I.s.

4. Find a journal willing to publish a dedicated volume, or obtain a publisher for the work as a book and negotiate the terms of a contract.

The objectives for FY 2003 include:

1. Do the bulk of the writing of the synthesis.

2. Hold a meeting mid-year of the P.I.s to discuss progress on component chapters and to integrate approach and effort across book.

3. Complete rough drafts of the component chapters of the integrated synthesis.

The Objectives for FY 2004 include:

1. Exchange drafts for internal review by synthesis team, make recommendations for change and revise chapters.

2. Make a multimedia presentation for the public.

4. Obtain outside peer review of revised rough draft.

5. Submit synthesis to the publisher.

B. Methods

The methods for conducting this synthesis are those employed in a large scholarly undertaking. They can conveniently be broken down into the following steps:

1. *Gathering the relevant information.* All of the EVOS final reports are in the office of Bob Spies, who will serve as Principal Investigator and editor. These reports are also available as PDF reports online at www.dtlcrepository.downlegal.com/ARLIS-/PDF. Many of the publications from the scientific literature are also available in Spies's office, at ARLIS, or at the EVOS Restoration Office in Anchorage. Bibliographies of Trustee- and Exxon-

sponsored studies is kept by the EVOS Restoration Office. Publications will be gathered and distributed by administrative staff at Applied Marine Sciences (AMS). ARLIS, the natural resources library in Anchorage, is available to support this phase of the project. AMS also subscribes to Cambridge Scientific Abstracts, an online service that provides literature searches returning full references for publications and their abstracts. Each of the contributing authors will be asked to keep a reference list using Endnote or another mutually agreed upon software package. These lists will be exchanged between authors and the editor to identify additional literature.

2. *Evaluation.* Each of the contributing authors will read the appropriate reports and publications, examine the relevant data sets, and then evaluate them with regard to anthropogenic and natural forces in ecosystem change. Contributing authors will be asked to take notes on phenomena reported by the authors of the primary literature that may be the results of system forcing.

3. *Initial synthesis meeting*: Early in the project, in the spring of 2002 and before the initial evaluation of the literature takes place, all of the contributing authors will meet and discuss innovative ways to approach the synthesis. It is likely that some approach based strongly on ecosystem processes will emerge given the backgrounds and initial discussions among the team. Writing assignments will be made during this meeting. It is envisioned that each chapter in the synthesis will have a lead author and others that contribute in order to have the maximum degree of sythesis.

4. *Chapter outlines.* Following the meeting, an outline of each of the chapters will be produced and a reference list will be circulated among the entire synthesis team. These lists will be reviewed and revised in light of any comments provided. The outline for the integrated synthesis will then be finalized.

5. *Obtaining a publisher.* The leading potential book publishers will be contacted to determine their interest in the synthesis based on the outline. A publisher will be chosen and negotiations for publications will be undertaken.

6. *Manuscript preparation.* The individual authors will write their chapters based on the outline. The editor will hold periodic conference calls and at least one face-to-face meeting per year will be held.

7. *Initial review.* Draft manuscripts will be exchanged among authors and with the editor during the first part of FY2003 for review.

8. *First revisions.* Review comments from authors and the editor will provide a basis for the first revision. The editor will monitor progress and encourage

completion as the deadline for revisions of the drafts approaches. At this stage we will contract with an independent science writer to suggest changes to make the book more accessible and engaging for the non-scientist.

9. *Independent review.* Outside reviewers will be enrolled to review the revised manuscripts and provide written comments.

10. *Final revision.* The final revisions will be incorporated and the manuscripts submitted for publication.

C. Organization

The following is a tentative organizational scheme for the effort, however it is likely to be revised as the synthesis team formulates an approach that will likely :

1. Introduction
2. physical oceanography and climate
3. nutrients and biological oceanography
4. fishes
5. nearshore processes (limited)
6. birds and mammals
7. ecotoxicolgy
8. synthesis, including a revised conceptual model for GEM

A recent major review of shoreline and nearshore impacts of the spill has been completed (Peterson, 2001). So, although we are allocating some additional effort in this area, it will of more limited than other aspects of the synthesis.

D. Cooperating agencies, contracts, and other agency assistance.

The Principal Investigator is an employee of AMS, which is proposed as the prime contractor for production of this synthesis. All of the other author contributions will be written on fixed price contracts with the authors contracted as consultants to AMS.

SCHEDULE

A. Measurable project tasks for FY2002 and FY2003

December 2001 Trustee Council approves project

March-May 2001 Synthesis team meets to identify approach

July 2002	Preliminary chapter outlines completed and list of references assembled
August 2002	Book outline finalized
September 2002	First drafts of chapters initiated
November 2002	Negotiations with a publisher completed
February 2003	Second meeting of synthesis team for integration
June 2003	Rough drafts of all chapters due
August 2003	Completion of internal reviews of chapter rough drafts
September 2003	Chapter reviews redistributed to authors with recommendations for revision
December 2004	Multimedia presentation completed
March 2004	Revised chapters due from authors
April 2004	Start of external review of chapters
June 2004	External chapter reviews due, distribute to authors
August 2004	Final revised chapters due
September 2004	Send entire manuscript to publisher

B. Project milestones (see schedule above)

C. Completion date

The project will be completed in September 2003.

Publication and Reports

The manuscript for book will be produced at the end of the three-year period. The title will be decided at a later date.

Professional conferences

The P.I. requests travel to one professional conference in 2003 to present the results of the synthesis effort and travel expenses to one annual EVOS meeting for each of the authors.

Normal agency management

Not applicable, as none of the authors is from an agency.

Coordination and integration

Coordination will be through the Office of the Chief Scientist working with the staff of the Restoration Office and ARLIS to obtain the materials necessary to complete the proposed work.

Proposed Principal Investigator

Robert B. Spies, Ph.D.
EVOS Chief Scientist
Applied Marine Sciences
4749 Bennett Dr., Suite L
Livermore, CA 94550
Phone (925) 373-7142
Fax (925) 373-7834
e-mail address: spies@amarine.com

Principal Investigator

Dr. Robert B. Spies has a Ph.D. from the University of Southern California (1971). He has over 30 years of expereince in marine science. He has been Chief Scientist to the EVOS Trustee Council since 1990. In that role he has reviewed all of the reports for the many scientific projects conducted following EVOS, conducted numerous workshops to identify gaps in studies of natural resources impacted by the spill, and has reported to the Executive Director and the Trustee Council on the status of the impacted ecosystem on a regular basis. Dr. Spies is also past editor of *Marine Environmental Research* and serves on its Editorial Board. He also serves on the Editorial Board of *Aquatic Toxicology*. He has over 40 publications on marine ecology and ecotoxicology.

Other key personnel

Dr. Thomas Weingartner. Dr. Thomas Weingartner is an observational physical oceanographer on the faculty of the University of Alaska's Institute of Marine

Science. For the past twelve years he has conducted research in the seas and oceans surrounding Alaska, including the Gulf of Alaska, Prince William Sound, and the Bering, Chukchi, and Beaufort seas. He is currently a Principal Investigator in the Gulf of Alaska GLOBEC program. His research interests include the effects of physical environmental variability on marine ecosystems.

Robert T. Cooney received his doctoral degree in Biological Oceanography from the University of Washington, Seattle (1971). He joined the faculty of the University Alaska Fairbanks and studied the plankton communities of Alaska waters for 30 years. His specialties include zooplankton assemblages found in coastal, shelf and oceanic waters of the northern Gulf of Alaska and Bering Sea. Dr. Cooney has had extensive experience with food-webs supporting juvenile pink salmon in Prince William Sound dating back to 1976. Collaborative investigations with the Prince William Sound Aquaculture Corporation and Alaska Department of Fish and Game were responsible for acquiring and using a real-time oceanographic buoy system in the Sound to log seasonal and annual changes in surface ocean climate and plankton. Most recently Dr. Cooney was the Lead Scientist for the EVOS-sponsored Sound Ecosystem Assessment (SEA) study of the post-spill recovery of pink salmon and herring. He is presently helping to revise the Gulf Ecosystem Monitoring program and implimentation studies.

Dr. Stan Rice-Stanley D. Rice has a Ph. D. in comparative physiology from Kent State University (1971). He has 30 years of experience in oil pollution work in Alaska; 15 years of program manager experience at the Auke Bay Lab; 12 years of experience on the *Exxon Valdez* spill. Short and long-term damages, and oil persistence are his primary research areas. Dr. Rice has over 100 peer-reviewed publications on oil effects. These publications include reviews and synthesis articles, covering effects of oil on fish, and specifically effects of oil on pink salmon. He has also contributed to the National Academy of Science reviews of oil inputs and effects. Dr. Rice has 25 papers on other contaminant issues as well.

Dr. Alan Springer has been involved in marine bird and mammal research in the N. Pacific for 25 years. In that time He has conducted studies at numerous breeding sites and at sea from southeastern Alaska to the Arctic Ocean, thereby gaining first hand knowledge of the haunts and habits of seabirds and marine mammals and an appreciation of the needs for and limitations of information on them. He also has broad experience in oceanographic studies and in research with lower trophic levels. As a peer reviewer during development of the APEX study, and as a core reviewer now, he is familiar with studies that have been supported by EVOSTC, as well as by others that

are relevant to the goals of this synthyesis. Throughout his career, he has attempted to understand birds, mammals, fish, and plankton in the context of marine food webs and the physical environment. Dr. Springer has published several papers that synthesize large amounts on information on various aspects of the marine ecology of the N. Pacific

Dr. Philip Mundy-- Dr. Mundy has a Ph.D. from the University of Washington (1979). Dr. Mundy has 27 years of experience as a fisheries scientist, including 24 years in Alaskan fisheries research and management. His work included being a reviewer of fisheries research on the oil spill from 1989 until he joined the Trustee Council staff in 1999. Dr. Mundy currently is the Chief Scientist for the Gulf Ecosystem Monitoring and Science Coordinator, Exxon Valdez Oil Spill Trustee Council, Anchorage, AK.

Nearshore biologist--We will designate an experienced nearshore biologist for a more limited synthesis effort. This invitation will be based on needs identified by the contributing authors once existing work has been reviewed and as the subject matter is developed for the synthesis.

Personnel time allocation

The involvement of the Chief Scientist, Dr. Spies, in the Restoration Program, is declining, particularly with regard to holding reviews and workshops. It is also anticipated that more of the administrative functions for the science program will reside in the EVOS office in FY2002-FY2003 than had previously been the case. Consequently, Dr. Spies will have the time to act as the Principal Investigator for this effort. Dr. Spies will be a very active editor and bring his extensive knowledge of the program to bear. He will be engaging the authors on a variety of issues and suggesting cross-cutting themes in the synthesis.

With regard to the time needed for Dr. Mundy, who is Chief Scientist for the GEM Program, to participate, there are several factors to consider. Dr. Mundy has already started a major effort to summarize the findings from studies of fish following the spill and has much to contribute in this regard. In October of 2001, we will make an assessment as to whether Dr. Mundy has the time to participate, or whether he should drop to the status of a co-author and find another lead for the chapter on fish.

Literature Cited

Francis, R.C., S.R. Hare, A.B. Hallowed and W.S. Wooster. 1998. Effects of interdecadalk climate variability on the oceanic ecosystems of the NE Pacific. Fisheries and Oceanography7, 1-21.

Hare, S.R. and N.J. Mantua. 2000. Empirical evidence for North Pacific regime shifts in 1997 and 1989. Prog. Oceanogr. 47, 103-145.

Peterson, C. 2001. The *Exxon Valdez* oil spill in Alaska: Acute, indirect and chronic effects on the ecosystem. Advances in Mar. Biol. 39, 1-103.

Approved 12-11-01
w/ Wang's 12-5-01 amendment attached

Implementation of an Ocean Circulation Model: A Transition from SEA (PWS) to GEM (GOA)

Project Number:	02603
Restoration Category:	Research
Proposer:	University of Alaska Fairbanks
Lead Trustee Agency:	ADFG
Cooperating Agencies:	
Alaska Sea Life Center:	No
Duration:	1-year project
Cost FY 02:	$80,000
Geographic Area:	GOA including PWS and Cook Inlet
Injured Resource/Service:	

ABSTRACT

During this transition year (FY02), we propose to establish a 3-D ocean circulation model in the Gulf of Alaska (GOA) to lay down a foundation for GEM starting in 2003 in order to couple this model to a hydrological model and a biological model. This model will cover the entire GOA, including PWS and Cook Inlet. The horizontal resolution of this model is 4'x2' minutes (about 3.7km at 60° N). This model will be forced by tides, the Alaska Current inflow/outflow, freshwater discharge, and wind stress derived from NCEP (National Center for Environmental Prediction).

INTRODUCTION

In the SEA program, extensive observations of phytoplankton and zooplankton, as well as oceanography, have been made during 1995–1998 (Cooney, 1996, 1997; McRoy et al. 1997; Thomas et al. 1997). Fish larvae and schools of some kinds were also measured (Stokesbury et al. 1997). The 3-D ocean circulation model explains some mechanisms with a application to biology (Mooers and Wang 1998; Wang et al. 2001). For example, the oceanic advection and diffusion only can explain the existing phytoplankton and zooplankton movement, while the spring blooms and sometime the later summer blooms (i.e., second bloom in the year) due to the ecosystem dynamics cannot be explained by a physical only model.

Based the observed data collected from 1995–1998 in PWS and the forcing of tide, coastal current inflow/outflow, freshwater discharge, and wind stress, a 3-D PWS model developed from the SEA Project (Wang and Ikeda 1996; Mooers and Wang 1998; Wang et al. 1999, 2001) has been used to produce a continuous 4-year, 3-D fields of velocity, and temperature, salinity. In addition, the interannual variability of PWS ocean circulation, temperature and salinity due to interannually variable atmospheric forcing has been studied. Thus, we can identify the key environmental parameters in a long-term monitoring program (such as GEM) to assist resource managers through sensitivity studies. During 1998-2000 (SEA Project 00398), the substantial progress has been made for the PWS ocean circulation modeling:

1. We provided 3-D velocity fields to A. Brown for her research (Brown et al. 1999), because she found that physical forcing from the 3-D model fits well with her biological data. Thus, she strongly urges us to provide four consecutive years (1995–1998) of the 3-D current velocity, temperature and salinity for her continuous proposal to EVOS.

2. We have collected the wind data from 1995-1998 at mid Sound station (see Fig. 1) and other stations (not shown) with the efforts of Dr. Vince Patrick, Jenny Allen, and Stephen Bodnar (the first-year subcontract). These data have a 30min interval, which were averaged to hourly or 3-hourly interval to drive the model.

3. The year-to-year variability of the circulation due to wind forcing has been examined (Figs. 2-4).

4. We are preparing a manuscript on the sensitivity studies of PWS circulation with respect to the forcing functions: winds, freshwater runoff, ACC inflow/outflow, and tide (Jin and Wang 2001).

NEED FOR THE PROJECT

A. Statement of Problem

Since SEA project started more than five-year ago, physical oceanographers and modelers at IARC and IMS/UAF have developed a PWS circulation model (Wang et al. 2001) and a coupled biological-physical model (Jin et al. 2001). Because the PWS model has a limited region with two open boundaries, physical conditions are required to prescribe these boundary conditions into the model. This drawback was noticed during the course of the research. To overcome this drawback and to face the challenge of the GEM goals, we propose to develop a GEM-based 3D

circulation model (Fig. 1), covering the entire GOA including PWS and Cook Inlet. This model has a potential for future coupling with

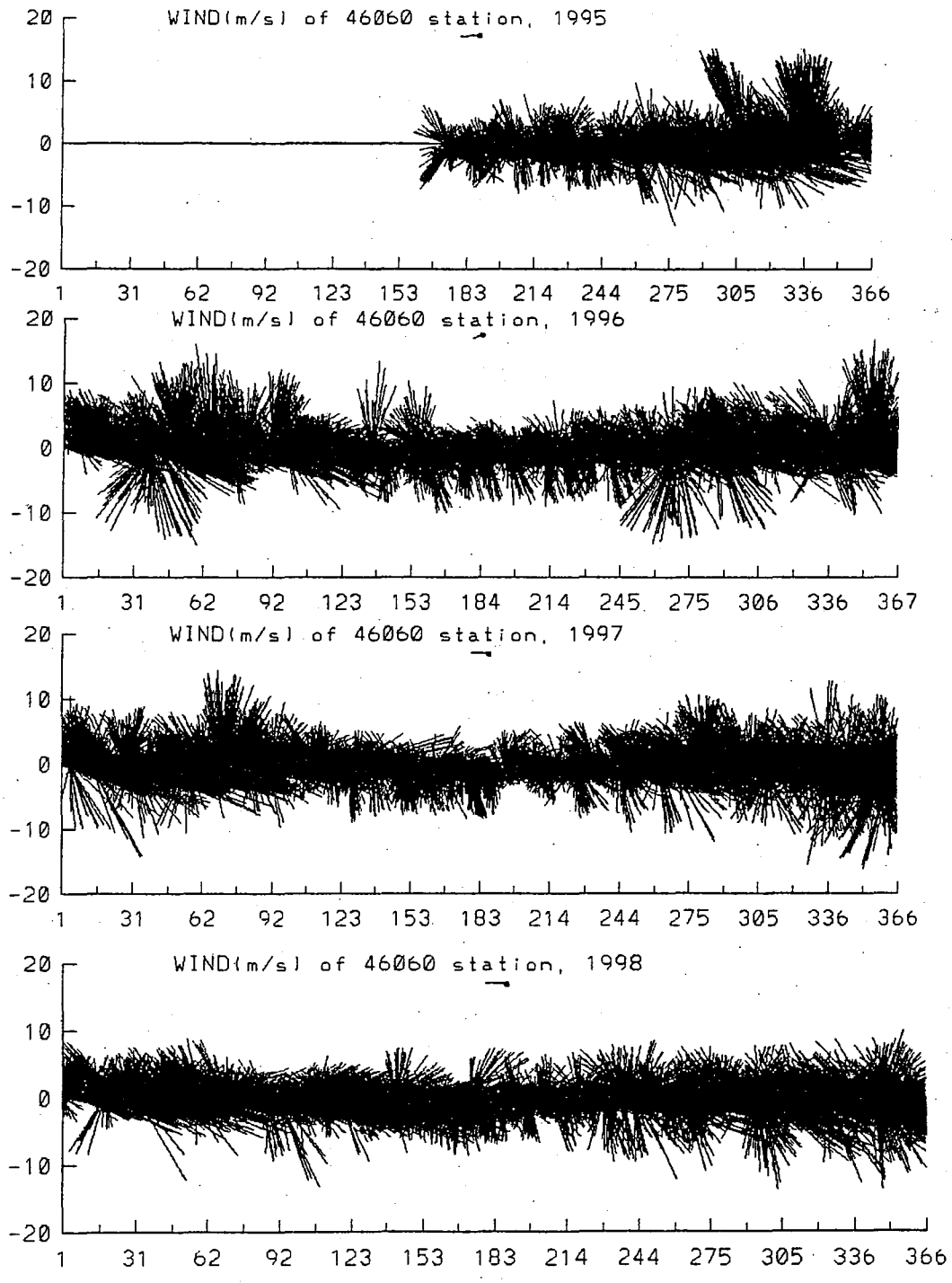

Fig 1. Wind vector at the mid-sound of PWS from 1995–1998.

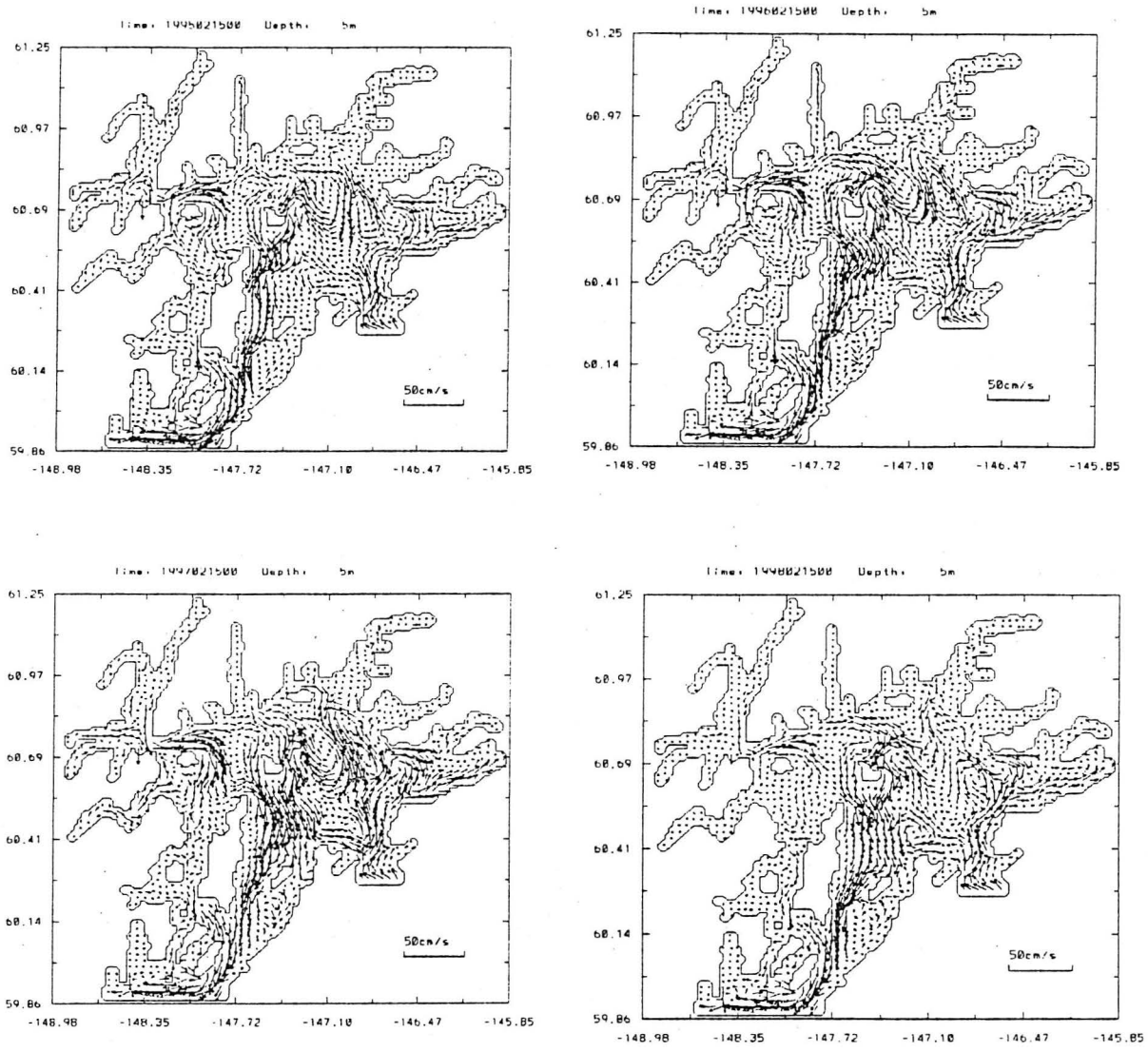

Fig. 2. Surface current of February 15 of 1995-1998.

