Approved TC 12-11-01
with attached amendment

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

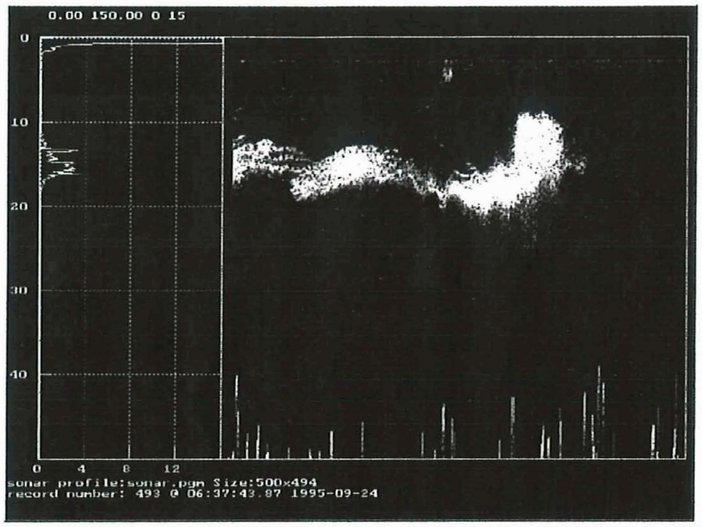
Biological assessment and ecological study of marine pelagic resources pose severe challenges from high cost and logistical difficulty to an inability to adequately address issues of spatial and temporal scale. Ship surveys in Alaska are severely limited by storm activity, are extremely costly, and research 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.



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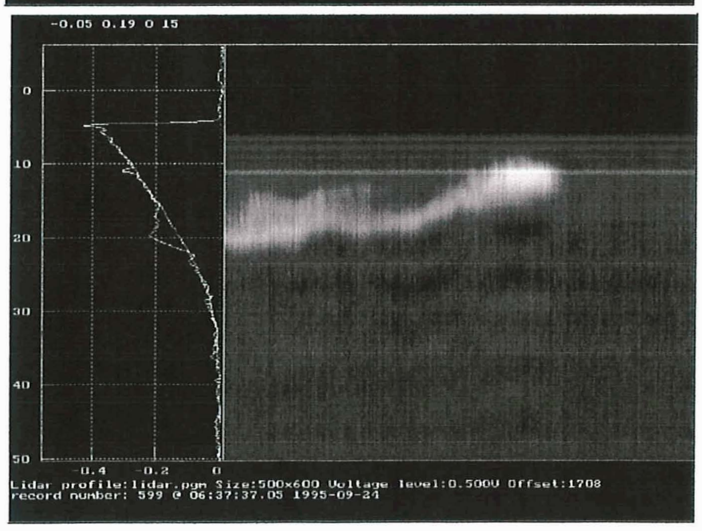
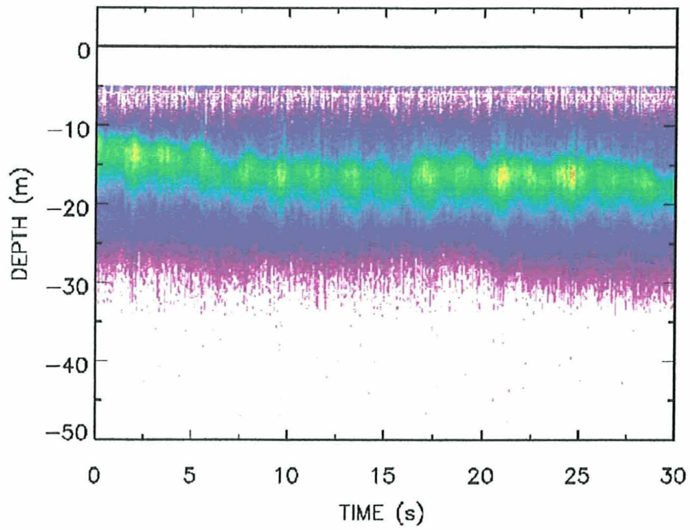


Figure 1. A comparison of signal reflection from a school of anchovy by shipboard acoustics (A) and by lidar (B; post-processed image). The images were collected synoptically (Churnside et al. 1997; http://www1.etl.noaa.gov/lidar/index.html).