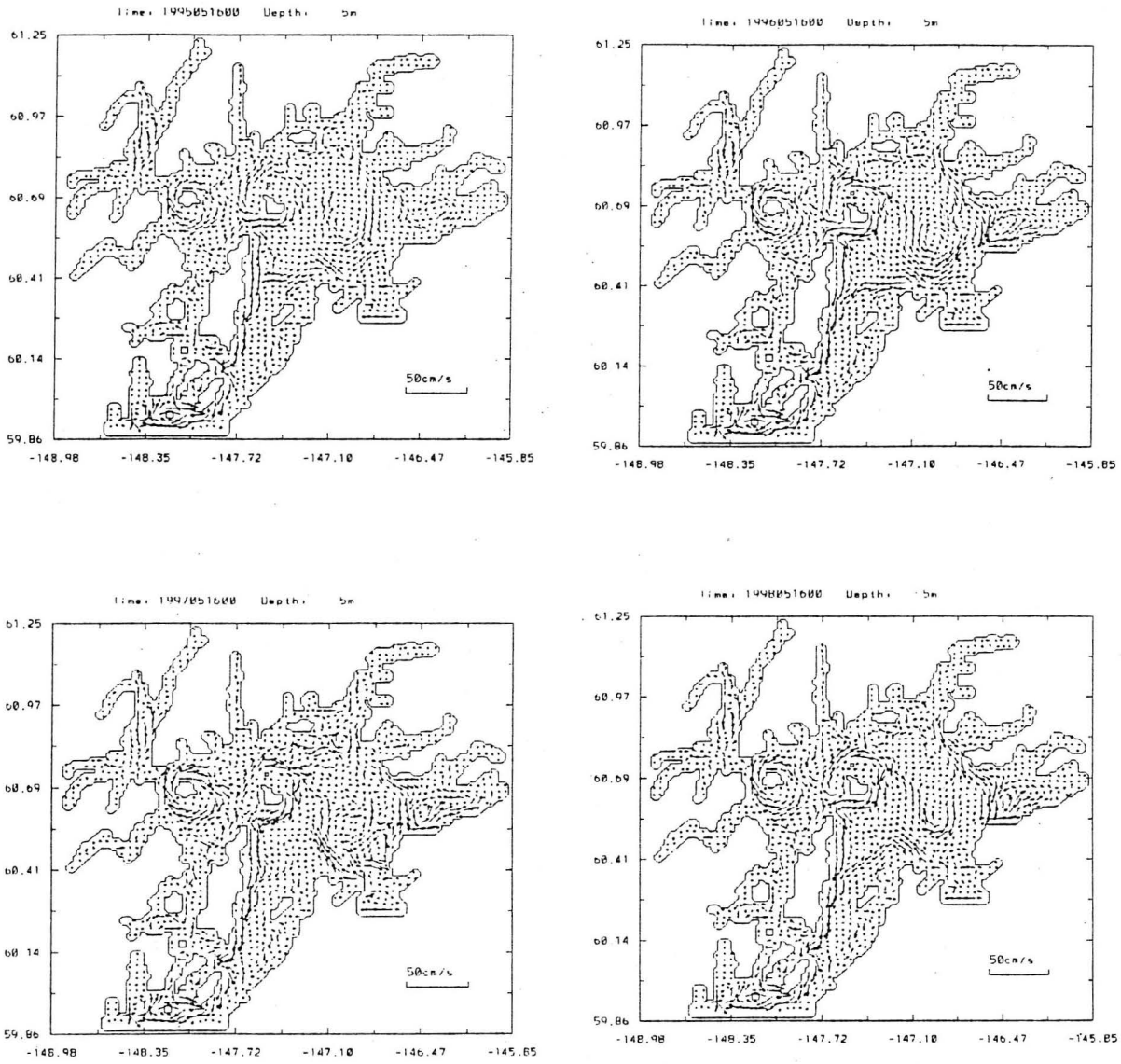

Fig. 3. Surface current of May 15 of 1995-1998.

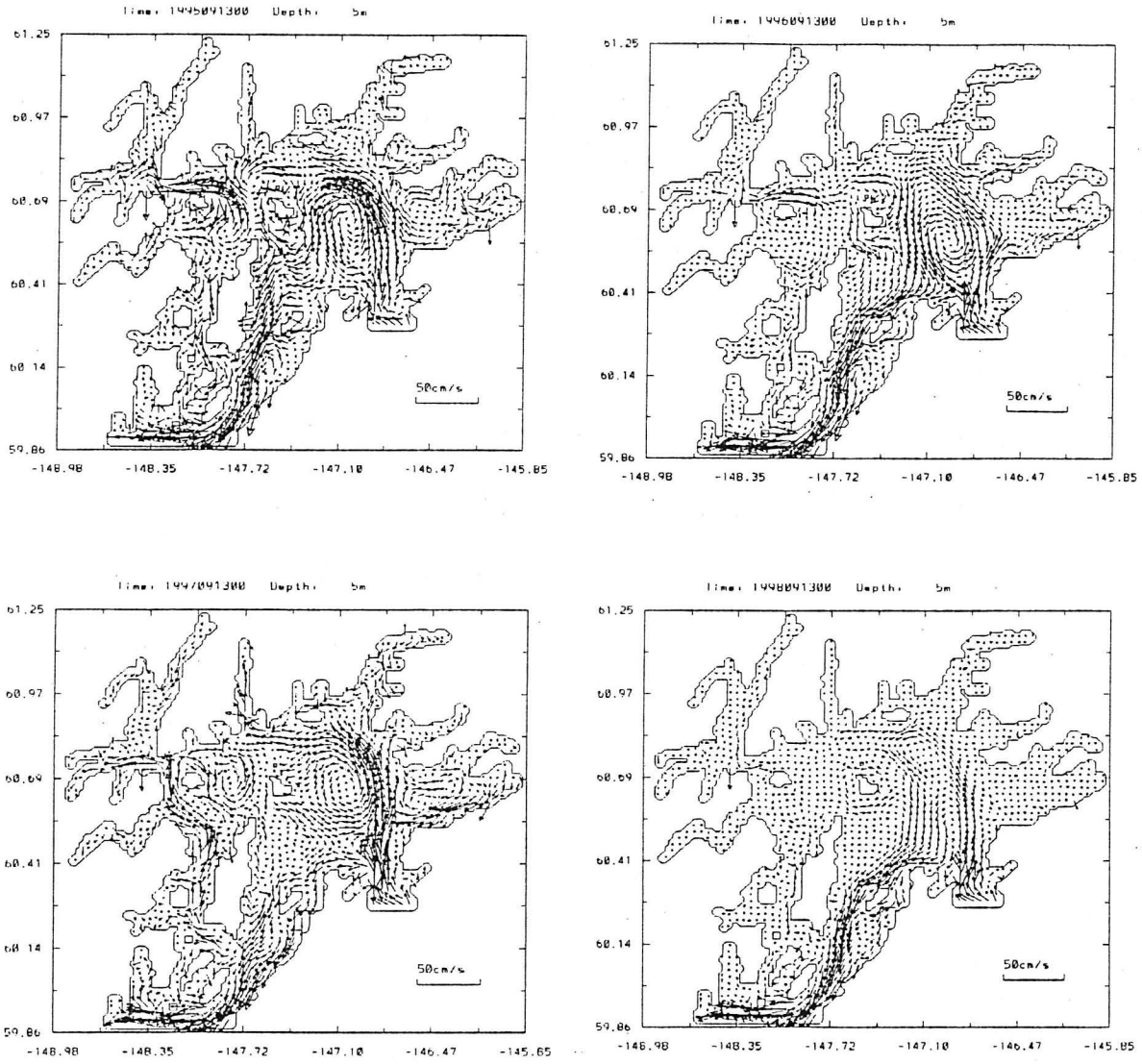

Fig. 4. Surface current of September 15 of 1995-1998.

1. Hydrological model to calculate freshwater runoff of the point source (rivers) and line source, because the line source was at least comparable to the point source.

2. Biological model with nutrients, phytoplankton, zooplankton, and detritus, which describe the primary and second productivity in the region.

3. Developing a nowcast/forecast system (Wang 1999, 2001) to provide prediction of the ocean states to users, such as environmental policy makers, managers, and fishing fleets, with sophisticated data assimilation of satellite-sensed sea surface height (SSH), SST, biological variables, surface current, as well as in situ oceanographic dataset of any type.

Therefore, it is essential to establish a 3D, high-resolution ocean circulation model at the very beginning of GEM to provide necessary physical setting/forcing/information to biological and

other disciplines. This model also can provide boundary conditions to the PWS model.

B. Rationale/Link to Restoration

The Gulf of Alaska (GOA) including PWS and Cook Inlet is located in the northestern Pacific. A systematic numerical simulation (study) of the physical oceanography and ecosystem in the region is essential and timely to understand the physical-biological system in order to provide scientific knowledge and information to the state government, local community, etc. Because of its rich resources in sea birds, mammals, salmon, forage fish, and many other animals,

Possibly because the North America's largest oil spill by T/V Exxon Valdez on March 24 1989 in PWS seriously damaged the ecosystem in PWS and the adjacent downstream waters in GOA, such as Cook Inlet and Kachemak Bay, extensive observational programs have been carried out in PWS and GOA. The SEA (Sound Ecosystem Assessment) project was a major effort since. This interdisciplinary project started in 1994 with major focus on pink salmon, Pacific herring habitat, ecology, and physical oceanography. As the physical component, the effort was placed on field program and numerical modeling.

After the implementation of 3D-PWS model and a passive tracer simulation were accomplished (Mooers and Wang 1998; Deleersnijder et al 1998), a seasonal simulation (12 consecutive months) has been followed up by Wang et al. (2001) using the SEA observations of 1996 only. However, the field observations in physical and biological oceanography from 1995–1998 during the SEA program have not fully validated. In addition, the interannual variability as observed can not be explained by PWS model only, unless a large region is included. Thus, after the SEA has been synthesized (SEA Synthesis Volume, 2001), it is necessary to step up to develop a large-scale, 3D, high-resolution ocean circulation model (http://www.frontier.iarc.uaf.edu:8080/~jwang) for the GEM research themes (http://www.oilspill.state.ak.us/future/gem.html), such as coupled biological-physical modeling, coupled hydrological-physical modeling, and towards a nowcast/forecast system for GOA (Wang 2001).

The simulated results will be valuable to assist resources managers to forecast pink salmon and Pacific herring abundance and to anticipate or understand changes in the ecosystem. In addition, key elements will be identified that will be pertinent to include in a long-term monitoring program, leading to an establishment of a nowcast/forecast system in GOA using this 3D-GOA model.

C. Location

The research is conducted for the ecosystem of GOA (Fig. 1) that will help understanding the basic physical environment and forcing to the biological research community and resource managers.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

Not only the research institutions (such as IMS and IARC of UAF), but also the local community (Regional citizens' Advisory Council, RCAC, at Cordova and Cook Inlet) will be involved. They are concerned with possible long-term oil spill impact on the ecosystem and local community as well.

PROJECT DESIGN

A. Objectives

1. Implement a 3D-GOA model to simulate ocean circulation, T, S, vertically mixing coefficients using 2.5 turbulence closure model. The model validation will be conducted using actual observations in the future.

2. Provide biologists and resource managers the 3-D fields (longitude, latitude, and depth) of velocity, T, S, etc. of the ocean states.

3. Put the simulation results in a new server at IMS-IARC/UAF to enhance the information exchange and scientific communication with Alaskan citizens and local community.

B. Methods

The above objectives will be accomplished using a 3D-GOA ocean circulation model (Fig. 5).

1. Forcing data

    i. Winds: The daily wind speeds and directions will be obtained from NCEP reanalysis, available from 1957-2000 (we need to purchase the data.)

    ii. Tides: Oceanic tidal harmonic constants for 6 major tides (M_2, S_2, S_2 K_1, P_1, O_1) will be specified in the southern boundary (Schwilerski 1980).

    iii. Freshwater runoff: The hydrological model for freshwater discharge into GOA will be implemented in year 2003 (GEM project) to provide runoff discharge. At the present time, the surface temperature and salinity will be restored to the NODC (National Oceanographic Data Center) Levitus T and S dataset.

    iv. Daily heat flux for the same period will be extracted from the NCEP reanalysis.

    v. The monthly inflow/outflow of Alaska Current and Alaska Stream will be fixed to the observations of Onishi and Ohtani (1999).

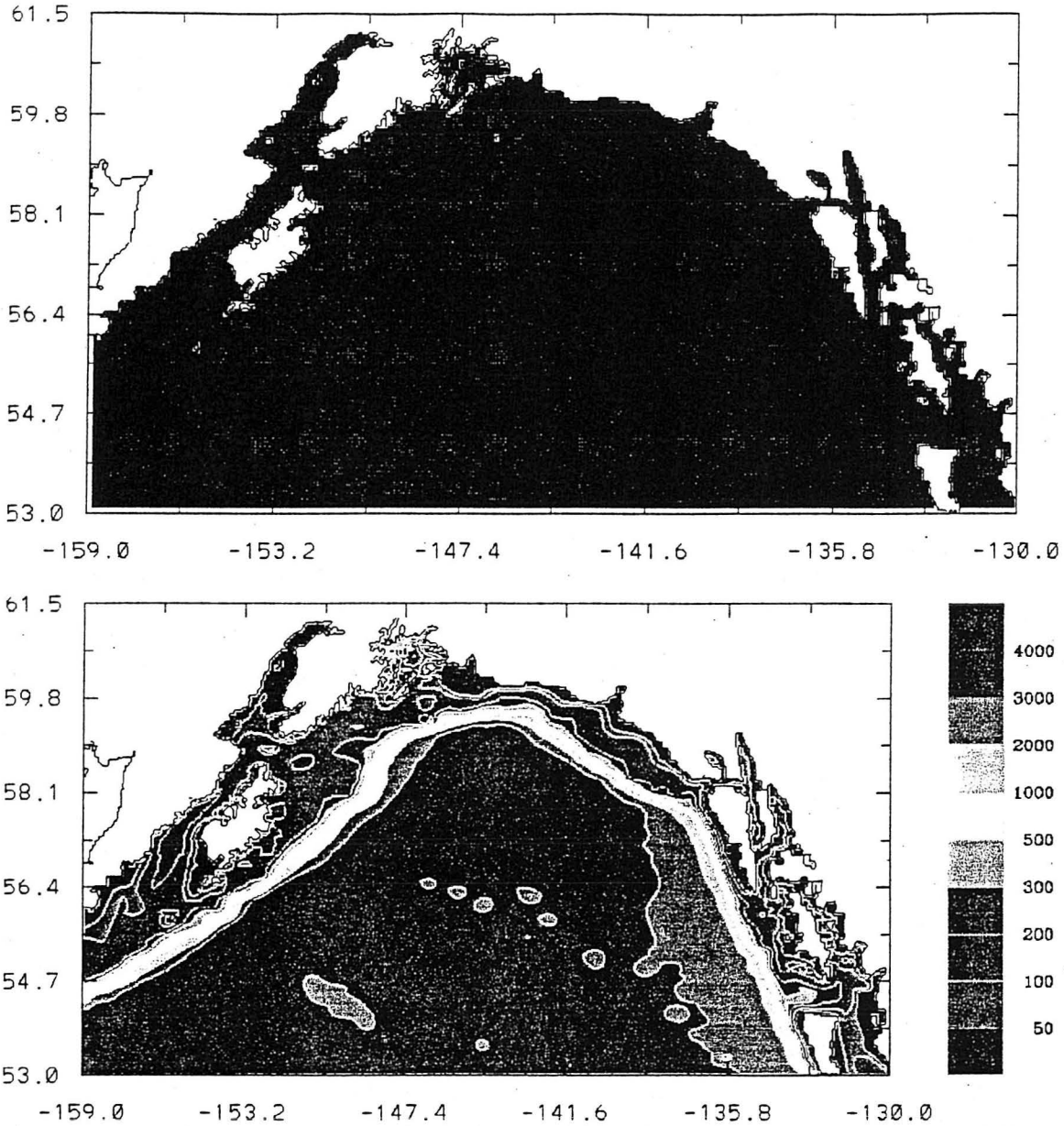

Fig. 5. Proposed 3D-GOA ocean circulation model for GEM: (upper) model grids and (bottom) topography).

2. Model simulations

The model resolution is about 3.75km and time stepping is 5mins/10secs for the internal/external mode. There are 20 levels in the vertical with 8 levels in the upper 50 meters to resolve the upper mixed layer. The purpose of this setting is to resolve the biological onset of the blooms in the upper mixed layer. Thus, the ocean model setting is suitable for the future biological model coupling.

Figure 6 shows the model run only under forcing of tides of six constituents. The model shows very strong tidal current in Cook Inlet, but weak tidal current in PWS, consistent with the observed information and previous tidal simulation in PWS (Wang et al 1997).

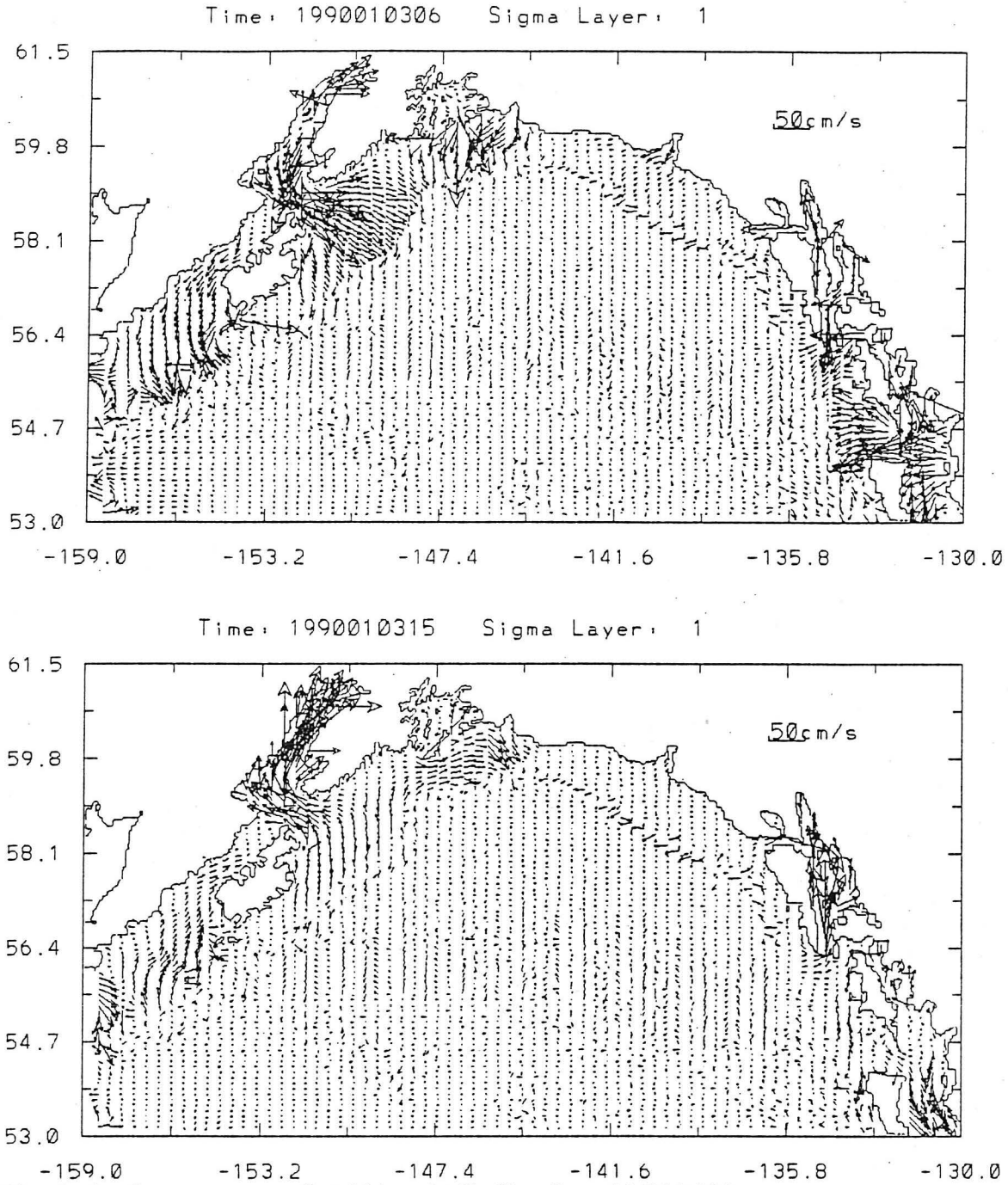

Fig. 6. Surface current at 6h (ebb) and 15h (flood) on 01/03/1990

A annual cycle (12-month) simulation will be conducted under the climatological (44-year mean) forcing described above (wind, heat flux, inflow/outflow with restoring to surface T and S) and tidal forcing. The outputs will be validated based on observations at coastal tide gauges, moorings, and CTD transects, etc.). Then, the model outputs (velocity, T, S, mixing coefficients, etc.) in 3D grids will be provided to biologists who need these outputs to verify their phytoplankton and zooplankton data. The monthly climatology for above mentioned variables will be produced.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

The data preparation will be conducted by Dr. Jin and a M.Sc. student (Yongmei Qin). The PI got funded from OSRI (Oil Spill Recovery Institute) for one-year (2000-2001) term (50K) of the proposal entitled "A 3-D coupled biological-physical model for the ecosystem in PWS, Alaska" to support 6-months of salary for Dr. Jin. This project will benefit the present proposed research by paying half of the time for Dr. Jin to focus on the intensive modeling work and data analyses.

SCHEDULE

A. Measurable Project Tasks for FY 02 (October 1, 2001 – September 30, 2002)

December 31:	Complete tide simulation and preparation of the NCEP climatological forcing
January 18–28 (3 of these days):	Attend Annual Restoration Workshop (Wang, Jin, maybe student as well)
March 31:	Start to implement the forcing data to the 3D-GOA model
August 31:	Complete the modelling of the seasonal cycle
September 15:	Put the simulation to the webside

B. Completion Date

September 30, 2002

PUBLICATIONS AND REPORTS

Manuscript (entitled "Tidal current and tidal residual current in GOA" will be prepared and submitted to a refereed journal for formal publication. I may present the results and publish another paper in the book entitled "Computer Modeling of Seas and Coastal Regions, V, 2002" in which I serve as a member of the International Advisory Committee for three years now.

PROFESSIONAL CONFERENCES

The PI and Dr. Jin plan to attend the annual EVOS meeting, 2002 Ocean Science Meeting in Hawaii, presenting the updated research results. This is an excellent way to communicate with our colleagues and to get recognised in the ocean science community. We also encourage the student (research assistant) to attend the scientific meeting and EVOS workshop.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This proposed research will be co-ordinated with 1) E. Brown's project (if her proposal gets funded) by providing her with the model outputs; 2) B. Norcross's proposal for EVOS by providing our 3-D model outputs, and other potential proposals for the restoration effort for GEM. We are willing to provide our simulation outputs to all EVOS-funded proposals by putting our simulation results on our website in both digital and graphic formats.

PROPOSED PRINCIPAL INVESTIGATOR

Jia Wang
Institute of Marine Science and IARC
University of Alaska Fairbanks
P.O. Box 757335
Fairbanks, Alaska 99775-7335
907-474-2685
907-474-2643
jwang@iarc.uaf.edu

PRINCIPAL INVESTIGATOR

Dr. Jia Wang, the PI, will be involved in the entire course of the project, providing scientific guidance to the project, without claiming salary. The PI needs one graduate student to conduct forcing data from NCEP reanalysis.

OTHER KEY PERSONNEL

Dr. Meibing Jin, who is currently working on this EVOS-funded project awarded to the PI (Wang), will continue conducting the simulation, and will partially supported by the OSRI fund for six months, plus UAF overhead (25%), benefit, and travel to scientific conferences/workshops.

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Revision 12-5

To: **EVOS Trustee Council**

From: **Jia Wang (PI)**

Date: **December 5, 2001**

Memo: **Revised Project Description (DPD) and Budget Justification of Proposal 02603**

Revised Detailed Project Description (DPD) of Proposal 02603 (2002 FY)

Our goal is unchanged, i.e., we still follow the GEM Science Plan to pursue the state-of-the-art ocean circulation simulation in the Gulf of Alaska, towards our goal for coupling the ocean circulation model to the hydrological model. In FY 2002, in addition to keeping our previously proposed (3) objectives and methods/approaches, we include a new component related to cooperation with another oceanographer, Dr. Dave Musgrave of the Institute of Marine Science, and a wider GOA research:

1) Dr. Musgrave has deployed a mooring using his North Pacific Research funding for physical and biological variables. He will provide these data for our GoA ocean circulation validation. This effort partially needs his time and data analysis.
2) He also will provide SeaWis satellite images for chlorophyll-*a,* which indirectly reflects the mesoscale eddies near PWS and its neighboring regions, which have been simulated by our 3-D GoA ocean circulation model.
3) He will work with PMEL modeler, Dr. Al Herman, for the larger domain ROMS model to provide us the southern boundary conditions to our POM, at least at the seasonal cycle (12-month climatology, such as 2-D (x-z plan) temperature, Salinity, velocity vs. time).

With these efforts added to project 02603, we will gain an in-depth understanding of the GoA ocean circulation. Thus, the budget is accordingly modified to request one-month salary and other benefits to Dr. Musgrave, which is $7,441.

Revised Budget

The funding will be $79,999, broken down as follows:

Reduction of the original proposal, which includes:

a) Reduction in travel costs, with only one round-trip proposed per site for the PI, (as discussed with Dr. Bob Spices)
b) Plus addition of one month salary and benefits for Dr. Musgrave and increase of data purchase.
c) Hourly rates and staff benefit rates comply with new rate agreement between University of Alaska and Office of Naval Research, which went into effect on July 1, 2001.

d) Increase of student tuition rate, in compliance with rate increase on July 1, 2001.

University indirect (25% on $59,812): $14,953

ADF&G (7% on $74,765): $5,234

Revision -2-01
Approved 12-11-01

2002 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel		$0.0
Travel		$0.0
Contractual		$74.8
Commodities		$0.0
Equipment		$0.0
Subtotal		$74.8
General Administration		$5.2
Project Total		$80.0
Full-time Equivalents (FTE)		1.4
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2003					

Dollar amounts are shown in thousands of dollars.

Comments:

FY02

Prepared:

Project Number: 02603
Project Title: Implementation of an Ocean Circulation Model: A transition from SEA (PWS) to GEM (GOA)
Agency: Alaska Department of Fish and Game

FORM 3A
TRUSTEE
AGENCY
SUMMARY

2002 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel		$54.1
Travel		$2.8
Contractual		$0.0
Commodities		$3.0
Equipment		$0.0
Subtotal		$59.9
Indirect		$14.9
Project Total		$74.8
Full-time Equivalents (FTE)		1.4
Other Resources (tuition)		

LONG RANGE FUNDING REQUIREMENTS					
Estimated FY 2003					

Dollar amounts are shown in thousands of dollars.

Comments:

The indirect rate is 25% TDC, as negotiated by the Exxon Valdez Oil Spill Trustee Council with the University of Alaska.

FY02

Prepared:

Project Number: 02603
Project Title: Implementation of an Ocean Circulation Model: A transition from SEA (PWS) to GEM (GOA)
Name: Jia Wang

FORM 4A
Non-Trustee
SUMMARY

2002 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Personnel Costs:			Months Budgeted	Monthly Costs	Overtime	Proposed FY 2002
	Name	Position Description				
	Wang, J.	PI	0.0	0.0		0.0
	Jin, M.	Research Assistant Professor	6.0	5.0		30.0
	TBA	M.S. Student	9.3	1.8		16.7
	Musgrave, D.	Associate Professor	1.0	7.4		7.4
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		16.3	14.2	0.0	
					Personnel Total	$54.1

Travel Costs:		Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 2002
	Description					
	Fairbanks to Anchorage (workshop)	500.0	1	3	187.0	1.1
	Fairbanks to Hawaii (Ocean Science meeting)	700.0	1	7	142.0	1.7
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$2.8

FY02

Prepared:

Project Number: 02603
Project Title: Implementation of an Ocean Circulation Model: A transition from SEA (PWS) to GEM (GOA)
Name: Jia Wang

FORM 4B
Personnel
& Travel
DETAIL

2002 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed FY 2002
Description	
Contractual Total	$0.0

Commodities Costs:	Proposed FY 2002
Description	
Project supplies	1.0
Data purchase	2.0
Commodities Total	$3.0

FY02

Prepared:

Project Number: 02603
Project Title: Implementation of an Ocean Circulation Model: A transition from SEA (PWS) to GEM (GOA)
Name: Jia Wang

FORM 4B
Contractual & Commodities DETAIL

2002 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 2002
Description			
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number of Units	
Description		

FY02

Prepared:

Project Number: 02603
Project Title: Implementation of an Ocean Circulation Model: A transition from SEA (PWS) to GEM (GOA)
Name: Jia Wang

FORM 4B
Equipment
DETAIL

4-15-fil
Approved TC 12-1

Digital Map Product Development from existing Seasonal Environmental Sensitive Area Maps of Cook Inlet/Kenai Peninsula, Alaska

Project Number:	02622
Restoration Category:	General Restoration
Proposer:	Hazardous Materials Response and Assessment Division, National Oceanic and Atmospheric Administration (NOAA)
Lead Trustee Agency:	NOAA
Cooperating Agencies:	None
Alaska Sea Life Center:	No
Duration:	1st year, 1-year project
Cost FY 02:	$36,600.
Geographic Area:	Cook Inlet and Kenai Peninsula
Injured Resource/Service:	All resources and services injured by the *Exxon Valdez* spill, since it is a sensitive areas mapping project

ABSTRACT

A series of national standardized digital map products will be produced from the existing seasonal environmental sensitive index (ESI) maps for Cook Inlet/Kenai Peninsula made by NOAA in 1994. A four map seasonal series was originally developed for Cook Inlet by the NOAA Hazardous Materials Response and Assessment Division in the ArcInfo digital format with the output and distribution primarily being poster maps at a scale of 1:450,000. Since then, combined with the greater demand for digital products, NOAA's digital ESI products have greatly expanded. NOAA proposes to transform the existing Cook Inlet/Kenai Peninsula digital data into a four-tiered nationally standardized set of digital map products with the deliverable being 100 CD's. These will be the same products that were just recently provided for the Prince William Sound ESI mapping project for EVOS contract # 99368.

The seasonal sensitivity maps of Cook Inlet/Kenai Peninsula have been shown to be a valuable tool for oil spill planning and response. At this point this data is only available in a poster-style format, and needs to be upgraded to a variety of digital map products for greater accessibility and usefulness.

B. Rationale/Link to Restoration

Updating the original digital files of the summary maps will satisfy several needs:

1) The existing maps are primarily available only as a series of four poster-style maps. Updating the digital files to all the above mentioned digital products will vastly expand the availability and usefulness of the ESI information. The information will be more readily accessible to decision makers, stake holders, resource managers and the public.

2.) Since the Cook Inlet ESI maps were last updated in 1994, a minor amount of new content data may need to be added to them.

3) The process of gathering data and reviewing the maps will provide the opportunity for resource agencies to discuss the concepts of what resources are most sensitive and require priority protection.

C. Location

The area to be covered by the seasonal sensitivity maps will be the same as the existing maps, that is, all of Cook Inlet and the outer Kenai Peninsula coast east to Day Harbor.

COMMUNITY INVOLVEMENT & TRADITIONAL ECOLOGICAL KNOWLEDGE

NOAA will work with the Cook Inlet Regional Citizen Advisory Council to make sure that the communities in Cook Inlet are aware of the mapping and digital update project and given the opportunity to participate and comment.

PROJECT DESIGN

A. Objectives

The objective of the mapping project is to:

Update the digital map output of the seasonal sensitivity map series for Cook Inlet/Kenai Peninsula, with the integration of minor content updates from the results of studies on the biological and human-use resources in the area since 1994.

B. Methods

NOAA has taken the lead in the U.S. in developing standards for sensitivity mapping for oil spill planning and response. Detailed guidelines for developing sensitivity maps have recently been revised and described in an October 1997 manual, *Environmental Sensitivity Index Guidelines, Version 2.0*, published as NOAA Tech. Memo. NOS ORCA 115, by the Hazardous Materials Response and Assessment Division. The Cook Inlet/Kenai Peninsula digital updates of the seasonal sensitivity map series will be produced in accordance with these guidelines, following the map content and format as used in the recent projects in the Kodiak Island/Shelikof Strait, in the Beaufort Sea, and in Prince William Sound.

The methods used for updating the 1994 summary Cook Inlet/Kenai Peninsula digital ESI data are basically in house procedures that will be carried out by our GIS staff. The output will be digital map data of Cook Inlet in four different digital formats. These include the following:

1. Full GIS format: double-precision ARC export files along with the relational database files

2. Desktop Mapping format: ArcView 3.x project and shape files where each major data element corresponds to a theme with links in place to the comprehensive flat file data structure. Data are also provided in single-precision MOSS format (MOSS is a simple ASCII format suitable for writing translators to other mapping software packages).

3. Free ESI Viewer: This freeware mapping and data base engine allows viewing, printing and simple query of the ESI data. Designed to run on either a PC or Macintosh platform, this program allows users without access to other mapping software to explore the digital ESI data. It is simple to install and a guided tour is provided on each CD.

4. ESI's in PDF format: Each of the four seasonal summary ESI maps will appear as a PDF file allowing zooming and panning. It is complete with an entire introduction which includes photos and descriptions of the shoreline types mapped. In this PDF format, the maps can be made available on the World Wide Web.

The 1994 summary ESI maps of Cook Inlet/Kenai Peninsula will be reviewed by the Alaskan Sensitive Areas Working Group (ASAWG) to determine if any minor content updates are necessary. The ASAWG consists of all the state;/federal natural resource agencies, the land management agencies, and the resource regulatory agencies. Also, primary data providers will be contacted, particularly for those databases that are regularly updated by management agencies. Examples include the USFWS digital database and colony status record files for seabird colonies and eagle nest sites, and the ADF&G catalog of waters important to anadromous fish.

Since NOAA has produced similar map products recently, we have good working relationships with all of the key data providers and technical experts who will be reviewing the maps. If any new data needs to be added or old data modified NOAA has established protocols for obtaining the necessary data from each source and for the review process.

Description of Sensitive Resources that are Shown on the Seasonal Maps

ESI atlases are comprised of three general types of information:

1) Shoreline Habitat Classification – Shoreline habitats are ranked according to a scale relating to biological sensitivity, natural persistence of oil, and ease of cleanup.

2) Biological Resources – Includes oil-sensitive animals and non-shoreline habitats such as submerged aquatic vegetation.

3) Human-Use Resources – Specific areas that have added sensitivity and value because of their use by humans, such as high-use amenity beaches, parks, marine

The seasonal maps show a sub-set of the most sensitive resources. Thus, only the most sensitive shoreline types are shown, namely:

ESI 5	Exposed Tidal Flats
ESI 8	Sheltered Rocky Shores
ESI 9	Sheltered Tidal Flats
ESI 10	Marshes

NOAA has developed a standard biological scheme which identifies seven major biological elements, based on major taxonomic and functional groupings. Each element is divided into groups of species, or sub-elements, with similar taxonomy, morphology, life-history, and/or behavior relative to oil spill vulnerability and sensitivity. Table 1 lists the biological resources that are included on the seasonal sensitivity maps for Cook Inlet. Table 2 lists the human-use resources to be included on the maps. This list will be reviewed based on meetings with community representatives, natural resource trustees, and response organizations.

TABLE 1. Biological resources to be included on the seasonal sensitivity map series for Cook Inlet/Kenai Peninsula.

Data element	Sub-element	Areas/Sites to be mapped
Marine Mammal	Pinniped (harbor seal and northern sea lion)	Haulouts, concentration areas
	Sea otter	Concentration areas
	Whale	Migratory or other concentration areas
Terrestrial Mammal	Deer	Intertidal concentration areas
	Small mammal (river otter)	Aquatic fur-bearer concentrations
Bird	Seabirds (see list in text)	Nesting colonies; concentration areas
	Raptor (bald eagle)	Nesting sites; concentration areas
	Shorebird	Migratory concentration areas
	Waterfowl	Wintering and migratory concentrations
	Passerine	Threatened/endangered or rare occurrences
Fish	Anadromous fish	Spawning streams
	Pacific herring	Spawning areas
Shellfish	Bivalve	Harvest areas; abundant beds
Habitat/Rare Plant	Rare plant	Threatened/endangered or rare species or communities
	SAV	Submerged aquatic vegetation

TABLE 2.Human-use resources to be included on the seasonal sensitivity map series for Cook Inlet.

Data element	Sub-element	Comments
Recreation/Access	Marina	Site
	Landing strip	Site
Management Area	National Park	Boundary
	State Park	Site
	National Forest	Boundary
	National Wildlife Refuge	Boundary
	State Critical Habitat Area	Boundary
Resource Extraction	Aquaculture site	Hatcheries
	Commercial fishery	Set-net sites
	Subsistence fishing	Designated key harvest sites
Cultural Resources	Archaeological site	Water-, coastal-, wetland-associated
	Historical site	Water-, coastal-, wetland-associated
Other Features	Oil facilities	
	Port facilities	
	Communities	
	Political boundaries	Boroughs
	Roads	
	Dispersant pre-approval zones	
	Annotation	

Final output products will consist of one hundred (100) CD's containing the updated digital map products for the summary Cook Inlet/Kenai Peninsula ESI maps.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Cooperating agencies who will provide information and review the digital map products include:

Alaska Department of Fish & Game

Alaska Department of Natural Resources

U.S. Fish & Wildlife Service

National Marine Fisheries Service

Communities of Tyonek, Nanwalik, Seldovia, Nikiski, Kenai, Soldotna, Homer and Seward

Cook Inlet Regional Citizens Advisory Council

Also, in-kind contributions have been obtained from a wide range of partners involved in oil spill planning and response.

Alyeska will provide access to their natural-resource databases for the Outer Kenai Peninsula and Lower Cook Inlet.

Alaska Department of Conservation has agreed to provide funding so that the state resource agencies can budget adequate time to review the existing ESI data for Cook Inlet/Kenai Peninsula and provide updates as necessary.

SCHEDULE

A. Measurable Project Tasks for FY 02 (October 1, 2001 - September 30, 2002)

The project schedule is outlined below.

October 1:	Review content of 1994 summary ESI maps of Cook Inlet/Kenai Peninsula and provide any new or updated data to NOAA
January 31:	Finalize the digital files of the Cook Inlet/Kenai Peninsula summary ESI maps
April 1:	Finalize the updated digital files into the four standardized digital map products
June 1:	Prepare and review CD's of the above
July 31:	Distribution of final CD of the updated digital data of the Cook Inlet/Kenai Peninsula summary ESI maps

B. Project Milestones and Endpoints

The milestones and endpoints for this project are straightforward: a digital database and CD's, completed within one year. The schedule is shown above.

C. Completion Date

The updated digital databases will be completed during FY02.

PUBLICATIONS AND REPORTS

There are no planned publications or reports, outside of the 100 CD's with the updated digital data map files and the associated metadata.

PROFESSIONAL CONFERENCES

None anticipated.

NORMAL AGENCY MANAGEMENT

Although NOAA HAZMAT is in the normal business of making ESI maps throughout the United States, updating the digital format of the Cook Inlet/Kenai Peninsula summary ESI map series would not normally receive attention until much later. The last edition was developed in 1994 and, as a result, retains adequate accuracy for use in oil spill response. Also, since 1989, Alyeska has developed a Graphical Resource Database (GRD) of the biological and human-use resources of a large portion of the Cook Inlet/Kenai Peninsula area that was last updated in 2000. This digital-only product has been made available to all the resource agencies in a read-only version (the files are in a rather proprietary, arcane format that makes that virtually inaccessible). In Alaska, NOAA is currently involved in a four-year program to complete the ESI mapping of Alaska's coastline, namely all of the western coastline. Nationally there is a drive to update and convert ESI maps to a digital format, and NOAA HAZMAT is heavily involved in this effort. Considering the vast amount of sensitive Alaska and U.S. coastline and the present status of the Cook Inlet/Kenai Peninsula resource data, NOAA would not be undertaking this digital ESI update of Cook Inlet/Kenai Peninsula as part of its normal activities in the near future. Yet we recognize the need for EVOS Restoration to make information from the EV spill area as available and accessible as possible to decision makers, stake holders, resource managers, and the public.

This ESI summary mapping project will allow us the unique opportunity to display all this data in several digital formats that are consistent and uniform, thus making the information more accessible to a much larger audience.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

There will be a high degree of coordination among Trustee and management agencies in all phases of this project: initial summary map content review, gathering updated data, and reviewing the digital products. Interaction will be initiated with the principal investigators of pertinent EVOS projects to ascertain new information that has been developed on locations and areas of concentrations of biological species that populate the Cook Inlet/Kenai Peninsula area. Since much of this data is not expected to change from the 1994 compilation, much of this project will be an internal computer exercise. Once digital prototypes of the final map products become available, a strong effort will be made to have resource managers and EVOS principal investigators "test out" the clarity, usefulness, and accuracy of these presentations.

PROPOSED PRINCIPAL INVESTIGATOR

John Whitney, Ph.D, NOAA HAZMAT, Anchorage, Alaska

PRINCIPAL INVESTIGATOR QUALIFICATIONS

Dr. Whitney is the NOAA Scientific Support Coordinator for Alaska. He has managed the last six seasonal sensitivity mapping projects conducted by NOAA and the U.S. Coast Guard, namely Kodiak Island/Shelikof Strait, the Prince William Sound ESI update, the Beaufort Sea, S.E. Alaska, the Aleutian Islands, and the Pribilof Islands.

OTHER KEY PERSONNEL

Robert Pavia, Ph.D, Acting Chief of NOAA HAZMAT and head of all NOAA HAZMAT ESI projects

Jill Petersen, HAZMAT Geographic Information System Specialist

Approved TC 12-1

[3abform(Trustee).XLS(MacExcel4)]Cook Inlet ESI budget

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel		$3.0
Travel		$1.0
Contractual		$30.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$34.0
General Administration		$2.6
Project Total	$0.0	$36.6
Full-time Equivalents (FTE)		0.1
	Dollar amounts are shown in thousands of dollars.	
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2003					

Prepared: 4/6/01

02622

Personnel Costs:		GS/Range/ Step	Months Budgeted	Monthly Costs	Overtime	Proposed FY 2002
Name	Position Description					
Jill Petersen	NOAA GIS Specialist	GS/13/7	1.0			3.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		1.0	0.0	0.0	
					Personnel Total	$3.0

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 2002
Description					
Anchorage-Kenai-Homer-Seward-Anchorage	0.2	4	4	0.1	1.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$1.0

Prepared: 4/6/01

Contractual Costs:		Proposed
Description		FY 2002
Data collection, compilation, and digitization		15.0
Digital Map Preparation and Production		15.0
When a non-trustee organization is used, the form 4A is required.	**Contractual Total**	$30.0
Commodities Costs:		Proposed
Description		FY 2002
	Commodities Total	$0.0

Prepared: 4/6/01

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 2002
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number	Inventory
Description	of Units	Agency

Prepared: 4/6/01

IC approved 12/7/00

A CPR-Based Plankton Survey Using Ships of Opportunity to monitor the Gulf of Alaska "Submitted Under the BAA"

Project Number:	02624-BAA
Restoration category:	Monitoring
Proposer:	Sonia Batten (Sir Alister Hardy Foundation for Ocean Science) & David Welch (Pacific Biological Station, DFO, Canada)
Lead Trustee Agency:	
Cooperating Agencies:	
Alaska SeaLife Center:	No
Duration:	1st year, 1-year project
Cost FY 02:	$120,600
Cost FY 03:	$000,000
Geographic Area:	Prince William Sound, Gulf of Alaska, Bering Sea
Injured Resource/Service:	Pacific salmon, Commercial fishing

ABSTRACT

This proposal presents the rationale for developing a plankton monitoring program for the Gulf of Alaska using ships of opportunity. Plankton are a critical link in the marine food chain whose dynamics are poorly understood, but respond rapidly and unambiguously to climate change and form the link between changes in the atmosphere and valuable upper trophic level populations, such as salmon, herring, shrimp, and groundfish. We review the evidence that many of the most valuable marine resources in the Gulf of Alaska are strongly influenced by changes in ocean climate. SoOPs are a cost effective platform for large scale monitoring and this proposal builds on recent experience gained with the CPR in the N. Pacific to prepare for the GEM program.