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).



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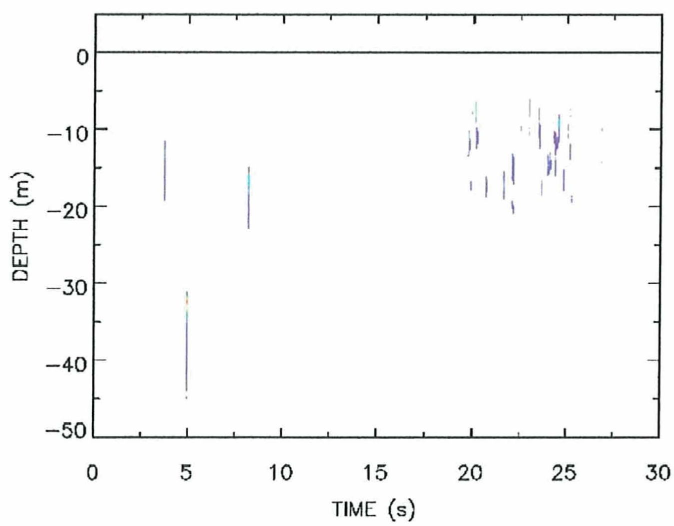

B.

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.

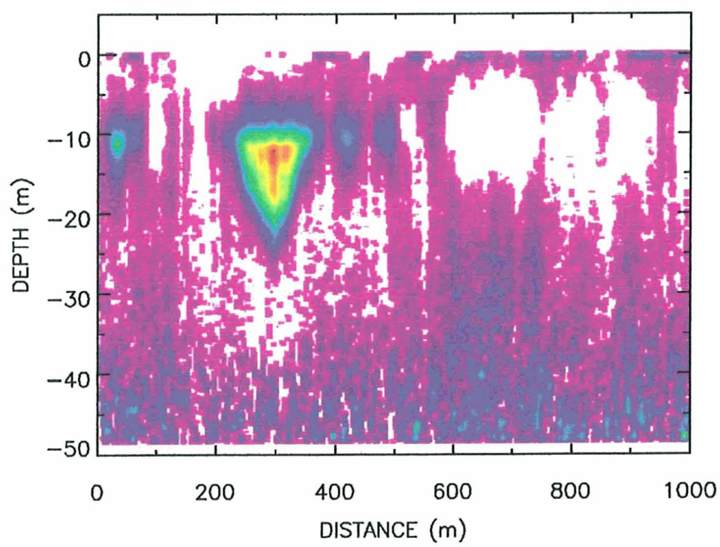

Figure 5. A raw data file output (displayed by shot number or distance with the background signal removed) of a fish schools in the Gulf of Alaska (attenuation depth here was approximately 40 m).

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.