INTRODUCTION

During 2000, and again in 2001, Continuous Plankton Recorders (CPR) have been deployed along an oil tanker route originating in Prince William Sound to initiate an ocean observing system for the Gulf of Alaska. This proposal seeks to make the experience gained during this study available to the GEM program. The current GOA CPR program was built on the long experience of using CPRs in the Atlantic where ships of opportunity have been towing them for over 70 years. The Sir Alister Hardy Foundation for Ocean Science (SAHFOS) has a long track record in working with a variety of commercial shipping companies, in some cases decades of collaboration with the same company, and operates CPRs on upwards of 20 different routes every month in its traditional sampling area. This experience was invaluable in setting up the north Pacific sampling (Fig 1 and described below) in 2000/2001 and successfully acquiring samples.

A cost effective monitoring program under GEM is likely to use ships of opportunity as the fundamental platform for collecting a wide variety of data because of the costs and time restrictions on using oceanographic vessels. Consistent timing in the scheduling of research ships over many years is unfeasible, and the costs of running special-purpose vessels prevents repeated sampling within a year. Repeat sampling is critical if changes in seasonal timing are to be identified. Our experience so far, which we describe so far, has been restricted to plankton and some basic physical data but this could be extended.

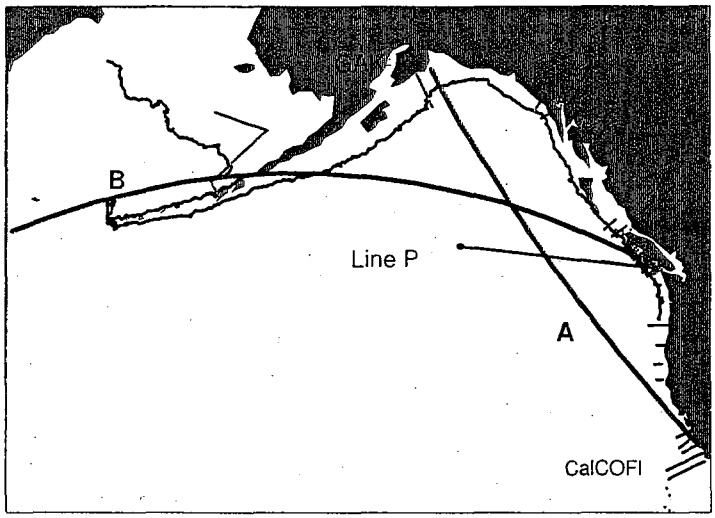


Fig. 1. The CPR plankton monitoring lines (A & B; in red), compared to other NE Pacific ocean monitoring locations (blue). The continental shelf edge is shown in black.

Zooplankton provide the link between primary production and higher trophic levels, providing food directly for some species such as herring, young salmon, and some whales and indirectly for all marine fish, birds, and mammals. They are sensitive to environmental change and because they have short life cycles (typically less than one year and often only months) provide a rapidly responding indicator of the state of the ecosystem and important scientific information on how climatic changes (such as regime shifts) alter ecosystems to affect marine fish populations. Furthermore, interpretation of their fluctuations is free from the considerations of fishing effort because they are not a harvested resource.

This proposal seeks funding for 2001/2002 to support the monitoring program recently begun under the North Pacific Marine Research (NPMR) fund. Significant progress towards a monitoring program for the Gulf of Alaska has been made with this two year project using ships of opportunity and the CPR. These data will provide some baseline information on plankton populations. However, if an optimum monitoring program is to be designed and implemented by GEM and other agencies it is necessary to continue this sampling and build on the approach. The NPMR project was advocated and supported by PICES and has been included as a pilot project

by the Living Marine Resources panel of the Global Ocean Observing System. Current funding finishes in Fall, 2001.

NEED FOR THE PROJECT

A. Statement of problem

Placement of oceanographic instrumentation packages on ships of opportunity has been proven as a cost effective means of acquiring useful data; however, implementing an effective program requires substantial expertise. The flexibility of the ship of opportunity platform needs to be considered so that appropriate measurements and the most suited instruments to obtain them can be used. The short-term objective of this proposal is to develop the sampling infrastructure, the spatial and temporal scales necessary to establish changes in the ocean distribution and abundance of plankton.

Monitoring of the physical environment to aid interpretation of the changes is in some ways simpler than acquiring the detailed biological information. The CPR is a proven (with quantifiable limitations), rugged, cost effective oceanographic instrument that provides species level information. GEM's mission is to *"sustain a healthy and biologically diverse marine ecosystem in the northern GOA and the human use of the marine resources in that ecosystem through greater understanding of how its productivity is influenced by natural changes and human activities"*. Our proposal will aid that mission by providing essential data and building a bridge to a much larger international monitoring effort for the North Pacific.

Large scale changes in Pacific salmon populations in all regions of western North America have been related to climate change in this century. Although best studied in salmon, similar influences are also thought to occur for other important upper trophic level organisms. The initial cause is likely due to changes in the structure of the atmosphere and then the ocean, which then pass up the food chain through the plankton to affect the fish and mammal populations at higher trophic levels. These changes are known to affect the abundance, productivity, and community structure of both continental shelf and open ocean plankton communities. The changes in plankton abundance have been related to the changes in salmon abundance, and reduced ocean productivity is probably the causal link leading to poor survival of salmon and other important resources in the ocean. These changes appear to have extended back centuries (e.g. Ware 1995), and to have affected a wide variety of Alaskan resources including shrimp and groundfish (e.g. Anderson and Piatt 1999) and salmon (e.g. Finney 1998).

Both the Pacific Ocean and Bering Sea lack the long-term monitoring necessary to detect changes in the ocean. This hampers our ability to detect and respond to either short or long-term climate change. Climate change seems to have driven the overall dynamics of Pacific salmon populations in the past, and to have been as important as the effect of commercial fisheries in determining population levels. Friedland (1998) has suggested that ignorance of decadal-scale changes in ocean productivity will doom salmon management efforts to failure in the Atlantic. Such comments probably apply equally to the Pacific. In addition, the effects of anthropogenic climate change due to global warming over the next few decades are expected to dwarf the climatic changes observed to date. To put the amount of future climate change expected in perspective, global warming is expected to successively add as much warming each following decade as has been observed over the entire 20th century. The cumulative change over the next

century is projected to be ten times that experienced in this century—and the changes in this century are the greatest in 1,000 years.

The climatic changes experienced in recent years are consistent with expectations from models for the early stages of global warming. In all regions of the West Coast of North America there have been abrupt changes in the productivity of salmon populations. These changes have not been expected from the standard fisheries management theories, nor could they be forecast from available data. However, the changes have had devastating economic impacts on coastal communities from Oregon to (most recently) Alaska. The pattern of failure in year-class strength of western Alaska chum and chinook populations or Bristol Bay sockeye salmon, as well as other many stocks and species in British Columbia and the Pacific Northwest demonstrates that the cause of the sudden downturn has a largely marine origin (e.g. Welch *et al* 2000). However, salmon spend part of their life history in both coastal and oceanic marine environments, and are therefore subject to environmental changes occurring in both regions.

An advantage of developing the CPR as oceanographic instrumentation on ships of opportunity for the GEM program is that it builds on existing work that has been endorsed by the scientific committee of PICES. Funding this proposal would put in place a monitoring framework that will build on the existing two years of baseline data collected using the CPR. At the PICES VIII annual meeting in October 2000 the PICES community struck a CPR Advisory Committee, which has begun moving towards developing a monitoring program that would eventually include a much broader range of environmental parameters using ships of opportunity (T, S, nutrients, Chl-a, photosynthetic rates from Fast Repetition Rate Fluorometry, and zooplankton size-structure (using OPCs (optical plankton counters)).

The changes that the Atlantic CPR program has documented in the 1990s are now being linked to the decline in Atlantic salmon populations, which are also experiencing substantially increased ocean mortality. Funding for our proposal would allow continued sampling of the plankton in multiple regions of the offshore and coastal regions of the eastern North Pacific and southern Bering Sea (Fig. 1). The monitoring lines would (a) sample the plankton along the coastal migration routes of the juvenile salmon in four locations, (b) quantify the distribution and abundance of plankton in the offshore (which appears to drive the abundance of shelf plankton populations in the Atlantic (Steele 1998); the relationship of shelf to offshore populations is unclear in the Pacific because of a lack of data), and (c) permit cross-comparisons with almost all existing eastern Pacific ocean surveys (CalCOFI in California; Line P in Canada; and GAK-1 near Seward, Alaska).

The lack of large-scale Pacific monitoring in the past has the advantage that setting up a proper basis for monitoring is not limited by worries about disrupting existing time series. Developing the new survey now, with the benefit of 70 years of experience in the Atlantic, is allowing us to tailor-make a survey specific to the ecosystem of the north Pacific that will take advantage of the revolution in automated monitoring sensors now occurring, and which will eventually complement the detailed zooplankton species identification possible with the CPR. This proposal seeks the support to extend the two year survey while we put in place the foundations of a long-term monitoring programme. Funding will also be sought elsewhere to broaden the survey and strengthen the involvement of other North Pacific agencies.

We are already in a time of apparently unprecedented climatic change. We relate the existing proposal to parallel initiatives to develop improved scientific monitoring and secure long-term

funding in a later section of the proposal. This initiative has been discussed by both the Monitoring Task Team at the PICES Annual Meeting in Hakodate Japan (October 2000), and designated as a GOOS-LMR pilot project for the North Pacific by the IOC Living Marine Resources Panel of the Global Ocean Observing System (GOOS), Third Session, Talcahuano Chile, in December 1999. This followed on an earlier LMRP report that noted: "In the PICES region, work was described in the north-west Pacific that could constitute an LMR (Living Marine Resources) pilot project, as could a north-east Pacific plan being developed for use of the Continuous Plankton Recorder (CPR)".

B. Rationale/Link to Restoration

The Trustee Council is planning the future of the oil spill restoration program through the formulation of a long-term research and monitoring effort, GEM. A ships of opportunity program originating in Prince William Sound using CPR technology makes a direct contribution to the development of GEM. The types of data acquired by CPR and other instruments that may be deployed using our approach would be appropriate to evaluating hypotheses regarding sources of change in productivity from earlier restoration projects (i.e. Sound Ecosystem Assessment, SEA). In particular, the role of changes in climate (i.e. "weather", when considered on decadal scale averages) in changing productivity would be amenable to evaluation by CPR and related data collected from ships of opportunity. Observations of climate change in the atmosphere and simple physical variables such as sea temperature and atmospheric pressure are readily available. These data show that large scale physical changes are evident which seem to be associated with changes in ocean productivity observed in upper trophic levels (i.e. fish production). However, correlative relationships frequently break down, and the lack of a mechanistic understanding of how the North Pacific can rapidly shift from one state to another ("regime shifts") limits our ability to manage these resources by setting harvest rates appropriate to the productivity of the populations. The data necessary to show directly that changes in primary or secondary plankton production are occurring have not been collected in a systematic fashion in the North Pacific, and have largely depended on opportunistic sampling from Japanese research ships sampling a series of transects only once a year.

The existing data linking intermediate trophic levels to the changes in the physical environment and to the changes in fish production are sporadic and based largely on mid-summer ocean sampling, and have not been collected in a way that allows identification of species composition changes. Mackas (1998) has demonstrated that the timing of the movement of the dominant zooplankton species to the surface mixed layer where they are available to salmon has shifted forwards by at least two months in the eastern North Pacific, emphasising the need for replicate sampling to establish seasonality. Neither the changes in seasonality observed in the Pacific (Mackas 1998) or the large changes observed in the Atlantic (Reid and Planque, 1999) would be identified by simply supporting the existing plankton collection framework in the Pacific Ocean; without the CPR survey the only repeated open ocean sampling of plankton in the eastern Pacific Ocean is the Canadian Line P, which is now typically occupied only 3 times per year (February, May-June and August-September). Batten *et al* (1998) used the Atlantic CPR data to evaluate the changes in the plankton before and after the Sea Empress oil spill in the Bristol Channel to see whether that oil spill had a measurable effect on the plankton community. Without similar data from baseline monitoring programs in the Pacific it will be impossible to address questions of how marine communities may change over time or whether specific anthropogenic effects have caused changes in the ecosystem.

It is important to study the ecosystem dynamics of regions outside of Prince William Sound or even the continental shelf region seaward of the Sound. The ocean outside Prince William Sound apparently forces plankton abundances within the sound (Cooney, *pers. comm.*). In the Atlantic, where much more plankton sampling has been carried out, shelf populations of *Calanus* are known to be driven by off-shelf populations. Steele (1998) comments "*The Calanus story described earlier, and corresponding work in the Pacific (Parsons and Lalli, 1988) indicates the need to consider the open ocean as the starting point for major shelf populations [of zooplankton]*".

In the Pacific Ocean, Cooney (1986) noted that "*The degree to which the* [Alaskan] *shelf is enriched by oceanic biomass can be estimated by measuring both the standing stocks and the rate of onshore surface flow. Cooney (1984) proposes that over an eight month period from March to November of each year, ~10x10^6 mt of zooplankton biomass are advected shoreward from the upper 50m of the bordering ocean. This biomass then moves into the outer edge of the Alaska Coastal Current along 1000 km of coastline in the northern Gulf of Alaska. This advected zooplankton biomass compares to the ~2x10^6 mt estimated as the production yielded by zooplankters resident in the Alaska Coastal Current. If this calculated contribution is at all accurate, the bordering ocean supplies an immense and significant amount of biomass to both shelf and coastal food webs each year*".

C. Location

For these reasons, it is important to place an ocean monitoring program in a broad context, and not to artificially restrict the study to only a small geographic area, since climatic change and environmental forcing may be expressed on much broader scales. Line A from our proposal would allow cross-comparison with historical plankton sampling done on the GAK-1, Line P, and CalCOFI lines (Fig. 1). Line B would provide comparison with the central Gulf of Alaska, the shelf on the south-western end of the Alaska Peninsula, and the southern Bering Sea and western Aleutians. These are all regions extensively used by Alaskan salmon during their ocean migrations, and therefore have relevance to Alaskans from many areas of the state.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

With only one year it is not practical to set up a local analysis facility since training in plankton identification takes many months before sufficient proficiency is acquired. However, in the long term a local station where such analyses could be carried out, with quality control and exchange procedures facilitated by an organisation such as SAHFOS, would be sensible and desirable. The keen understanding of nature shown by many native communities suggests that in the future it may be possible to train local individuals as technicians in the art and practice of taxonomic identification.

PROJECT DESIGN

A. Objectives

1. To develop and apply the ship of opportunity approach to oil tankers and other large merchant vessels in order to obtain data on lower trophic levels for the Gulf of Alaska and adjacent waters.
2. To deploy the CPR from ships of opportunity on selected transects and to process the samples obtained for plankton species abundances. This third year of data would significantly enhance our understanding of the plankton communities of the Gulf of Alaska; determination of the extent of large scale spatial heterogeneity in the plankton of this region will aid the planning of the GEM sampling program and go some way towards establishing the expected degree of seasonal and interannual variability.
3. To further enhance the use of ships of opportunity by supplementing the biological data with physical sensors. The first year of data collection has identified large changes in plankton community composition and biomass within different regions of the Gulf of Alaska. A desirable long-term goal is to extend the sampling program to include a broader range of physical, chemical, and biological variables. As a first step, we suggest that sensors be installed to collect data on temperature, salinity, and fluorescence that can be compared with the zooplankton data from the CPR. A self-contained T-S-F unit that can be mounted on the towed CPR is available at modest cost (ca. $15,000 plus operating costs), but collaboration with the proposal by Okkonen and Royer to place a thermosalinograph and fluorometer internal to the ship would be preferable because of the scientific collaboration that would result. The ultimate goal of a ship of opportunity monitoring program would be to have a fully self contained suite of sensors either internal to the ship or on a towed body. This objective would go some way towards realising that goal.

B. Methods

Standard CPR methodology

CPRs are towed in the surface mixed layer at a depth of about 7m by commercial ships of opportunity on their regular routes of passage. Water enters the front of the CPR through a small square aperture (1.27cm), passes along a tunnel and through a silk filtering mesh (with a mesh size of 270μm) which retains the plankton and allows the water to exit at the back of the machine. The movement of the CPR through the water turns an external propeller which, via a drive shaft and gear-box, moves the filtering silk across the tunnel at a rate of approximately 10cm per 18km of tow. As the filtering silk leaves the tunnel it is covered by a second band of silk so that the plankton are sandwiched between these two layers. The silk and plankton sandwich is then wound on into a storage chamber containing preservative. At the end of the tow the machine is returned to the laboratory and the silks are processed in a routine way. The silk is cut into separate samples (each representing 18kms of tow and about $3m^3$ of seawater) which are randomly apportioned amongst the analysts for plankton analysis. (The $3m^3$ sample volume analyzed is comparable to that which would be measured by an OPC towed along the same track line).

The first step is the assessment of phytoplankton colour (the greenness of the sample) which is determined by comparison with standard colour charts. It is a representation of the total phytoplankton biomass and includes the organisms that are too fragile to survive the sampling process intact but which leave an impression on the silk. Hard-shelled phytoplankton are then semi-quantitatively determined under a microscope by viewing 20 fields of view and recording

the presence of all the different taxa in each field. Small zooplankton are identified and counted into categories of abundance from a subsample (1/50 of the sample) whilst all zooplankton larger than about 2mm are counted with no subsampling. Identification is carried out to the highest practicable taxonomic level and is a compromise between speed of analysis and scientific interest. Since copepods make up the vast majority of the zooplankton most copepods are identified to species level whilst rarer groups are identified to a lower level. Although CPR sampling is continuous, the midpoint of the sample is used to label it with latitude, longitude, time and date. All of this information is stored on a relational computer database so that the questions of when, where, and how much can be answered. All of the samples are archived after analysis so that they can be re-examined at any time, for example, if a scientist with an interest in a specific group wishes to study it in more detail, or an incident occurs which warrants closer examination of the samples from that area.

The CPR is a relatively simple, rugged piece of oceanographic equipment. It can withstand being deployed from large ships moving at speeds of around 20 knots and still function, and over 95% of tows successfully record plankton. It has the ability to carry instruments to record the physical environment of the plankton which can be invaluable supplementary information when distinguishing between communities. A high level of expertise is needed to carry out the taxonomic analysis but SAHFOS has an excellent team of analysts, some members with over 30 years of experience.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

We propose that the collection of temperature, salinity and fluorometric data be assigned to Drs Okkonen and Royer (UAF and Old Dominion Universities) under their proposed project, but in the event that they are unable to do so SAHFOS can arrange for the purchase and maintenance of a self-contained instrument to collect this data. Welch is employed by DFO in Canada and is chairman of the PICES *"Climate Change and Carrying Capacity"* program. PICES also sponsors the CPR research with its CPR advisory panel, which is constituted under the Monitoring Task Team of the 4Cs program. These agencies will contribute staff time and institutional resources to the project but do not require funding from this proposal.

SCHEDULE

A. Measurable Project Tasks for FY 02 (October 1, 2001 – September 30, 2002)

January 14-23:	Attend annual restoration workshop
January:	Liase with shipping company regarding 2002 schedule. Arrange and carry out any necessary davit transfer or testing.
February:	Ship equipment to vessel in Long Beach
Late March :	First sampling from Alaska to California
Late April:	Second sampling from Alaska to California
May:	Ship equpiment to vessel in Vancouver
Early June:	Third sampling from Alaska to California
Mid June:	Sampling from Vancouver to Kamchatka (coincident with Line P cruise)
Mid July:	Fourth sampling from Alaska to California
Mid August:	Fifth sampling from Alaska to California
Early October:	Attend PICES XI meeting, China.

B. Project Milestones and Endpoints

April:	Sampling schedule will be confirmed (although still subject to change according to requirements of the Shipping companies)
August 31st:	All 2002 sampling completed Integrate biological data with physical data acquired by Okkonen and Royer
September 30th:	Preliminary taxonomic processing complete. Quality control will be ongoing
October, 2002:	Attend PICES X meeting (China) and CPR Advisory Panel to present and review results and collaborate for development of broader scientific program.

C. Completion Date

All sampling will be completed during Fiscal year 02. Taxonomic processing will also be completed during FY02 although it is anticipated that quality control will be ongoing after September 2002, according to normal SAHFOS procedures. Analysis of the results and completion of the final report will be achieved by the deadline of April 15th 2003.

PUBLICATIONS AND REPORTS

It is not expected that publications will be submitted during FY02, since sampling will not be completed until the latter part of the year. However, at least one publication will be prepared upon completion of the analyses.

PROFESSIONAL CONFERENCES

Funding is already secured for attendance at the PICES X meeting which occurs just in FY02. Although the PICES XI meeting will be held just after the end of FY02 (in mid October 2002) we ask for support for one CoPI (Batten) to attend this meeting. PICES has been instrumental in the setting up of the Pacific CPR sampling and the results from this proposal will be reviewed at the CPR advisory panel and MONITOR task team meetings. Review and collaboration with the Pacific science community will be essential to strengthening future monitoring efforts.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

Primary collaboration is most simply achieved by coordination of this project with the Okkonen & Royer proposal to collect basic physical oceanographic data on the same oil tankers, which will provide useful synergies and a broader base to the monitoring effort. The collected CPR data are freely available to other investigators and we have already had discussions with Weingartner et al's GAK-1 project (EVOS Project 340: Long-Term Oceanographic Monitoring), and the Canadian Line P program (Dave Mackas has also taken on the role as chair of the PICES MONITOR task team, and Charlie Miller of OSU is the chair of the PICES CPR Advisory Panel).

PROPOSED PRINCIPAL INVESTIGATOR

Dr Sonia Batten
Sir Alister Hardy Foundation for Ocean Science
1, Walker Terrace, The Hoe, Plymouth, PL1 3BN, UK
Telephone 44-(0)1752-221112
Fax 44-(0)1752-221135
Email soba@wpo.nerc.ac.uk

Dr. David Welch
Department of Fisheries and Oceans Canada
Pacific Biological Station, Nanaimo, V9R 5K6, British Columbia, Canada
Telephone 1-250-7556-7218
Fax 1-250-756-7053
Email welchd@pac.dfo-mpo.gc.ca

PRINCIPAL INVESTIGATOR

Sonia Batten –. Will oversee the sampling program, processing of samples and carry out statistical analyses of the acquired data. Will coordinate production of the final report and publications. Qualifications: PI on NPMR project, SAHFOS Assistant Director

David Welch – Will take responsibility for co-ordinating the broader scale monitoring effort, and developing a co-ordinated program amongst the Pacific science community. Welch is currently co-PI on the NPMR project, and chairman of the PICES 4Cs program and the Alfred P. Sloan Foundation's Census of Marine Life Pacific project, "POST".

Experience of SAHFOS

The Continuous Plankton Recorder (CPR) was devised in the 1920s by Sir Alister Hardy, who wanted a simple, cost effective way of sampling the plankton. He intended the CPR to provide information on plankton for the herring fishermen (then an important commercial North Sea fishing industry) to enable them to better assess fishing prospects on the basis of the type of plankton present. Right from the beginning Hardy intended that the results of the survey be used as an aid to understanding changes in stocks, to improve fishery management and help determine the potential productivity of the seas. He designed the CPR to be towed behind commercial ships on their regular routes of passage and so avoided expensive research ships. The first operational tow took place in 1931 and since then, apart from a break for the Second World War, the CPR survey has operated continuously in the seas around Britain and now world-wide. It is one of the longest running marine monitoring programmes in the world and since 1931 more than 200,000 samples have been analysed and CPRs have been towed for over 4 million miles.

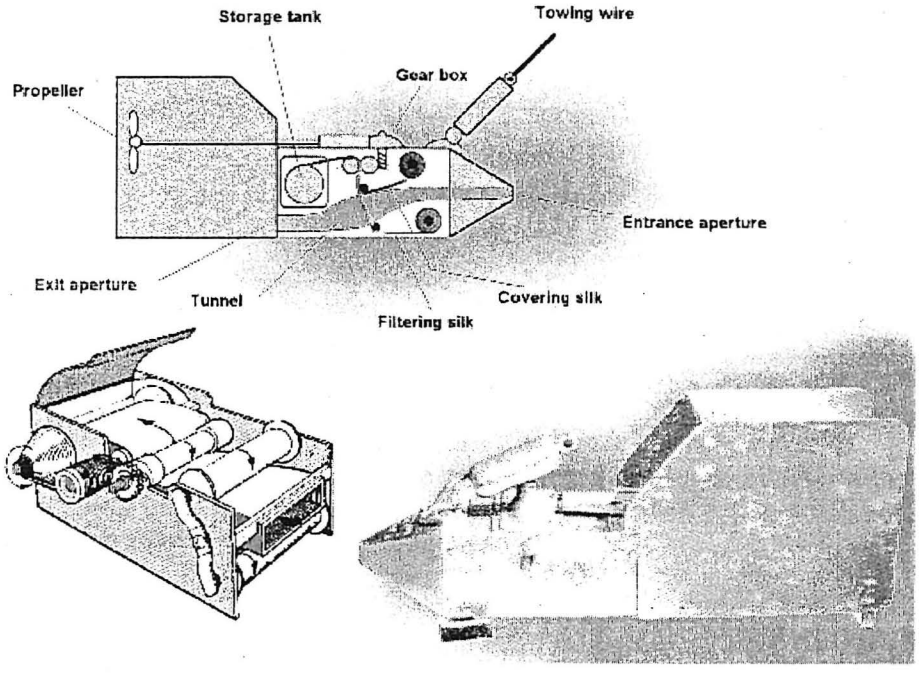


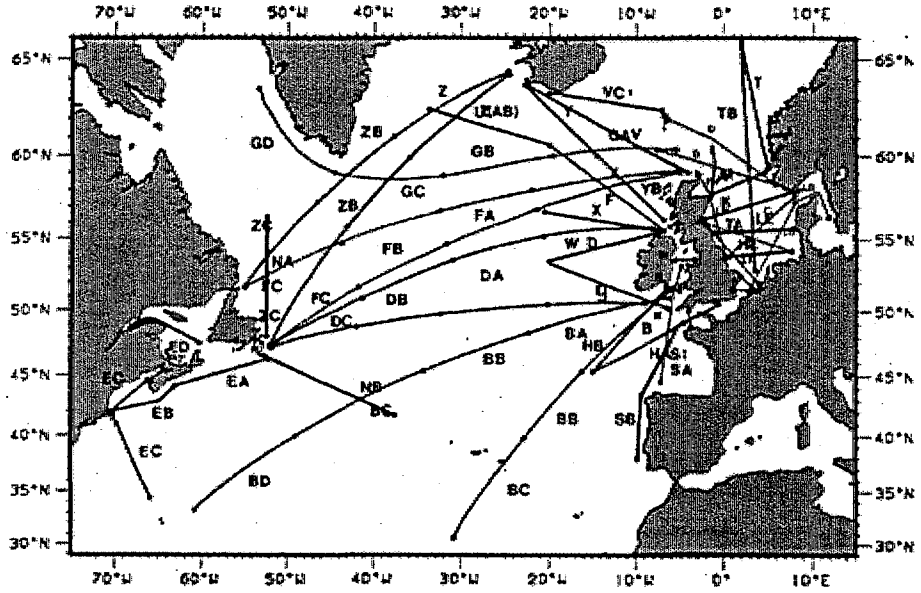
Diagram showing a cutaway view of the original CPR , the plankton filtering mechanism, and a photograph of the instrument.

The CPR survey today

Although originally publicly funded, a change in science policy forced the closure of the survey in 1989. International concern compelled a rescue package to be immediately set in place

to enable the team of analysts and technicians to stay together until the official establishment of the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) which was set up as a charitable trust to operate the CPR survey. Since its inception in 1991 SAHFOS has grown into a dynamic research operation receiving funding from all over the world to maintain and deploy Hardy's device across the seas and oceans, to analyse and interpret the results and provide this information to the scientific community. The staff complement of around 18 includes two technicians who service the Recorders, administrative and logistics staff and a team of 13 analysts (including some part-time) who carry out the taxonomic analysis, manage the database and undertake research. SAHFOS also hosts students and researchers from all over the world who want to use the data for their own studies. The business of the Foundation is overseen by a Council of Management made up of a President, Vice-President, Treasurer and Trustees. Sponsoring Governors from each of the agencies contributing to the funding are also invited to participate in Council meetings.

At present, approximately 25 routes operate each month from the SAHFOS base in the UK (Fig. 2). These routes cover the North Sea and North Atlantic which has historically been the main area of coverage, however, in 1996 sampling began in the Gulf of Guinea, West Africa, during 1997 a Mediterranean survey began and in 1998 the Baltic was sampled for the first time.



Plankton survey routes in the North Atlantic. At present, equivalent monitoring of the eastern North Pacific Ocean does not exist, except for point samples taken 2-3 times per year along the Canadian survey, Line P.

OTHER KEY PERSONNEL

Captain Peter Pritchard is the operations manager of SAHFOS and has over 10 years experience in liasing with shipping companies to arrange towing of CPRs. Will be responsible for coordinating the sampling program through regular communication with shipping agents and Masters/crew and arranging dispatch and return of equipment.

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Accomplishments To Date

The first year of sampling with the CPR in the North Pacific went exceptionally well. Excellent co-operation and support for the program was achieved with two shipping companies who operated on the desired routes. Polar Tankers Inc. (originally ARCO Marine Inc.), who towed an initial pilot survey for SAHFOS in 1997, operated the crude oil carrier *Polar Independence* from Valdez to Long Beach throughout 2000. Seaboard International Shipping Company Ltd operated the container ship *Skaubryn* from Vancouver to Japan and offered to tow a CPR on any of these trips. Both companies gave considerable support and assistance to SAHFOS over and above helping with logistics by communicating ship schedules as soon as was practicable. All six deployments (Fig. 2) successfully collected samples and although a few samples were lost owing to mechanical glitches, over 95% of the target sampling was achieved.

Initial taxonomic processing of the 2000 samples is complete although quality control of some samples is still ongoing. Preliminary findings from these data show that *Neocalanus plumchrus*, the largest contributor to mesozooplankton biomass in the Gulf of Alaska, varies its developmental duration, and therefore the timing of its peak biomass, by as much as five weeks according to latitude (Batten *et al.,* in prep.). Much of this variability can be explained by

temperature differences, and is not surprising given that temperature is known to influence the duration of invertebrate development. However, the extensive CPR sampling enabled such a pattern to be described, and potentially quantified, for the first time. Understanding the variability of zooplankton biomass determined by ocean climate conditions is essential to interpreting the data collected through monitoring efforts.

The community composition of the samples collected on the single east west transect was examined and an ordination of the data (Fig 3) showed that distinct communities could be identified. This is an encouraging result, verifying that the CPR approach is capable of distinguishing different regional communities, and thus allowing changes in their distribution, or community composition, to be tracked.

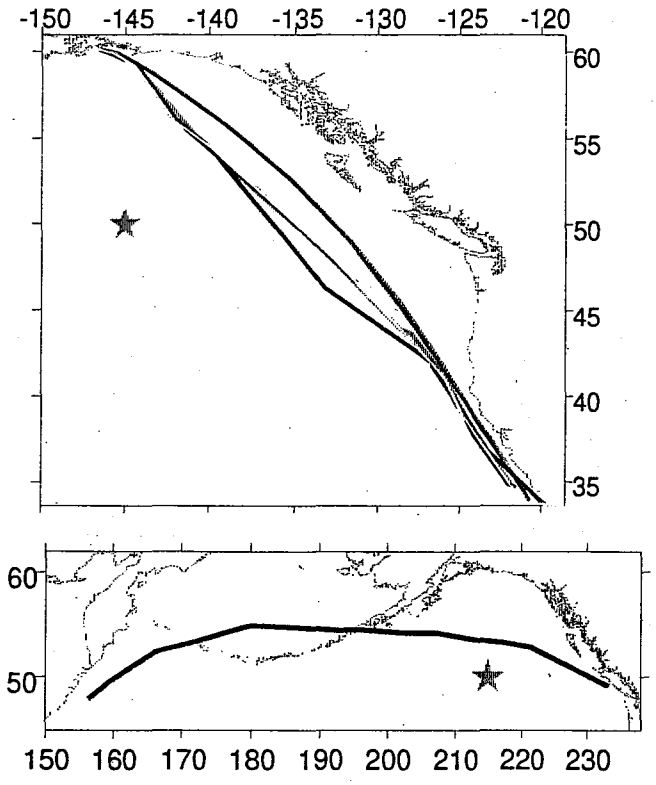

Figure 2. The positions of the transects operated in 2000. (a) Monthly N-S and (b) E-W in June. Key to colours: March (Green), April (Red), May (Brown), June (Violet), July (Blue), August (Orange). Station Papa is shown for reference (Star).

The sampling programme for 2001 is underway, as this proposal is submitted, with a similar sampling strategy to 2000. Further analyses of the 2000 data will be undertaken, including statistical determinations of the spatial variability (decorrelation length scales for example) and continued assessments of temporal variability as the 2001 data become available.

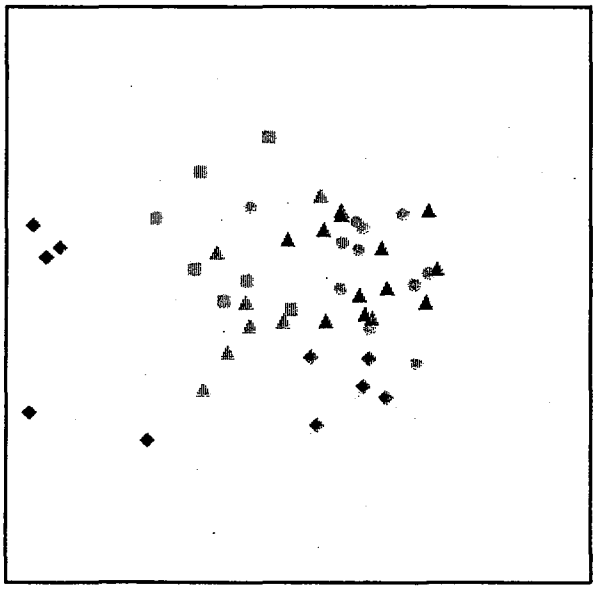

Fig 3. Multidimensional scaling analysis of zooplankton community composition on the Vancouver to Kamchatka transect in June/July 2000.

Revised 26-01
TC approved 12-11-

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel		$0.0
Travel		$0.0
Contractual		$112.7
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$112.7
General Administration		$7.9
Project Total	$0.0	$120.6
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2003					

Dollar amounts are shown in thousands of dollars.

Comments:

FY02

Prepared:11/26/01

Project Number: 02624-BAA
Project Title: CPR-Based Plankton Survey Using Ships of Opportunity
Agency: NOAA

FORM 3A
TRUSTEE
AGENCY
SUMMARY

Revised 11-26-01

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel		$57.7
Travel		$5.2
Contractual		$21.3
Commodities		$5.5
Equipment		$0.0
Subtotal	$0.0	$89.7
Indirect		$23.0
Project Total	$0.0	$112.7
Full-time Equivalents (FTE)		1.5
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
Estimated FY 2003					

Dollar amounts are shown in thousands of dollars.

Comments:

Indirect rate is 40% of salary (personnel) costs

$0 for NEPA compliance (Not Applicable)
$2 for annual restoration workshop attendance
$3.8 for report writing (1 month for S.Batten)
$0 for publications (peer reviewed publications will be submitted, however, the results from FY02 will not be published within FY02 on current publishing timescales)
$3.2 for professional conferences (PICES XI)
$0 for community involvement.

No other funds are anticipated, although efforts will be made to obtain funding for further sampling or processing of collected samples.

FY02

Prepared: 11/26/01

Project Number: 02624
Project Title: A CPR-Based Plankton Survey Using Ships of Opportunity
Name: Sir Alister Hardy Foundation for Ocean Science

FORM 4A
Non-Trustee
SUMMARY

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Personnel Costs:			Months	Monthly		Proposed
	Name	Position Description	Budgeted	Costs	Overtime	FY 2002
	S. Batten	Principal investigator/lead researcher	3.5	3.8	0.0	13.3
	P. Pritchard	Operations Manager	1.0	4.1	0.0	4.1
	R. Barnard	Technician	1.0	2.8	0.0	2.8
	L. Gregory	Technician	1.0	2.8	0.0	2.8
	Various	Taxonomists (team of ~12 people)	11.5	2.9	0.0	33.4
	D. Stevens	Data Manager	0.5	2.5	0.0	1.3
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
		Subtotal	18.5	18.9	0.0	
					Personnel Total	$57.7

Travel Costs:		Ticket	Round	Total	Daily	Proposed
	Description	Price	Trips	Days	Per Diem	FY 2002
	S. Batten and D. Welch to attend annual restoration workshop	0.8	2	4	0.1	2.0
	S. Batten to attend PICES XI meeting	1.2	1	10	0.2	3.2
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
					Travel Total	$5.2

FY02

Project Number: 02624
Project Title: A CPR-Based Plankton Survey Using Ships of Opportunity
Name: Sir Alister Hardy Foundation for Ocean Science

FORM 4B
Personnel
& Travel
DETAIL

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed FY 2002
Description	
Leasing of Continuous Plankton Recorders ($0.9 per tow)	5.4
Transport of CPRs for servicing between tows, and servicing costs	12.0
Computing services (these are provided by the Plymouth Marine laboratory at an agreed rate PA. Pro rata costs indicated)	3.9
Contractual Total	$21.3

Commodities Costs:	Proposed FY 2002
Description	
Filtering mesh ($0.2 per unit)	5.5
Commodities Total	$5.5

FY02

Project Number: 02624
Project Title: A CPR-Based Plankton Survey Using Ships of Opportunity
Name: Sir Alister Hardy Foundation for Ocean Science

FORM 4B
Contractual & Commodities DETAIL

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2002
none needed			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage: Description	Number of Units
existing CPRs will be used. Rental costs charged above cover replacement and repair	
external bodies	2
internal mechanisms	11

FY02

Project Number: 02624
Project Title: A CPR-Based Plankton Survey Using Ships of Opportunity
Name: Sir Alister Hardy Foundation for Ocean Science

FORM 4B
Equipment
DETAIL

Approved 12-11-01

Planning for GEM

Project Number:	02630
Restoration Category:	Research/Monitoring
Proposer:	Restoration Office / Trustee Council
Lead Trustee Agency:	ADF&G (Restoration Office)
Cooperating Agencies:	All
Alaska SeaLife Center:	No
Duration:	3rd year 3-year project
Cost FY 02:	TOTAL $304,71,000 ($63,800 approved August; $240,900 proposed December)
Cost FY 03:	$0
Geographic Area:	Spill area wide
Injured Resource/Service:	All injured resources and services

ABSTRACT

This project will conclude planning and begin initiation of the Trustee Council's vision for long-term monitoring and research in the Gulf of Alaska, the Gulf Ecosystem Monitoring and Research program (GEM). Planning and implementation during FY 02 will be based on the draft GEM Program Document until its review by the National Research Council (NRC) is complete. The document describes how a network of monitoring and research activities will be implemented over a five-year period starting in FY 03 using synthesis, research, modeling, and data management-information gathering. As directed by the Trustee Council, the GEM program is closely coordinated with, and complementary to, related large-scale marine science programs and organizations in the Gulf of Alaska and adjacent waters. In FY 02, GEM planning will support the final review by the NRC, develop the FY03 *Invitation to Submit Proposals,* and continue development of the draft GEM Strategic Plan for Monitoring and Research.

INTRODUCTION

In conjunction with the 10th anniversary of the 1989 oil spill, the Trustee Council, in March 1999, formally dedicated a portion of the Restoration Reserve to long-term monitoring and research in the spill area and adjacent northern Gulf of Alaska. This project will conclude planning for implementing the Trustee Council's vision, now known as the Gulf Ecosystem Monitoring and Research program (GEM). In FY 00 a draft scoping document, the Draft GEM Science Program (April 2000), was developed and submitted to the NRC for preliminary review. This report was preceded and followed by an extensive public involvement process. Meetings to gather advice on the content and future of GEM were held in communities throughout the spill-affected region with stakeholder groups, Alaska Native organizations, state and federal policy makers, and scientists. This consultation continued into FY 01 with a statewide GEM workshop that drew attendance from throughout the U.S. Building on ideas from the consultations, the workshop and preliminary NRC recommendations, the draft GEM Program Document, including a draft monitoring and research plan, was produced. In FY 02, this project will support the final review by the NRC and continue development of the draft plan.

NEED FOR THE PROJECT

A. Statement of the Problem

In order for the Trustee Council's vision for GEM to be implemented over a five-year period starting in FY 03, the following activities need to be completed in FY 02: 1) collection and assimilation of reviews from the NRC, the scientific community and the public; 2) revision of the draft GEM Program Document into a form that can be approved by the Trustee Council; 3) development of the FY 03 *Invitation to Submit Proposals*; 4) establishment of a set of committees and work groups to assist with further development of the GEM program; and 5) a series of workshops to assist in that effort.

B. Rationale/Link to Restoration

In deciding to allocate a significant portion of the Restoration Reserve for long-term monitoring and research, the Trustee Council explicitly recognized that complete recovery from the oil spill will not occur for decades and that long-term observation and, possibly, restoration actions are needed if injured resources and services are to be fully restored. The Council further recognized that conservation and improved management of these resources and services will require a substantial ongoing investment to improve understanding of the biology and marine and coastal ecosystems that support the services as well as the people of the spill region. Hence, the Council made a commitment to development of a long-term monitoring and research program for the spill region that will inform and promote the full recovery and restoration, conservation, and improved management of spill-area resources.

C. Location

The transition to the GEM program will occur primarily at the Restoration Office in Anchorage, with input from spill-area communities and key experts outside Alaska. Monitoring and research carried out under GEM will take place mostly in the coastal and marine environment within the oil-spill area and, to the extent necessary, in adjacent parts of the northern Gulf of Alaska.

COMMUNITY INVOLVEMENT AND TRADITIONAL ECOLOGICAL KNOWLEDGE

The incorporation of substantial community involvement and the use of traditional ecological knowledge into the overall GEM program are important goals to be addressed during this phase of planning for the GEM project. The Restoration Office will work closely with the Public Advisory Group and other members of the public in order to ensure that community interests are coordinated with plans for long-term monitoring and research. Advice from the communities will also be sought in how best to reconstitute the Public Advisory Group to ensure community participation. Community and TEK experts will be included as committees and work groups are developed and will be encouraged to participate in workshops.

PROJECT DESIGN

A. Objectives

Specific objectives are to:

1) Revise the draft GEM Program Document (GPD) in response to NRC and public comment and support the process of its adoption by the Trustee Council.
2) Develop the content of the FY 03 *Invitation to Submit Proposals* and the FY 03 Work Plan.
3) Begin development of a "State of the Gulf Report" and provide regional input to a status report on North Pacific Resources.
4) Continue development of GEM Monitoring and Research Program.
    a) Provide scientific guidance and support in developing the proposed Scientific and Technical Advisory Committee (STAC), subcommittees, work groups, and new procedures for peer review and proposal solicitations.
    b) Provide scientific support to the committees in furthering development of the GEM Monitoring and Research Strategic Plan, including updating and maintaining GEM gap analysis database.
    c) Assist Data Manager in developing data and information policies and procedures.
    d) Work with stakeholders, interested community groups, and existing community-based projects to develop meaningful ways to incorporate traditional ecological knowledge and community involvement into the program.
    e) Initiate and develop modeling advisory group.
    f) Initiate and develop Intertidal and Subtidal study plan.
    g) Initiate and develop the Alaska Coastal Current and Offshore study plans.
    h) Initiate and develop the Watershed study plan.

5) Consult and coordinate with other marine research efforts.
   a) Develop a network of partnerships to complement core monitoring efforts, aid in the peer review process and expand the scope of the GEM Program. Potential partners include NEP GLOBEC, USGOOS, CORE, PICES, SSSF, NPRB, NPRAAFC, AAAS and others.
   b) Assist State of Alaska in planning for June 2002 Oceans and Watersheds Symposium and first State of Alaska's Oceans and Watersheds Report, due in fall 2002.
   c) Assist with other meetings.
   d) Develop outreach with marine-related NGOs.
   e) Expand outreach on GEM program.

B. Methods

The methods described below are organized by project objective (in parentheses):

(1) Revise the draft GEM Program Document in response to NRC and public comment and support the process of its adoption by the Trustee Council. In response to NRC comments, the document's section on Program Management (Volume I Chapter 6,) and other related sections will be further developed to support GEM initiation and development. Additional information will be provided the NRC upon request. The final NRC review is expected in the spring of 2002, and a final draft of the GEM Program Document will be developed and submitted to the Trustee Council for adoption as soon thereafter as possible.

(2) Develop the content of the FY 03 *Invitation to Submit Proposals* and the FY 03 Work Plan. The FY 03 *Invitation to Submit Proposals* will be developed this year in two phases. Phase I will follow the normal schedule (invitation issued in mid-February, proposals due mid-April, draft recommendation out in early June) and include three basic types of projects: continuing oil-related injury, ongoing GEM transition, and GEM synthesis. These projects can go forward pending the final NRC review report. Phase II will follow receipt of the final NRC report, final revision of the GEM Program Document, its adoption by the Trustee Council, and preliminary subcommittee work and is anticipated to be issued in early fall 202, with a Trustee Council decision slated for December 2002-January 2003.