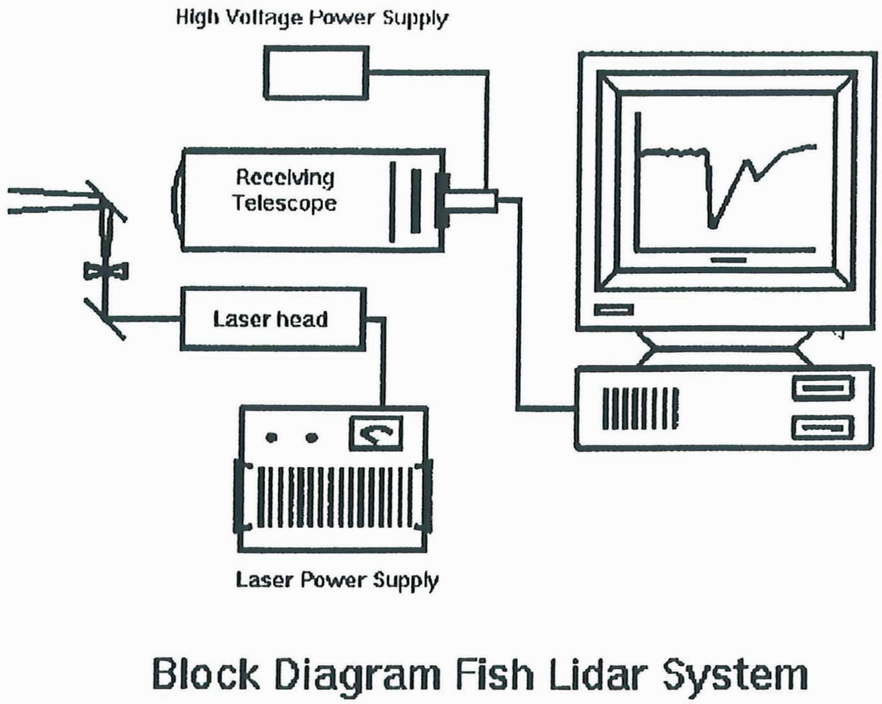

Figure 8.Block diagram for the lidar system

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.

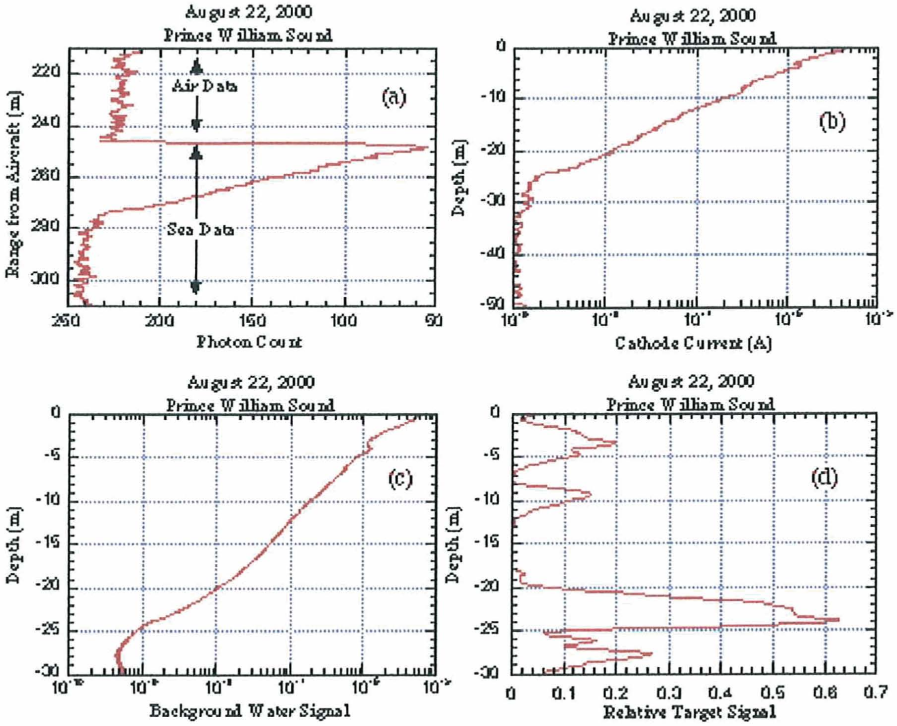

Figure 9. Fish lidar data from 22 August 2000. See text for details.

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.