(3) Begin development of a "State of the Gulf Report" and provide regional input to a status report on North Pacific Resources. Working in cooperation with the PICES Secretariat and PICES members, begin developing the "State of the Gulf Report" as part of a larger north Pacific effort now being organized and coordinated by the PICES Secretariat. This effort will also be coordinated with the State of Alaska's first State of the Oceans and Watersheds Report, scheduled for fall 2002.

(4) Continue development of GEM Monitoring and Research Program. This objective will take the combined efforts of the existing Restoration Office staff, the Trustee Council's Chief Scientist, and some additional staff support as we continue with the transition to the GEM Program. During FY 02, all the administrative functions of the program will be reviewed

(procedures for issuing invitation for proposals, receiving and reviewing proposals, reporting requirements, project management, etc.) and recommendations made to the Trustee Council on how to streamline the program, increase efficiency, reduce costs, and ensure public input and involvement and scientific credibility. The office will use existing staff plus 6 months internship and 6 months additional scientific support to assist in this effort. Specifically, staff will

a) Provide scientific guidance and support in developing the proposed Scientific and Technical Advisory Committee (STAC), subcommittees, work groups, and new procedures for peer review and proposal solicitations. Staff will be instrumental in defining the processes, locating members and organizing staff support for developing the committees.

b) Provide scientific support to the committees in furthering development of the GEM Monitoring and Research Strategic Plan. This will include improving and maintaining the GEM gap analysis database and the GEM and TC bibliographies and supporting document collections.

c) Assist Data Manager in developing data and information policies and procedures. Quality data management is a priority for the GEM Program. Establishing a Data Advisory Working Group and developing data and information policies and procedures will involve substantial meeting time.

d) Work with stakeholders, interested community groups, and existing community-based projects to develop meaningful ways to incorporate traditional ecological knowledge and community involvement into the program.
Scientific support will be provided to further develop this aspect of the GEM Program. Staff will work with the Chugach Regional Resources Commission's tribal natural resource management planning effort, the proposed Fisheries Management Applications Work Group, and other efforts to facilitate this, as well as examine new opportunities.

d) Initiate and develop modeling advisory group. An oceanographic modeling workshop was convened in November 2001 to start to build consensus on physical modeling and data collection. Post-meeting follow-up will be conducted in conjunction with GEM transition physical modeling and Hinchinbrook mooring project development.

e) Initiate and develop Intertidal and Subtidal study area. An organization meeting of the Nearshore Monitoring Workshop project (02395) was held in Santa Barbara in November. A day-long session is scheduled at the Annual Workshop in January 2002, with follow-up on ideas to be developed at the workshop.

f) Initiate and develop the Alaska Coastal Current and Offshore study areas. Participate in the NEP-GLOBEC 2001 principal investigators meeting, the US GOOS Steering Committee, and the PICES Monitor Work Group, and coordinate with relevant institutions (NOAA, ADF&G, CORE, CoML, etc.)

h) Initiate and develop the Watershed study area. Develop a one-day workshop on watershed issues as they relate to marine-terrestrial linkages scheduled for January 2002. Participate as a member of the steering committee of Project 02612, Nutrient Cycling in the Kenai River Watershed, and work with PIs in the development of the project study plan.

(5) Consult and coordinate with other marine research efforts.

a) Develop a network of partnerships. This will be accomplished through development of an MOA with regional agencies and institutions, participation in CORE and PICES, active memberships on the Alaska SeaLife Center Scientific Advisory Committee, the Science Coordination Panel of the Southeast Sustainable Salmon Fund, the Board of the North Pacific Research Board, the PICES MONITOR Task Team, and the US GOOS Steering Committee, and by attending and making presentations on GEM at meetings of scientific organizations and other marine research institutions including NEP-GLOBEC, NPAFC, AFS, AAAS, AGU, ASLO, KBRR, PWSSC-OSRI, and at academic institutions such as UAF and UAA.

b) Assist State of Alaska in planning for June 2002 Oceans and Watersheds Symposium and Report. The Trustee Council will be a co-sponsor with the State of Alaska and numerous other organizations in the first statewide Alaska Oceans and Watersheds Symposium June 18-19, 2002, to be followed in fall 2002 with the first State of Alaska's Oceans and Watersheds Report. Funds will be provided to assist in this effort. In addition, in-kind staff support will be provided to assist with planning and logistics.

c) Assist with other meetings. The Trustee Council is frequently asked to contribute to the costs of other scientific and policy meetings and symposia that would be of benefit to the GEM Program. Participation in this manner greatly aids in building partnerships.

d) Develop outreach with NGOs. As interest in Alaska's marine environment expands, a number of existing and newly established non-profits are focusing their attention on marine issues. Briefings will be held for these groups, and their concerns incorporated as GEM develops.

e) Expand outreach on GEM. A new brochure on the GEM Program will be prepared and the website updated and expanded to include more recent information and be more user friendly.

C. Cooperating Agencies, Contracts, and Other Agency Assistance

Federal and state resource agencies will be actively involved in further development of GEM, as will other institutions, particularly the scientific committees involved with planning and implementing monitoring and research in the north Pacific Ocean. These include, for example, the North Pacific Research Board, the North Pacific Marine Science Organization (PICES), the North Pacific Anadromous Fish Commission (NPAFC), the Global Oceans Ecosystems Dynamics (GLOBEC) Northeast Pacific Project (NOAA-NSF), the Ocean Carrying Capacity (OCC) study of the National Marine Fisheries Service (NMFS), the Fisheries and Oceanography Coordinated Investigations (FOCI) of NMFS-PMEL, and other NOAA entities.

SCHEDULE

A. Measurable Project Tasks

October 2001: Participate in PICES MONITOR task team meeting to present draft GEM Program Document (GPD)
November 2001: Attend NPMR presentations on project results (NPRB coordination)
November 2001: Meet with NRC to hear oral comments on draft GEM Program Document
November 2001: Hold physical oceanographic modeling workshop on GEM transition projects
November 2001: Participate in Watershed Workshop Planning Meeting
November 2001: Participate in US GOOS Steering Committee meeting to plan 2002 Workshop on implementing regional coastal monitoring programs
December 2001: GEM brochure completed
December 2001: Web site updated
January 2002: EVOS Annual Meeting, including meetings on Watershed & Intertidal/Subtidal
February 2002: Issue Invitation for Proposals for FY 03, Phase I
April 2002: Receive comments from NRC on GEM Program Document
April 2002: STAC committee process in place
May 2002: 1st STAC meeting
June 2002: Subcommittee process in place
June 2002: Submit revised GEM Program Document for Trustee Council approval
June 2002: Oceans and Watersheds Symposium

B. Project Milestones and Endpoints

Obj. 1, GEM Program Document – adopted June 2002
Obj. 2, Invitation Phase 1 – released February 2002; Phase II – released October 2002
Obj. 3, State of Gulf Report – completed Fall 2002
Obj. 4, Program development/implementation – ongoing throughout life of GEM
Obj. 5, Consult/coordinate – ongoing throughout life of GEM

C. Completion Date

Trustee Council is expected to adopt GEM Program Document June 2002. Implementation costs in FY 03 and beyond will be part of regular administrative budget (Project /100).

PUBLICATIONS AND REPORTS

The product of this project will be the GEM Program Document. No reports will be required and no additional publications are expected.

PROFESSIONAL CONFERENCES

The GEM Program will be discussed at the PICES and NPAFC meetings in October 2001, at the U.S. GOOS Committee meeting in February 2002, and at the American Fisheries Society National Meeting in August 2002. Attendance at additional professional conferences may be required for coordination and integration.

NORMAL AGENCY MANAGEMENT

The Trustee Council directed the executive director and chief scientist to develop a plan for long-term monitoring and research (i.e., GEM) in a resolution adopted on March 1, 1999, in regard to the expenditure of Restoration Reserve funds. Thus, this project is something that is appropriately carried out by the Restoration Office.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

This project will be fully coordinated with and among Trustee agencies, scientific peer reviewers, the Public Advisory Group, and others.

PROPOSED PRINCIPAL INVESTIGATORS

Molly McCammon, Executive Director
Exxon Valdez Oil Spill Trustee Council
441 W. 5th Ave., Suite 500
Anchorage, Alaska 99501
907-278-8012
907-276-7178 (fax)
molly_mccammon@oilspill.state.ak.us

Dr. Phil Mundy, Science Coordinator
Exxon Valdez Oil Spill Trustee Council
441 W. 5th Ave., Suite 500
Anchorage, Alaska 99501
907-278-8012
907-276-7178 (fax)
phil_mundy@oilspill.state.ak.us

Dr. Robert Spies, Chief Scientist
Exxon Valdez Oil Spill Trustee Council
Applied Marine Sciences
4749 Bennett Drive, Suite L
Livermore, California 94550
925-373-7142
925-373-7834 (fax)
spies@amarine.com

Ms. McCammon has 28 years of experience in Alaska in business, journalism, communications, and public policy, emphasizing natural resource issues. She has been Executive Director of the Trustee Council since 1994.

Dr. Mundy has 28 years of experience as a fisheries scientist, including 25 years in Alaskan fisheries research and management. As Science Coordinator since 1999, Phil has been key to development of the Gulf Ecosystem Monitoring (GEM) program. He has worked as a reviewer of research on the oil spill since 1989.

Dr. Spies has 35 years of experience as a scientist in marine pollution and toxicology, the effects of petroleum on marine organisms, and benthic ecology. He is president of Applied Marine Sciences, Inc. and has been the Trustee Council's Chief Scientist since 1991.

Revised 1-27-01
Approved 12-11-0

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 01	Proposed FY 02	PROPOSED FY 02 TRUSTEE AGENCIES TOTALS					
			ADEC	ADF&G	ADNR	USFS	DOI	NOAA
				$187.0	$117.7			
Personnel	$56.7	$55.2						
Travel	$20.0	$60.0						
Contractual	$161.5	$160.0						
Commodities	$5.5	$0.0						
Equipment	$0.0	$10.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$243.7	$285.2				Estimated FY 2002		
General Administration	$19.7	$19.5						
Project Total	$263.4	$304.7						
Full-time Equivalents (FTE)								
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

NOTE: Of the $301.0 requested, the Trustee Council approved $63.8 in August 2001. The December request to the Council is for the balance of $240.9.

PREPARED 11/27/01

FY02

Project Number: 02630
Project Title: Planning for Long-Term Research & Monitoring Program
Lead Agency: ADFG/Restoration Office

FORM 2A
MULTI-TRUSTEE
AGENCY
SUMMARY

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 01	Proposed FY 02
Personnel	$6.8	$55.2
Travel	$20.0	$60.0
Contractual	$0.0	$50.0
Commodities	$5.5	$0.0
Equipment	$0.0	$10.0
Subtotal	$32.3	$175.2
General Administration	$1.0	$11.8
Project Total	$33.3	$187.0
Full-time Equivalents (FTE)		
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					

Dollar amounts are shown in thousands of dollars.

Comments:

FY02

Project Number: 02630
Project Title: Planning for Long-Term Research & Monitoring Program
Agency: ADFG/Restoration Office

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 02
						0.0
Intern (APPROVED AUGUST)			3.0	3.2		9.6
Intern			3.0	3.2		9.6
						0.0
Staff scientist			6.0	6.0		36.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		12.0	12.4	0.0	
					Personnel Total	$55.2

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 02
Travel for Restoration Office staff and other personnel as needed					10.0
for PICES meeting (Victoria, B.C. in October), modeling workshop					0.0
including participants), and meetings with other potential					0.0
collaborators (APPROVED AUGUST)					0.0
					0
Travel for STAC and subcommittee meetings and community					50.0
involvement workshops; also for travel for Restoration Office					0.0
staff and other personnel as needed					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$60.0

FY02

Project Number: 02630
Project Title: Planning for Long-Term Research & Monitoring Program
Agency: ADFG/Restoration Office

FORM 3B
Personnel
& Travel
DETAIL

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed FY 02
Description	
External meeting support (PICES, Oceans & Watersheds Symposium, other)	45.0
Internal meeting support (space rental, printing, etc.)	5.0
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	$50.0

Commodities Costs:	Proposed FY 02
Description	
Commodities Total	$0.0

FY02

Project Number:02630
Project Title: Planning for Long-Term Research & Monitoring Program
Agency: ADFG/Restoration Office

FORM 3B
Contractual & Commodities DETAIL

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 02
			0.0
Computer and software for staff scientist; upgrade computer projector			10.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$10.0

Existing Equipment Usage: Description	Number of Units	Inventory Agency

FY02

Project Number: 02630
Project Title: Planning for Long-Term Research & Monitoring Program
Agency: ADFG/Restoration Office

FORM 3B
Equipment
DETAIL

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 01	Proposed FY 02	LONG RANGE FUNDING REQUIREMENTS					
Personnel	$7.4	$0.0						
Travel	$0.0	$0.0						
Contractual	$161.5	$110.0						
Commodities	$0.0	$0.0						
Equipment	$0.0	$0.0						
Subtotal	$168.9	$110.0						
General Administration	$12.4	$7.7						
Project Total	$181.3	$117.7						
Full-time Equivalents (FTE)								
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

Comments:

FY02

Project Number: 02630
Project Title: Planning for Long-Term Research & Monitoring Program
Agency: ADNR

FORM 3A
TRUSTEE
AGENCY
SUMMARY

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Personnel Costs:		GS/Range/	Months	Monthly		Proposed
Name	Position Description	Step	Budgeted	Costs	Overtime	FY 02
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		0.0	0.0	0.0	
					Personnel Total	$0.0

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	Fy 02
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.0

FY02

Project Number: 02630
Project Title: Planning for Long-Term Research & Monitoring Program
Agency: ADNR

FORM 3B
Personnel
& Travel
DETAIL

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

Contractual Costs:		Proposed
Description		FY 02
Applied Marine Sciences (Chief Scientist Bob Spies) to assist with modeling workshop and development of first GEM invitation, including working with habitat subcommittees (APPROVED AUGUST).		40.0
Applied Marine Sciences (Chief Scientist Bob Spies) to assist with revision of GEM Program Document, continued development of GEM invitation, review of operating procedures and policies, and initial STAC and subcommittee work.		70.0
When a non-trustee organization is used, the form 4A is required.	**Contractual Total**	$110.0
Commodities Costs:		Proposed
Description		FY 02
	Commodities Total	$0.0

FY02

Project Number: 02630
Project Title: Planning for Long-Term Research & Monitoring Program
Agency: ADNR

FORM 3B
Contractual & Commodities DETAIL

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET
October 1, 2001 - September 30, 2002

New Equipment Purchases:	Number	Unit	Proposed
Description	of Units	Price	FY 02
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
			0.0
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	$0.0

Existing Equipment Usage:	Number	Inventory
Description	of Units	Agency

FY02

Project Number: 02630
Project Title: Planning for Long-Term Research & Monitoring Program
Agency: ADNR

FORM 3B
Equipment
DETAIL

approved 12-11-01

Effectiveness Of Citizens' Environmental Monitoring Program

Project Number:	02667
Restoration Category:	Monitoring
Proposer:	Cook Inlet Keeper
Lead Trustee Agency:	ADEC
Cooperating Agencies:	
Alaska SeaLife Center:	No
Duration:	1st year, 1-year project
Cost FY 02:	$17,900
Cost FY 03:	
Geographic Area:	Cook Inlet basin
Injured Resource/Service:	This project takes an ecosystem approach towards monitoring and restoration and will result in direct and indirect benefits to all injured resources and lost or reduced services located in the Cook Inlet basin.

ABSTRACT

Cook Inlet Keeper will analyze five years of past data from the Keeper's Citizens' Environmental Monitoring Program (CEMP): the first consistent, credible, and coordinated community-based water quality monitoring program in Alaska. Keeper's Stream Ecologist will determine if sampling frequency, methods, parameters, and site selection are effective at meeting the monitoring objectives of detecting significant changes in water quality over time. The results will assist Cook Inlet Partners (Kenai Watershed Forum, Anchorage Waterways Council, Wasilla Soil and Water Conservation District) refine their community monitoring efforts and may lead to future community-based monitoring programs.

INTRODUCTION

Cook Inlet Keeper is requesting one year of funding from the EVOS Trustee Council through the Ecosystem Synthesis/GEM Transition: Community-Based Monitoring Programs. This project will analyze past data collections that will lead to more effective and scientifically defensible community monitoring efforts.

In 1996, Cook Inlet Keeper established its Citizens' Environmental Monitoring Program (CEMP) to actively involve citizens in collecting reliable water quality data in the Cook Inlet basin. With funding from Alaska's Department of Environmental Conservation and guidance from a Technical Advisory Committee, Keeper developed a Kachemak Bay Pilot Project as a working template that could be adopted by other groups interested in conducting citizen-based monitoring programs. The objectives of CEMP are to 1) inventory baseline water quality in the Cook Inlet basin, 2) detect and report significant changes and track water quality trends, and 3) raise public awareness of the importance of water quality through hands on involvement. Water quality parameters, data quality objectives, and site selection criteria were developed with a Technical Advisory Committee made up of professionals representing various federal, state, and local agencies and diverse scientific backgrounds.

In 1999, Keeper entered into an agreement with the Anchorage Waterways Council and the University of Alaska Anchorage's Environment & Natural Resources Institute to facilitate citizen-based water monitoring and assessment of the Anchorage Bowl. Keeper then entered into a similar agreement with the Wasilla Soil and Water Conservation District to begin monitoring in the Mat-Su Valley. As interest in CEMP continues to grow, there is a need to evaluate the effectiveness of the monitoring protocols and sampling design to meet the monitoring objectives. Keeper proposes to analyze five years of CEMP data to determine if sampling frequency, methods, parameters and site selection are effective at detecting significant change in water quality over time. These results will be useful to GEM when citizen-based monitoring programs are considered for funding in the future.

NEED FOR THE PROJECT

A. Statement of Problem

One of the biggest challenges to restore habitat and water quality following the *Exxon Valdez* oil spill has been the lack of adequate baseline data describing conditions before the spill. Since the oil spill, scientist have worked diligently to collect information describing recovery of species and habitats. But until recently there was no comprehensive long-term study to document water quality conditions in Southcentral Alaska. Baseline information provides a benchmark for measuring future changes in water quality and a basis for developing and implementing pollution prevention and best management practices.

As state and federal budgets for water quality monitoring continue to decline, citizens have stepped in to gauge the health of our public resources. Despite various philosophies on the environment, everyone agrees that clean water and healthy fisheries should be protected. Diverse stakeholders such as fishermen, landowners, outdoor enthusiasts, Alaska Natives, scientists, educators, families, conservationists, and decision makers are expressing a desire to better understand and protect our water resources. Cook Inlet Keeper is leading the way and providing citizens with the opportunity to expand our knowledge of the Cook Inlet watershed.

Since Cook Inlet Keeper established Alaska's first consistent, credible, and coordinated volunteer water quality monitoring program in 1996, other groups throughout Alaska have requested Keeper's assistance in establishing volunteer monitoring in their communities. Toward that end, Keeper has formally partnered with the Anchorage Waterways Council, Kenai Watershed Forum, and Wasilla Soil and Water Conservation District to train more than 200 volunteers throughout the Cook Inlet watershed to monitor more than 90 freshwater and estuarine sites. With five years of data collected, it is important to ensure that sampling frequency, methods, parameters, and site selection are effective at meeting the monitoring objectives of detecting significant changes in water quality over time.

B. Rationale/Link to Restoration

Developing a monitoring system to detect and recognize significant change is challenging because natural systems are inherently dynamic and spatially heterogeneous. Many changes are not a result of human activity and are reflective of natural variability. An important step of every monitoring program is determining if the project objectives can actually be attained by the methods, parameters, and analyses used. To determine if a monitoring program is successful at detecting real change and not just natural variability, the statistic power of the monitoring design needs to be assessed.

With five years of data collected, Keeper can now determine if the CEMP protocols influence data variability which can affect data interpretation. Improvements in sampling protocols can then be made to better represent water quality in the Cook Inlet basin. Determining the effectiveness of CEMP protocols will ensure that monitoring projects developed by current partners (Anchorage Waterways Council, Kenai Watershed Forum, and Wasilla Soil and Water Conservation District) as well as future citizen-based programs around the Gulf of Alaska will be successful in detecting changes in water quality over time.

C. Location

The Cook Inlet watershed was hit hard by the *Exxon Valdez* oil spill. The currents in the Gulf of Alaska caused oil to move up into Cook Inlet, along the Kenai Peninsula and back down the Alaska Peninsula, soaking much of the shoreline and ocean floor with crude oil. As a result, many of Cook Inlet's coastal resources, and the services which they support, were impacted.

Although some recovery has occurred, Cook Inlet's sensitive resources face ongoing threats from a host of unsustainable activities, including rapid filling of wetlands; additional oil spills from an aging oil and gas infrastructure; discharge of pollutants from industrial activities; and increased nonpoint runoff from population growth and sprawl. Approximately 400,000 people, nearly 2/3 of Alaska's population, live in the vast Cook Inlet watershed, and a population

increase of 600% over the past thirty years has substantially magnified pressures on Cook Inlet's sensitive resources.

Communities involved in and affected by Keeper's Citizen Environmental Monitoring Program include Wasilla, Anchorage, Kenai, Soldotna, Ninilchik, Anchor Point, Homer, Seldovia, Port Graham, Nanwalek, and others. Citizens throughout the Cook Inlet watershed will benefit from refinements or changes that are made to CEMP protocols based on the results of this project. Citizens in other Gulf of Alaska watersheds will benefit when future citizen-based monitoring programs are developed.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE

Because citizens are the true owners of public water resources, Keeper strives to involve them in hands on activities aimed at improving and protecting habitat and water quality and promoting resource stewardship. Citizen-based monitoring is a community-owned and community-driven effort. It is a highly effective way to bridge the gap between citizens and natural resource agencies. Citizens are directly involved in collecting and tracking water quality information, and have a greater sense of ownership of the monitoring findings.

Citizen monitoring is also an important way to integrate traditional environmental knowledge (TEK) with science. Many of the citizens who become involved in the monitoring efforts have a long history with their local regions. Keeper is set to begin working with Alaska Native organizations, including the Port Graham/Nanwalek Watershed Council and Ninilchik Traditional Council in citizen monitoring efforts. Keeper recognizes the powerful role that TEK can play to further water quality monitoring goals. Visual and other observations through narration, photographs and sketches may be one way to better incorporate TEK into citizen-based monitoring, and Keeper will continue to work to strengthen TEK components.