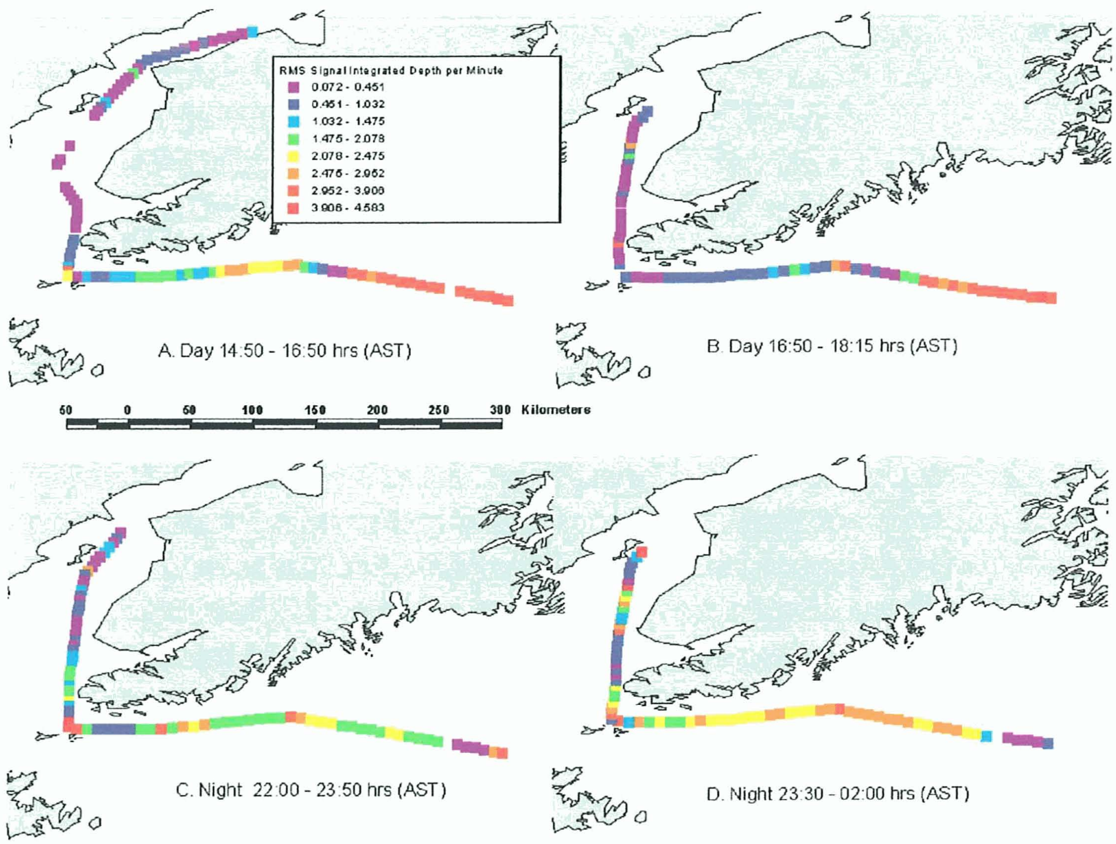

Figure 10. A view of the meta data or file summary along a single survey near the lower Cook Inlet and Outer Kenai coast. Each square is a single file representing about 4.5 km and the Root Mean Square signal integrated over all depths and shots is show as 10^{-4} volts. The left and right hand figures 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.

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 7-6-01
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 FY 2003					
General Administration	$0.0	$5.8						
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		$10.5						
Travel		$2.8						
Contractual		$0.0						
Commodities		$0.1						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$13.4	Estimated FY 2003					
General Administration		$1.6						
Project Total	$0.0	$15.0	$40.0					
Full-time Equivalents (FTE)		0.1						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

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

Commodities Costs:	Proposed
Description	FY 2002
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
			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						
Personnel		$0.0						
Travel		$0.0						
Contractual		$59.4						
Commodities		$0.0						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$59.4	Estimated FY 2003					
General Administration		$4.2						
Project Total	$0.0	$63.6	$240.0					
Full-time Equivalents (FTE)		0.2						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

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		$18.1
Travel		$4.1
Contractual		$25.2
Commodities		$0.1
Equipment		$0.0
Subtotal	$0.0	$47.5
Indirect		$11.9
Project Total	$0.0	$59.4
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 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:

Name	Position Description	Months Budgeted	Monthly Costs	Overtime	Proposed FY 2002
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
					0.0
	Subtotal	2.8	13.1	0.0	
				Personnel Total	$18.1

Travel Costs:

Description	Ticket Price	Round Trips	Total Days	Daily Per Diem	Proposed FY 2002
Field testing R/T Fairbanks-Anchorage	0.5	2	10	0.1	2.0
(Brown)					0.0
EVOS workshop and research planning (Fairbanks-Anchorage)	3.0	1	4	0.2	0.9
(Brown)					0.0
Scientific Meeting (GLOBEC/PICES)	0.6	1	4	0.2	1.2
(Brown)					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: Description	Proposed FY 2002
communications	0.1
Aerial Survey Contract (aircraft and imaging services)	25.0
Copy/Reproduction	0.1
Contractual Total	$25.2

Commodities Costs: Description	Proposed FY 2002
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
			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