As part of citizen-based monitoring, participating communities have access to project information because they own and drive the project. Keeper compiles and presents all collected

water quality monitoring findings in a variety of ways. In addition to publishing formal reports with narrative, charts, graphs, GIS maps and photos, Keeper also publishes monitoring information in its bi-annual newsletter and on its web page. Keeper often incorporates photos and GIS maps of water quality monitoring sites in its reports, articles, and web page as visual tools to help citizens understand the monitoring efforts.

Keeper values community participation, and believes the best way to involve people is by traveling to communities to gain a better understanding of local needs and interests. In 1998, Keeper produced the *Cook Inlet GIS Atlas* on CD ROM which synthesizes more than 125 computer map layers of pollution, habitat, streams, and other information. Keeper worked with over 20 community-based groups to take the CD ROM to 13 Cook Inlet communities to give citizens a visual understanding of their local watersheds, and to share Keeper's GIS mapping and water quality monitoring information. Since that time, Keeper has had several groups from throughout Cook Inlet request information and services to assist them with their efforts to understand their local watersheds.

PROJECT DESIGN

A. Objectives

The overall objectives of CEMP are to 1) inventory baseline water quality in the Cook Inlet basin, 2) detect and report significant changes and track water quality trends, and 3) raise public awareness of the importance of water quality through hands on involvement. The proposed project has the following objectives:

1. Evaluate whether CEMP sampling frequency, sampling methods, water quality parameters, and site selection are effective at detecting significant changes in water quality over time.
2. Generate recommendations for improvements to CEMP protocols to better represent water quality in the Cook Inlet, which will lead to more effective and scientifically defensible community monitoring efforts.

B. Methods

Keeper staff will analyze five years of CEMP data using 1) descriptive statistics, graphs, and analysis of variance to determine variability within sites, between sites, and over time and 2) power analysis to determine the statistical power of the sampling program to detect change.

The CEMP database consists of data collected from 1996 to 2001 at a total of 89 sites (47 estuarine, 42 freshwater) in the Kachemak Bay watershed. Surface water samples are taken at all monitoring stations monthly between September and April and twice monthly from May through August for a total of 16 sampling events per site per year. Primary parameters (water temperature, turbidity, pH, salinity, and dissolved oxygen) are measured using standard EPA-approved procedures and/or methods which are in use by established citizen volunteer monitoring programs (e.g. Friends of Casco Bay's Citizens Water Quality Monitoring Program, Texas Watch's Volunteer Environmental Monitoring Program). Methods for additional parameters (apparent color, conductivity, nitrate-nitrogen, ortho-phosphate, fecal and total coliform bacteria) are taken from the "Volunteer Estuary/Lake/River/Stream Monitoring: A Method's Manual" published by U.S. EPA.

All data are reviewed by Keeper's Research Coordinator to ensure they meet program data quality objectives. The data quality objectives and quality assurance procedures for this program have been designed to identify and correct problems in data collection and reporting. Should the results of quality assurance reviews indicate that the integrity of data are questionable and data quality objectives are not being met, the data are flagged as unacceptable for inclusion in the CEMP database. None of the suspect data will be included in the proposed data analysis.

The null hypothesis for the CEMP is that there will be no significant mean difference in water quality parameters over time. For the CEMP data to be sufficiently powerful enough to test this, Keeper needs to determine if 1) sample size for baseline data is adequate, 2) precision of CEMP methods are adequate, and 3) temporal and geographic coverage is adequate. The robustness of the CEMP protocols to reject the null hypothesis will be analyzed with SPSS Base 10.1 for Windows and SamplePower 2.0 software.

Preliminary analysis will entail generating descriptive statistics and graphical presentations of the data from all sites. Descriptive statistics will include overall mean, standard deviation, and range and will be generated for each site for each water quality parameter. Outliers will be identified and interpreted. A temporal analysis using analysis of variance (ANOVA) will measure changes in water quality parameters over a variety of temporal scales (i.e. annual, seasonal, monthly) at each sampling site.

A power analysis, using sample size and standard deviations, will be performed for each parameter for each site. This analysis will determine what magnitude of change (i.e. effect size) the present sampling design can detect. If the effect size detectable is deemed too large, results from the power analysis will reveal what sample size and/or precision are needed to measure the desirable effect size. These results will provide insight into adequate sampling frequency as well as appropriate sampling methods and parameters.

In an effort to understand spatial trends in the data, sites will be grouped by location within the Kachemak Bay. Groupings could include freshwater vs. estuarine sites, north vs. south side-of-the-bay sites. ANOVA tests will be used to detect significant differences between sites and site groupings. These results will be valuable for determining if the geographic coverage of CEMP sites is adequate.

Correlation coefficients between parameters will be examined to see which water quality characteristics are related to each other. Correlations with ancillary data (i.e. precipitation, wind speed and direction, solar radiation) from Homer Airport's meteorological record will be explored.

Based on the results of the analysis, recommendations to improve the CEMP protocols will be proposed and presented to the CEMP Technical Advisory Committee. These improvements will be disseminated to the Cook Inlet partners in a project report. Keeper will also convene an annual water quality conference among current and potential monitoring partners and agencies to communicate findings from the analysis and to facilitate CEMP planning and development.

C. Cooperating Agencies, Contract, and Other Agency Assistance

Cook Inlet Keeper is the only organization requesting funds for this project.

SCHEDULE

A. Measurable Project Tasks for FY 02 (October 1, 2001 – September 30, 2002)

October 2001 – July 2002:	Analyze CEMP data to determine effectiveness of protocols
August– September 2002:	Production and release of project report which will include recommendations for improvements to CEMP protocols
Ongoing:	Work with new potential partners to help them develop credible monitoring programs. Potential new partners include: Port Graham/Nanwalek Watershed Council, Ninilchik Native Association, Eklutna Tribal Council, Native American Fish and Wildlife Society
December 2002:	Convene meeting with current and potential monitoring partners and agencies to communicate findings from analysis
March 2003:	Incorporate suggestions into the CEMP Quality Assurance Project Plan
April 15, 2003:	Submit final report to EVOS (FY02)

B. Project Milestones and Endpoints

The first project objective, which is completion of data analysis, will be complete by July 31, 2002. Production/release of analysis report, project objective #2, will be complete by September 30, 2002. Implementation of suggestions for refinement to CEMP protocols generated from analysis and agreed upon by the Technical Advisory Committee and partner groups will occur during FY 2003 and are not part of the proposed project objectives.

C. Completion Date

All of the project objectives will be met by the end of FY 2002. The final project report will be submitted to EVOS Trustee Council by April 15, 2003.

PUBLICATIONS AND REPORTS

In October 2001, Keeper will released "Cook Inlet Citizens' Environmental Monitoring Project Annual Water Quality Status Report" which will present five-years of water quality data collected by volunteers in the Kachemak Bay watershed. As with previous annual reports, the October 2001 report will be distributed to concerned citizens, agency personnel, tribal councils, and the press. Previous annual reports are available on the Keeper's web page at http://www.inletkeeper.org/cemp/cempd1.asp.

In September 2002, Keeper will release the proposed project report: "Evaluating the Effectiveness of Citizen's Environmental Monitoring Project", which will be distributed to current and potential partner groups, agencies, and concerned citizens.

PROFESSIONAL CONFERENCES

No travel funds beyond the Trustee Council's Annual Restoration Workshop are budgeted for FY 2002

NORMAL AGENCY MANAGEMENT

Not applicable.

COORDINATION AND INTEGRATION OF RESTORATION EFFORTS

Cook Inlet Keeper has a close relationship with many of the restoration efforts that have been funded by the Trustees Council. Most notably, Keeper shared its *Cook Inlet GIS Atlas* on CD ROM and Annotated Bibliography to assist the Kachemak Bay National Estuarine Research Reserve's Ecological Characterization Project, and the Cook Inlet Information Monitoring and Management Systems database project. Keeper is linked to the CIIMMS web page, and once its water quality database and interactive GIS maps become available on the Internet, they will be integrated with the CIIMMS database. The information Keeper shares with CIIMMS contributes greatly to a more holistic understanding of Cook Inlet's resources, pollution sources, and other conditions.

Keeper is working with Kachemak Bay National Estuarine Research Reserve to bring together citizen volunteer monitors and professional researchers to deploy a systematic array of electronic sensors along the south and north sides of Kachemak Bay, which will coincide with volunteer water quality monitoring sites, to assess water circulation patterns throughout the Bay. Keeper also collaborates with UAA's Kachemak Bay Campus which makes an in-kind contribution of lab space for water quality laboratory analysis.

Keeper cooperates with agencies that conduct water quality monitoring in the Cook Inlet basin. These agencies include: U.S. Geological Survey, Alaska Department of Environmental Conservation, U.S. Environmental Protection Agency, National Oceanic and Atmospheric Administration, Alaska Department of Fish and Game, Alaska Department of Natural Resources, and the Cook Inlet Regional Citizens Advisory Council. Representatives from each of these agencies participate as members of Keeper's TAC. Also, DNR's Division of Forestry invited Keeper to present its water quality information at a planning meeting to help it determine a need for monitoring forestry activities and impacts on the Kenai Peninsula, and the ADF&G has used Keeper's water quality reports to help guide their future plans for monitoring, so as not to duplicate existing efforts.

In addition to Trustees-funded Restoration Projects, Keeper collaborates with numerous other local and national groups and agencies. For example, Keeper is a partner in the Pratt Museum's Kachemak Bay Discovery Project, a member of the River Network and a member of the National Water Keeper Alliance. Keeper works closely with all monitoring efforts in Cook Inlet including those conducted by: the Anchorage Waterways Council, University of Alaska Anchorage's Environment and Natural Resources Institute, Wasilla and Homer Soil and Water Conservation Districts, Kenai Watershed Forum, Anchor Point Community Rivers Planning Coalition, Seldovia Oil Spill Response Team, and Port Graham/Nanwalek Watershed Council (memorandums of understanding attached). Keeper plans to include more partners in the future such as the Chickaloon Native Village, Ninilchik Traditional Council, Kenai National Wildlife Refuge, and more.

Cook Inlet Keeper's monitoring project has been funded through ADEC by EPA 319 nonpoint source grant money over the last three years, along with other sources to meet EPA's required 40% non-federal match. Keeper's other monitoring support has included grants from the Skaggs Foundation ($8,000 in 1999 and $5,000 in 2001), Norcross Wildlife Foundation ($10,000 in 1999 and $13,000 in 2001), River Network Watershed Assistance Grant ($20,000 in 1999), Bullitt Foundation ($10,000 in 2000), individuals and businesses (~$10,000/yr.) fees for GIS services (~$5,000/yr.), and in-kind contributions of time and services (~$25,000/yr.).

Keeper's monitoring budget for FY 02 is $205,313. Keeper anticipates a few more years of funding from EPA, including $105,000 in FY 02. Keeper will raise additional funding including grants, individuals, businesses and fees for services. Keeper currently has a grant pending with the U.S. Fish and Wildlife Foundation. Keeper is also exploring the feasibility of a business fundraising effort to solicit businesses to adopt monitoring sites for the cost of sampling equipment needed to monitor that site for one year.

Keeper is requesting $16,700 from EVOS for FY 02 to cover Keeper staff time and office supplies to perform the needed analysis, which will ensure the consistency and credibility of citizen-based monitoring in Alaska. Funding from EVOS will also help Keeper make citizen-collected data more useful to scientists and to make the data available for public access. This

project will provide agencies and the public with the information needed to better understand threats to, and solutions for coastal resources, and will lead to improved stewardship and coastal watershed and wildlife habitat protection in Alaska.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

Not applicable.

PROPOSED PRINCIPAL INVESTIGATOR IF KNOWN

Name:	Sue Mauger, Stream Ecologist
Affiliation:	Cook Inlet Keeper
Mailing Address:	PO Box 3269, Homer, Alaska 99603
Phone number:	(907) 235-4068
Fax number:	(907) 235-4069
E-mail Address:	sue@inletkeeper.org

PRINCIPAL INVESTIGATOR

Sue Mauger is the Stream Ecologist for the Lower Kenai Peninsula Watershed Health Project at Cook Inlet Keeper. Sue joins the staff in Homer after completing a Masters in Fisheries Science at Oregon State University. Sue also has a B.S. in Zoology from Duke University and worked in the Chesapeake Bay studying Blue Crabs and coordinated research projects for Earthwatch Institute in Massachusetts. Sue became director of the volunteer monitoring project for the Xerces Society in Portland, Oregon in 1994, working with high school students and local citizens to develop benthic invertebrate monitoring programs in watersheds along the Oregon coast.

OTHER KEY PERSONNEL

Joel Cooper, Research Coordinator

Joel joined Keeper's staff in 1998 to coordinate and oversee Keeper's citizen water quality monitoring program. Prior to joining Keeper, some of Joel's work experience included conducting stream surveys for the U.S. Forest Service, serving as an Organic Chemist for the Rocky Mountain Analytical Laboratory, and working as Environmental Scientist for the Southern Illinois University Department of Pollution Control. Joel holds a B.S. in Environmental Studies focusing on forestry, chemistry, plant and soil sciences from Southern Illinois University.

Mike Gracz, Geographic Information System (GIS) Specialist

Mike is a forest ecologist with degrees from State University of New York College of Environmental Science & Forestry (B.S.) and the University of Washington (M.S.). He has backgrounds in computer mapping technologies, forest disturbance ecology and botany. Prior to joining Keeper in 1997, Mike worked for the Kenai National Wildlife Refuge, Alaska Maritime National Wildlife Refuge, and Olympic National Park.

Carl Schoch, Kachemak Bay Science Coordinator, Oceanographer/Quantitative Ecologist

Carl Schoch is the science coordinator for the Kachemak Bay Research Reserve in Homer, Alaska (a NOAA NERR), and adjunct researcher at Oregon State University. He has a Ph.D. in Oceanography from the College of Oceanic and Atmospheric Sciences at Oregon State University. Carl will serve as the statistical advisor for this project.

approved 12-11-01

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel		$0.0
Travel		$0.0
Contractual		$16.7
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$16.7
General Administration		$1.2
Project Total	$0.0	$17.9
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS					
Estimated FY 2003					

Dollar amounts are shown in thousands of dollars.

Comments:

FY02

Prepared: 12/14/01

Project Number: 02667
Project Title: Effectiveness of Citizens' Environmental Monitoring Program
Agency: ADEC

FORM 3A
TRUSTEE
AGENCY
SUMMARY

EVOS Trustees Council
Budget Form
October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel		$11.0
Travel		$0.5
Contractual		$1.6
Commodities		$0.1
Equipment		$2.0
Subtotal		$15.2
Indirect		$1.52
Project Total		$16.7
Full-time Equivalents (FTE)		3.9
Other Funds		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2003					

Dollar amounts are shown in thousands of dollars.

Cook Inlet Keeper is requesting the full $16,700 for this one-year project from the EVOS Trustees Council.

FY 02

Prepared:
12-Apr-00

Project Number: 02667
Project Title: Effectiveness Of Citizens' Environmental Monitoring Program
Agency: Cook Inlet Keeper

FORM 4A
Non-Trustee
SUMMARY

Personnel Costs:	Months	Monthly		Prop

EVOS Trustees Council
Budget Form
October 1, 2001 - September 30, 2002

Personnel Costs:			Months Budgeted	Monthly Costs	Overtime	Proposed FY 2001
Name	Position Description					
S. Mauger	Stream Ecologist		3.0	2.8		8.4
J. Cooper	Research Coordinator		0.8	2.9		2.3
M. Gracz	GIS/Web Specialist		0.1	3.0		0.3
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
						0.0
	Subtotal		3.9	8.7	0.0	
					Personnel Total	$11.0

Travel Costs:	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 2001
Description					
1 - RT Homer to Anchorage - Annual Restoration Workshop	0.17	1	2	0.05	0.3
1 Rental Car - 2 days for Annual Restoration Workshop ($50/day)					0.1
Accommodation 2 nights - Annual Restoration Workshop ($50/day)					0.1
					0.0
					0.0
					0.0
					0.0
				Travel Total	$0.5

FY 02

Prepared:
12-Apr-00

Project Number:
Project Title: Effectiveness Of Citizens' Environmental Monitoring Program
Agency: Cook Inlet Keeper

FORM 4B
Personnel
& Travel
DETAIL

EVOS Trustees Council
Budget Form
October 1, 2001 - September 30, 2002

Contractual Costs:	
Description	Proposed FY 2001
Communications (phone, fax, email) with TAC, other monitoring groups, etc.	0.5
Postage	0.1
Printing/copying of final report	1.0
Contractual Total	**$1.6**

Commodities Costs:	
Description	Proposed FY 2001
Supplies	0.1
Commodities Total	**$0.1**

FY 02

Prepared:
12-Apr-00

Project Number:
Project Title: Effectiveness Of Citizens' Environmental Monitoring Program
Agency: Cook Inlet Keeper

FORM 4B
Contractual & Commodities DETAIL

EVOS Trustees Council
Budget Form
October 1, 2001 - September 30, 2002

New Equipment Purchases: Description	Number of Units	Unit Price	Proposed FY 2001
SPSS Base 10.1 Software for Windows	1	1.0	1.0
Sample Power 2.0	1	1.0	1.0
			0.0
			0.0
			0.0
			0.0
			0.0
Indicate replacement equipment with an R.		**New Equipment Total**	$2.0

Existing Equipment Usage: Description	Number of Units
19' patrol skiff	1
36' research vessel	1
Computers	8
Printers	2
GIS Map Plotter	1
Xerox machine	1
monitoring kits	41
monitoring meters	5

FY 01

Prepared:
12-Apr-00

Project Number:
Project Title: A Prototype Citizen-based Monitoring and Watershed Assessment
Agency: Cook Inlet Keeper

FORM 4B
Equipment
DETAIL

approved 12-11-01

Developing an Interactive Water Quality and Habitat Database and Making it Accessible on the Web

Project Number:	02668
Restoration Category:	Monitoring
Proposer:	Cook Inlet Keeper
Lead Trustee Agency:	Not Known
Cooperating Agencies:	Other database committee members include: Alaska Department of Environmental Conservation, UAA's Environment and Natural Resource Institute, Mat-Su Borough, Anchorage Waterways Council, Wasilla Soil and Water Conservation District, Homer Soil and Water Conservation District, and the Kenai Watershed Forum
Alaska SeaLife Center:	No
Duration:	1-year request for funding
Cost FY 02:	$16,100 (direct costs are $15,000 out of estimated $79,500 budget)
Geographic Area:	Cook Inlet basin
Injured Resources/Service:	This project will result in direct and indirect benefits to all injured resources and lost or reduced services located in the Cook Inlet basin.

ABSTRACT

The project partners have come together to form a database committee to create a consistent data management system where all citizen groups and agencies can equally share, report and review their water quality and habitat data. The committee's objective is to make data more accessible and more useful to decision makers, stakeholders, resource managers, and the public. The committee will uplink a shared interactive database on the Internet where it can be viewed and queried with GIS watershed maps, photos and graphs so that it is user-friendly, educational and meaningful. Access to this data will help facilitate a better understanding about threats to, and solutions for, water quality and habitat.

INTRODUCTION

Cook Inlet Keeper and its partner groups are requesting one year of funding from the Exxon Valdez Oil Spill Trustees Council through the Ecosystem Synthesis/GEM Transition: Improving accessibility of research results. This project will establish a unified water quality and habitat database and make it accessible on the Internet where it can be viewed and queried with GIS maps, photos and graphs in a user-friendly and meaningful way.

Cook Inlet Keeper was the first community-based group in Alaska to implement a credible Citizen Environmental Monitoring Program founded on U.S. Environmental Protection Agency- and Alaska Department of Environmental Conservation-approved methods. In 1996, Keeper convened a Technical Advisory Committee comprised of water quality professionals, and began to train volunteers to monitor water quality and habitat in and around Kachemak Bay. As part of its monitoring work, Keeper created Alaska's first EPA- and ADEC-approved Quality Assurance Project Plans and Volunteer Manual which assure scientific credibility of citizen-collected data.

As a result of its successes, Keeper has moved into a Quality Assurance Agent role to guide and support other Cook Inlet communities in their efforts to establish similar monitoring programs. Keeper works with the Kenai Watershed Forum to support citizen-based monitoring of the Kenai River, and with UAA's Environment and Natural Resource Institute, the Anchorage Waterways Council, and the Wasilla Soil and Water Conservation District through formal Memoranda of Understanding to facilitate volunteer monitoring in the Anchorage Bowl and the Mat-Su Valley. Keeper also networks with Anchor Point's Community Rivers Planning Coalition, Seldovia Oil Spill Response Team, Ninilchik Traditional Council, and Port Graham/Nanwalek Watershed Council on monitoring projects in Kachemak Bay and on lower Kenai Peninsula salmon streams.

In December 2000, Keeper organized the first annual full-day monitoring partner group meeting in Anchorage. The purpose of the meeting was to link current and potential monitoring groups and agencies together to coordinate efforts, build credibility, and exchange information and ideas. This meeting was well attended by over 26 professionals representing 14 different organizations and agencies including: Cook Inlet Keeper, Homer Soil and Water Conservation District, Anchorage Waterways Council, Kenai Watershed Forum, Wasilla Soil and Water Conservation District, Port Graham/Nanwalek Watershed Council, University of Alaska Anchorage's Environment and Natural Resource Institute, Alaska Department of Environmental Conservation's (ADEC) Nonpoint Source Program, U.S. Geological Survey (USGS), U.S. Fish and Wildlife Kenai National Wildlife Refuge, Environmental Protection Agency (EPA), *Exxon Valdez* Oil Spill Trustees Council, and Cook Inlet Information Management and Monitoring System. The meeting included discussions of quality control procedures, volunteer and equipment management, and data management and accessibility.

To tackle the questions of data management and accessibility, a database committee was formed composed of Cook Inlet Keeper, Alaska Department of Environmental Conservation, UAA's Environment and Natural Resource Institute, Mat-Su Borough, Anchorage Waterways Council, Wasilla and Homer Soil and Water Conservation Districts, and the Kenai Watershed Forum. The committee is working on the following three objectives: 1) create a consistent data management system where all citizen groups and agencies can equally share, report and review

their water quality and habitat data; 2) interface citizen-collected data with EPA's STORET to make it more useful to agencies; and 3) make habitat and water quality data accessible on the Internet in a user-friendly, interactive format with links to GIS watershed maps, photos and graphs.

All citizen-based monitoring groups in Cook Inlet will be using the same database, leading to the most complete and comprehensive water quality database in Alaska. By linking this information to the Internet, this project will provide agencies and the public with the information needed to make more informed decision on resource management and water quality and habitat protection in Alaska.

NEED FOR THE PROJECT

A. Statement of Problem

The Cook Inlet watershed was hit hard by the *Exxon Valdez* oil spill. The currents in the Gulf of Alaska caused oil to move up into Cook Inlet, along the Kenai Peninsula and back down the Alaska Peninsula, soaking much of the shoreline and ocean floor with crude oil. As a result, many of Cook Inlet's coastal resources, and the services which they support, were impacted.

Although some recovery has occurred, Cook Inlet's sensitive resources face ongoing threats from a host of unsustainable activities, including rapid filling of wetlands; additional oil spills from an aging oil and gas infrastructure; discharge of pollutants from industrial activities; and increased nonpoint runoff from population growth and sprawl. Approximately 400,000 people, nearly 2/3 of Alaska's population, live in the vast Cook Inlet watershed, and a population increase of 600% over the past thirty years has substantially magnified pressures on Cook Inlet's sensitive resources.

Because of the rapid changes taking place in Southcentral Alaska, it is essential that we invest in long-term monitoring now before further impacts have occurred. The baseline information collected from monitoring will provide a benchmark for measuring future changes in water quality and habitat, a basis for developing and implementing best management practices and pollution prevention techniques.

As state and federal budgets for monitoring continue to decline, agencies rely heavily on other sources of monitoring information. In recent years, citizens have stepped in to fill this important role to gauge the health of our viable yet stressed public resources. Since 1998, Cook Inlet Keeper has been working with other groups to collect water quality and habitat information for the Cook Inlet watershed. Keeper is now ready to synthesize this information and make it more accessible to agencies, decision makers and the public to help facilitate a greater understanding about threats to, and opportunities for, water quality and habitat.

B. Rationale/Link to Restoration

The Cook Inlet watershed supports a rich fabric of life, including sea otters, harbor seal, orca whales, several species of waterfowl, diverse intertidal and subtidal communities, and all five species of wild Pacific salmon. Healthy coastal resources are critical to the economic and social wellbeing of Cook Inlet communities. One of the challenges in the efforts to restore the environment following the *Exxon Valdez* oil spill has been the lack of adequate data describing conditions prior to the spill. It is essential that monitoring take place in Cook Inlet now, before more impacts are realized, so that reference conditions can be established from which to notice changes. Yet, state and federal agencies responsible for water quality monitoring are strapped by budget cuts, and unable to collect the water quality information needed to ensure compliance with state and federal water quality standards.

Citizens care about water quality and habitat, and want to participate in efforts to understand their watersheds. Several Cook Inlet communities have already begun to organize to protect local habitat and water quality. Many of these efforts, however, begin without knowing what resources are available, or what other groups are working toward similar goals.

By improving access to habitat and water quality information, this project will help improve our understanding of water quality and habitat, enhance watershed stewardship among citizens, and provide decision makers, agencies and communities with the tools they need to manage human uses and reduce pollution. As a result, this project will improve the rate of natural resource recovery in the Cook Inlet watershed and help prevent future harms from occurring.

C. Location

Keeper's Citizens' Environmental Monitoring Program takes place in the Cook Inlet basin, which covers 47,000 square miles of terrestrial, coastal and marine habitat in Southcentral Alaska. Communities involved in and affected by the project include Anchorage, Palmer, Wasilla, Kenai, Soldotna, Ninilchik, Anchor Point, Homer, Seldovia, Port Graham, and Nanwalek. Other communities which may play more of a role in the project in the future include: Talkeetna, Willow, Knik, Chickaloon, Eklutna, Eagle River, Girdwood, Cooper Landing, Nikiski, Tyonek and others. Although this project currently focuses within the geographic boundaries of the Cook Inlet watershed, the online, interactive database is being used as a prototype for the State and will eventually evolve into a clearinghouse for Alaska-wide water quality data.

COMMUNITY INVOLVEMENT AND TRADTIONAL KNOWLEDGE

Citizen-based monitoring is a community-owned and community-driven effort. It is a highly effective way to bridge the gap between citizens and natural resource agencies. Citizens are directly involved in collecting and tracking water quality information, and have a greater sense of ownership of the monitoring findings.

Citizen monitoring is also an important way to integrate traditional environmental knowledge (TEK) with science. Many of the citizens who become involved in the monitoring efforts have a long history with their local regions; and during that time, have observed environmental changes. Visual and other observations through narration, photographs and sketches are one way that TEK

is incorporated, and Keeper continues to strengthen TEK components of citizen-based monitoring.

This project will further community involvement in the Citizen Environmental Monitoring Program by providing communities with greater access to monitoring result and translating it in visual ways which are educational and meaningful. Audiences which may find particular use for monitoring data include community planners, local and Tribal governments, commercial and sport fishermen, university personnel and students, environmental consultants, decision makers, and resource agencies such as Alaska Department of Fish and Game, the U.S. Fish and Wildlife Service, U.S. Geological Service, and others. This project will create a database where citizen information, including Traditional Environmental Knowledge, is shared so that it can be compared to agency science, and help facilitate an exchange of information and ideas about habitat and water quality.

PROJECT DESIGN

A. Objectives

The overall goal of this project is to make data more accessible and more useful to decision makers, stakeholders, resource managers, and the public. The objectives include:

1) Create a consistent data management system where all citizen groups and agencies can equally share, report and review their water quality and habitat data;

2) Interface citizen-collected data with EPA's STORET to make it more useful to agencies; and

3) Make habitat and water quality data accessible on the Internet in a user-friendly, interactive format with links to GIS maps, photos and graphs.

B. Methods

The database committee has identified the following priorities for a consistent data management and reporting system:

1. move data in a simple and easy way;
2. make data available to the public on the Internet in an educational and meaningful way with links to charts, watershed maps and photos;
3. interface data with EPA's STORET water quality database so that it is more useful to scientists and resource managers;
4. allow for local groups to view their own data once it is entered;
5. create a way for local groups to compare their data with data from other citizen monitoring partners and with agencies;
6. allow local groups to view water quality data from any source which is relevant to their area of interest;
7. include database securities protocols that are appropriate for the web; and

8. allow for a database system which opens up a wider variety of water quality and habitat parameters and methods.

The committee has identified model programs for guidance. Specifically, the partners are looking at the IOWATER (www.iowater.net) program as an exciting prototype for its on-line interactive database. The partners also realize there are other existing systems of Alaska data that they can use to help build a unified database – those include: 1) Keeper's Access database which is used by Keeper, Kenai Watershed Forum, Wasilla Soil and Water Conservation District, and Anchorage Waterways Council; 2) CIIMMS database; 3) Mat-Su Borough Lake data which is under development; 4) ENRI's EDAS access database which is for professional-level aquatic macroinvertebrate data; 5) ENRI's Educational database which is purely educational and being developed for web application; 6) EPA's STORET which is the national water quality database clearinghouse for all EPA-funded projects; 7) USGS's NWIS for professional USGS-collected data; and 8) Anchorage Municipality Water quality database.

The database committee is considering two possible directions: 1) use, maintain and continue to develop Cook Inlet Keeper's Access database, and interface this data with Internet in ways that meet needs and interests of citizen-based groups and then export data from the Access database into STORET to meet research needs and goals; OR 2) enter data directly into STORET through an interface module and then extract the data for local needs through a data-download or through the EPA developed report application for uplink to the Internet with links to maps, graphs and photos.

ADEC is currently performing an analysis of the proposed STORET data sources with special attention to required STORET fields and rules. Simultaneously, ADEC is looking at other possible database scenarios. This analysis will be complete in early fall 2001, at which point the project partners will be well positioned to move forward with the project objectives. This timing will work nicely with the EVOS funding schedule.

In the fall of 2001, the partners will be ready to contract with a database specialist to help the committee implement the interface and output that best meets their database priorities and objectives. A $15,000 grant from the *Exxon Valdez Oil Spill* Trustees Council will provide the partners with the funds they need to make this essential data compilation and dissemination project a success. Support from the Trustees will result in the most coordinated, credible and consistent water quality data management system in Alaska where citizens and agencies can equally share, report and review water quality and habitat information.

Although this project currently focuses within the geographic boundaries of the Cook Inlet watershed, this database will be used as a prototype for the State and will eventually evolve into a clearinghouse for Alaska-wide volunteer-collected water quality and habitat data. This project will result in essential compilation and analysis of citizen-collected data, and make this information more accessible to agencies and the public. By improving access to monitoring results, this project will help improve our understanding of water quality and habitat, enhance watershed stewardship among citizens, and provide decision makers, agencies and communities with the tools they need to management and protect our natural resources.

C. Cooperating Agencies, Contracts and Other Agency Assistance

The database committee is composed of the various agencies and groups who participate in citizen-based monitoring and have a vested interested in getting a shared database on the Internet. These groups include:

Alaska Department of Environmental Conservation – ADEC is the primary funder of citizen-based monitoring programs in Alaska and is collaborating closely with monitoring groups to make their data more useful to agencies and more accessible to the public. ADEC is working with the committee to determine the best ways citizen-collected data can be interfaced with EPA's STORET, so that Alaska's data can be compared with water quality information from throughout the Nation. CIIMMS is working closely with ADEC in this role.

UAA's Environment and Natural Resource Institute: ENRI serves on the database committee and is working to link macroinvertebrate monitoring data to the database. This and other biological monitoring data are key to understanding habitat issues related to water quality.

Mat-Su Borough: The Borough coordinates a citizen-based Lake's Monitoring Program in the Mat-Su Valley. Currently there is little interface between lake monitoring and stream and estuarine monitoring. The Mat-Su Borough is working with the database committee to expand the parameters and the methods in the shared database so that it is compatible with lake monitoring.

Anchorage Waterways Council, Wasilla Soil and Water Conservation District, Homer Soil and Water Conservation District, and Kenai Watershed Forum: These four groups oversee community-based water quality monitoring efforts in their local areas, and currently share the same Quality Assurance protocols, methods and database. They are working with the database committee to determine ways to incorporate other methods and parameters in the database to make it more comprehensive of water quality and habitat information, and to link the database on the Internet to improve the exchange and review of data among and between the partner group.

Cook Inlet Keeper: Cook Inlet Keeper coordinates citizen-based monitoring on the lower Kenai Peninsula. Furthermore, Keeper serves as the Quality Assurance Agent to oversee the quality performance of other citizen-based monitoring efforts in the Cook Inlet watershed. Keeper has played a key role in pulling various citizen and agency groups together to facilitate the exchange of information and ideas and is taking a lead in facilitating the database committee in meeting its objective.

SCHEDULE

A. Measurable Project Tasks for FY 02 (October 1, 2001 – September 30, 2002)

October 1:	Contract with database and web specialist
October 15:	Determine best data system that allows for all parameters and methods and meets committee's database priorities

	and meets committee's database priorities
November 1:	Identify and create GIS maps and graphs to link with database
December 1:	Create interface between database, GIS and the Internet
January 14-23:	Attend annual restoration workshop
February 1:	Establish securities for database access on the web
March 1:	Formalize Standard Operative Procedures for quality oversight of database use and data management
May 1:	Uplink database on the web and conduct press and other outreach to key audiences to announce its availability
May 1:	Oversee use of the database by monitoring partner groups as a way to enter and manage their habitat and water quality data
July 1:	Evaluate product and plan accordingly
August 1:	Update and maintain web page
April 13, 2003:	Submit annual report

B. Project Milestones and Endpoints

Fulfillment of project objectives will be measured by the following milestones:

1. Database system in place where all citizen groups can equally share, report and review water quality data (May 2002)
2. Citizen-collected data uplinked to EPA's STORET (December 2001)
3. Interactive database accessible on the internet with links to maps, photos and graphs (July 2002)
4. Final Report on project to EVOS Trustees Council (April 15, 2003)

C. Completion Date

This database and Internet product will be complete by September 30, 2002. The final report for EVOS Trustees Council will be complete by April 15, 2003.

PUBLICATIONS AND REPORTS

In October 2001, Keeper will released "Cook Inlet Citizens' Environmental Monitoring Project Annual Water Quality Status Report" which will present five-years of water quality data collected by volunteers in the Kachemak Bay watershed. As with previous annual reports, the October 2001 report will be distributed to concerned citizens, agency personnel, tribal councils, and the press. Previous annual reports are available on the Keeper's web page at http://www.inletkeeper.org/cemp/cempd1.asp.

PROFESSIONAL CONFERENCES

Cook Inlet Keeper is not requesting any EVOS funds for professional conferences.

NORMAL AGENCY MANAGEMENT

Not applicable.

COORDINATION AND INTEGRATION OF RESTORATION EFFORTS

Cook Inlet Keeper has a close relationship with many of the restoration efforts that have been funded by the Trustees Council. Most notably, Keeper shared its *Cook Inlet GIS Atlas* on CD ROM and Annotated Bibliography to assist the Kachemak Bay National Estuarine Research Reserve's Ecological Characterization Project, and the Cook Inlet Information Monitoring and Management Systems database project. Keeper is linked to the CIIMMS web page, and once its water quality database and interactive GIS maps become available on the Internet, they will be integrated with the CIIMMS database. The information Keeper shares with CIIMMS contributes greatly to a more holistic understanding of Cook Inlet's resources, pollution sources, and other conditions.

Keeper is working with Kachemak Bay National Estuarine Research Reserve to bring together citizen volunteer monitors and professional researchers to deploy a systematic array of electronic sensors along the south and north sides of Kachemak Bay, which will coincide with volunteer water quality monitoring sites, to assess water circulation patterns throughout the Bay. Keeper also collaborates with UAA's Kachemak Bay Campus which makes an in-kind contribution of lab space for water quality laboratory analysis.

Keeper cooperates with agencies that conduct water quality monitoring in the Cook Inlet basin. These agencies include: U.S. Geological Survey, Alaska Department of Environmental Conservation, U.S. Environmental Protection Agency, National Oceanic and Atmospheric Administration, Alaska Department of Fish and Game, Alaska Department of Natural Resources, and the Cook Inlet Regional Citizens Advisory Council. Representatives from each of these agencies participate as members of Keeper's TAC.

In addition to Trustees-funded Restoration Projects, Keeper collaborates with numerous other local and national groups and agencies. For example, Keeper is a partner in the Pratt Museum's Kachemak Bay Discovery Project, a member of the River Network and a member of the National Water Keeper Alliance.

Cook Inlet Keeper's monitoring project has been funded through ADEC by EPA 319 nonpoint source grant money over the last three years, along with other sources to meet EPA's required 40% non-federal match. Keeper's other monitoring support has included grants from the Skaggs Foundation ($8,000 in 1999 and $5,000 in 2001), Norcross Wildlife Foundation ($10,000 in 1999 and $13,000 in 2001), River Network Watershed Assistance Grant ($20,000 in 1999), Bullitt Foundation ($10,000 in 2000), individuals and businesses (~$10,000/yr.) fees for GIS services (~$5,000/yr.), and in-kind contributions of time and services (~$25,000/yr.).

Keeper's monitoring budget for FY 02 is $205,313. Keeper anticipates a few more years of funding from EPA, including $105,000 in FY 02. Keeper will raise additional funding from other grants, individuals, businesses and fees for services.

Funding from EVOS will help Keeper make citizen-collected data more useful to scientists and to make the data readily accessible to decision makers, stakeholders, resource managers, and the public. This project will provide agencies and the public with the information needed to better understand threats to, and solutions for coastal resources, and will lead to improved stewardship and coastal watershed and wildlife habitat protection in Alaska.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

Not applicable.

PROPOSED PRINCIPAL INVESTIGATOR IF KNOWN

Name:	Joel Cooper, Research Coordinator
Affiliation:	Cook Inlet Keeper
Mailing Address:	PO Box 3269, Homer, Alaska 99603
Phone number:	(907) 235-4068
Fax number:	(907) 235-4069
E-mail Address:	joel@inletkeeper.org

PRINCIPAL INVESTIGATOR

Joel joined Cook Inlet Keeper's staff in 1998 to implement a professional-level monitoring program on lower Kenai Peninsula Salmon Streams. Later that year, Joel moved to Keeper's Citizens' Environmental Monitoring Program to coordinate and oversee citizen water quality monitoring in Kachemak Bay. Prior to joining Keeper, some of Joel's work experience included conducting stream surveys for the U.S. Forest Service, serving as an Organic Chemist for the Rocky Mountain Analytical Laboratory, and working as Environmental Scientist for the Southern Illinois University Department of Pollution Control. Joel has a B.S. in Environmental Studies focusing on forestry, plant and soil sciences from Southern Illinois University, and considerable sampling and monitoring experience with the U.S. Fish & Wildlife Service, National Park Service and the U.S. Forest Service.

OTHER KEY PERSONNEL

Jeff Hock, Database Chief – Alaska Department of Environmental Conservation
Russell Kunibe, Analyst Programmer – Alaska Department of Environmental Conservation
Elaine Major, Research Associate – UAA's Environment and Natural Resource Institute
Harry Banks, Program Analyst – Mat-Su Borough Planning Department
Dan Bogan, Volunteer Coordinator – Anchorage Waterways Council
Laura Eldred, Program Director – Wasilla Soil and Water Conservation District
Robert Ruffner, Program Director – Kenai Watershed Forum
Shirley Schollenberg, Program Director – Homer Soil and Water Conservation District

ATTACHMENTS

(one copy each)

Database Committee List

Approved 12-11-C

FY 02 *EXXON VALDEZ* TRUSTEE COUNCIL PROJECT BUDGET

October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel		$0.0
Travel		$0.0
Contractual		$15.0
Commodities		$0.0
Equipment		$0.0
Subtotal	$0.0	$15.0
General Administration		$1.1
Project Total	$0.0	$16.1
Full-time Equivalents (FTE)		0.0
Other Resources		

LONG RANGE FUNDING REQUIREMENTS

Estimated FY 2003					

Dollar amounts are shown in thousands of dollars.

Comments:

NOTE: Trustee Council funds will be a contribution to the $79,500 project cost outlined on the following pages.

FY02

Prepared: 4/12/01

Project Number: 02668
Project Title: Developing an Interactive Water Quality and Habitat Database & Making it Accessible on the Web
Agency: ADEC

FORM 3A
TRUSTEE
AGENCY
SUMMARY

4-026

EVOS Trustees Council
Budget Form
October 1, 2001 - September 30, 2002

Budget Category:	Authorized FY 2001	Proposed FY 2002
Personnel		$19.2
Travel		$0.9
Contractual		$42.1
Commodities		$0.1
Equipment		$10.0
Subtotal		$72.3
Indirect		$7.23
Project Total		$79.5
Full-time Equivalents (FTE)		6.0
Other Funds		$64.5

LONG RANGE FUNDING REQUIREMENTS					
Estimated FY 2003					

Dollar amounts are shown in thousands of dollars.

The project partners are requesting $15,000 from the Exxon Valdez Oil Spill Trustees Council. The additional $64,500 has already been secured as either in-kind or monetary match. The match includes: 16,700 of personnel which is primarily the time of committee members valued at $20/hour X 80 hours/member; 400 in travel to database committee meetings; 32,100 in contractual which includes ADEC contract to perform an analysis of STORET and the partners' contract for a database/web specialist to fulfill the project objectives; 10,000 in equipment for any necessary computer software; and 5,330 in administrative costs. The partners are requesting the following from EVOS: 2,500 in personnel to oversee committee and contracts; 500 in travel for EVOS annual workshop; 10,000 for contract to database/web specialist; 100 for supplies and 1,900 for administrative overhead.

FY 02

Project Number: 02668
Project Title: Developing an Interactive Water Quality and Habitat Database and Making it Accessible on the Web
Agency: Cook Inlet Keeper

FORM 4A Non Trustee SUMMARY

Prepared:
12-/ 00

EVOS Trustees Council
Budget Form
October 1, 2001 - September 30, 2002

Personnel Costs:			Months	Monthly		Proposed
Name	Position Description		Budgeted	Costs	Overtime	FY 2001
J. Cooper - Keeper	Research Coordinator		1.0	3.2		3.2
J. Hock - ADEC	Database Chief		0.5	3.2		1.6
R. Kunibe - ADEC	Analyst Programmer		1.0	3.2		3.2
C. Fries - CIIMMS	Director		0.5	3.2		1.6
E. Major - ENRI	Research Associate		0.5	3.2		1.6
H. Banks - M-S Borough	Planning Department		0.5	3.2		1.6
D. Bogan - AWC	Monitoring Coordinator		0.5	3.2		1.6
L. Eldred - WSWCD	Program Director		0.5	3.2		1.6
R.Ruffner- KWF	Program Director		0.5	3.2		1.6
S. Schollenberg - HSWCD	Program Director		0.5	3.2		1.6
						0.0
						0.0
		Subtotal	6.0	32.0	0.0	
					Personnel Total	$19.2

Travel Costs:	Ticket	Round	Total	Daily	Proposed
Description	Price	Trips	Days	Per Diem	FY 2001
1 - RT Homer to Anchorage - Annual Restoration Workshop	0.17	1	2	0.05	0.3
1 Rental Car - 2 days for Annual Restoration Workshop ($50/day)					0.1
Accommodation 2 nights - Annual Restoration Workshop ($50/day)					0.1
1 - RT Homer to Anchorage for database committee meeting	0.17	1	1	0.05	0.2
1 - RT Kenai to Anchorage for database committee meeting	0.12	1	1	0.05	0.2
					0.0
					0.0
				Travel Total	$0.9

FY 02

Prepared:
12-Apr-00

Project Number:
Project Title: Developing an Interactive Water Quality and Habitat Database and Making it Accessible on the Web
Agency: Cook Inlet Keeper

FORM 4B
Personnel
& Travel
DETAIL

EVOS Trustees Council
Budget Form
October 1, 2001 - September 30, 2002

Contractual Costs:	Proposed
Description	FY 2001
Teleconferences for database committee	1.5
Other Communications (phone, fax, email)	0.1
Contract for database design, interface with GIS and web, and interface with STORET	40.5
Contractual Total	$42.1

Commodities Costs:	Proposed
Description	FY 2001
Supplies	0.1
Commodities Total	$0.1

FY 02

Prepared:
12-Apr-00

Project Number:
Project Title: Developing an Interactive Water Quality and Habitat Database and Making it Accessible on the Web
Agency: Cook Inlet Keeper

FORM 4B
Contractual & Commodities
DETAIL

EVOS Trustees Council
Budget Form
October 1, 2001 - September 30, 2002

New Equipment Purchases:	Number of Units	Unit Price	Proposed FY 2001
Description			
Internet/Database/GIS interfacing software like Internet Map Server	1	10.0	10.0
			0.0
			0.0
			0.0
			0.0
			0.0
Indicate replacement equipment with an R.		**New Equipment Total**	$10.0

Existing Equipment Usage:	Number of Units	
Description		

FY 01

Project Number:
Project Title: Developing an Interactive Water Quality and Habitat Database and Making it Accessible on the Web
Agency: Cook Inlet Keeper

FORM 4B
Equipment
DETAIL

Prepared:
12-Apr-00