Evaluation of Airborne Remote Sensing Tools for Gulf Ecosystem Monitoring and Research (GEM) Monitoring

Project Number:	030584
Restoration Category:	Monitoring; GEM Transition
Proposer:	P.I., Evelyn D. Brown, University of Alaska Fairbanks (UAF) School of Fisheries and Ocean Sciences Co-P.I. James H. Churnside, National Oceanic and Atmospheric Administration (NOAA) Environmental Technology Laboratory (ETL), Boulder, CO
Lead Trustee Agency:	Alaska Department of Fish & Game (ADF&G)
Cooperating Agency:	NOAA
Alaska Sea Life Center:	No
Duration:	2nd year of proposed 3-year project; reduced to 2 years total
Cost FY 03:	$39,300
Geographic Area:	Prince William Sound and Northern Gulf of Alaska
Injured Resources:	Potential survey species include sea birds (common murre, marbled murrelet, pigeon guillemot) and fish (Pacific herring, pink salmon, sockeye salmon)

ABSTRACT

This is the year-two completion phase for a project initiated in FY02 with data collection from July 2002. The main objective is an evaluation of airborne remote sensing tools for GEM ecological interpretation of the data collected. The instrument package consists of: 1) a pulsed lidar to map subsurface features to a maximum of 50 m; 2) an infrared radiometer to map Sea Surface Temperature (SST) day; 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 remotely sensed data.

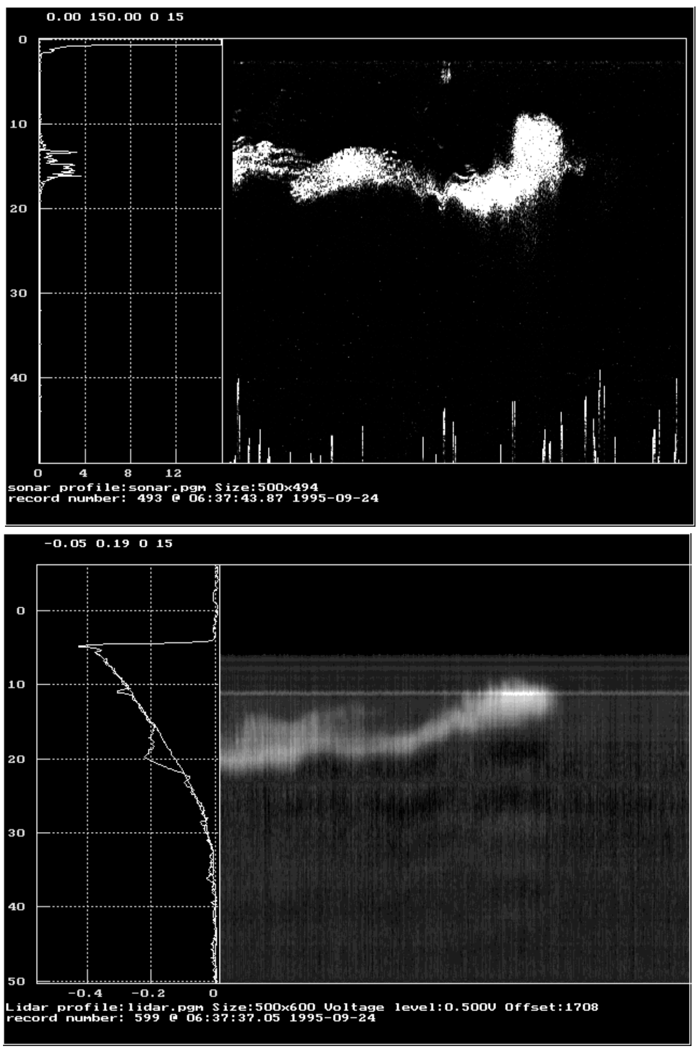
INTRODUCTION (duplication of FY02 proposal)

Biological assessment and ecological study of marine pelagic resources poses 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, high cost, overbooking, and year-in-advance scheduling. In addition, ships and acoustics have depth limitations that miss shallow, nearshore regions and 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 the 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 solve some of these problems, but frequent cloud cover is a problem in Alaska. All of these issues can be addressed by using increasingly high-speed, cost-effective data collection tools that can document structure in real time, without disturbance, and that can be used to supplement satellite data on cloudy days; i.e. airborne remote sensing and visual survey methods.

Airborne remote sensing and visual survey methods cost less than 10% of a ship survey per survey kilometer and depth penetration has been improved to more than three times the visual range with the use of lidar (described here). The synoptic views that 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 images 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). Airborne remote sensing shows particular promise for the field of marine ecology in determining predator-prey relationships, capturing ephemeral biological events, and defining spatial and temporal scale. The accuracy of remotely 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, reflects off fish and particles in the water, and returns 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 with other instruments on a single platform, 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 remotely 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 have been very encouraging (Figure 1).

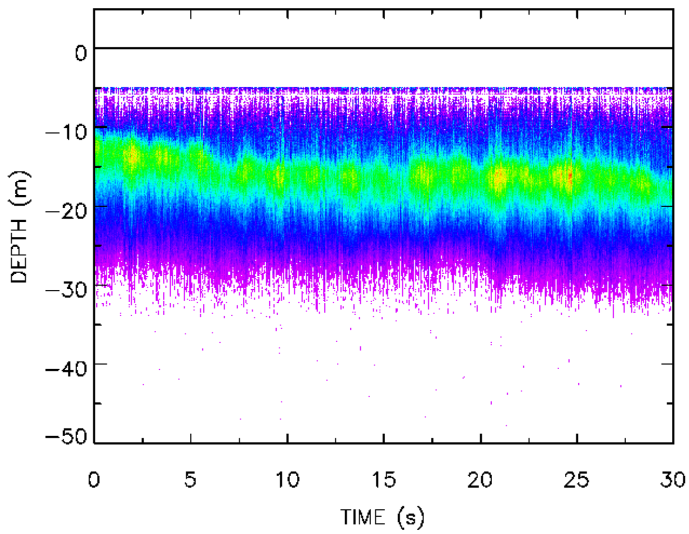


A.

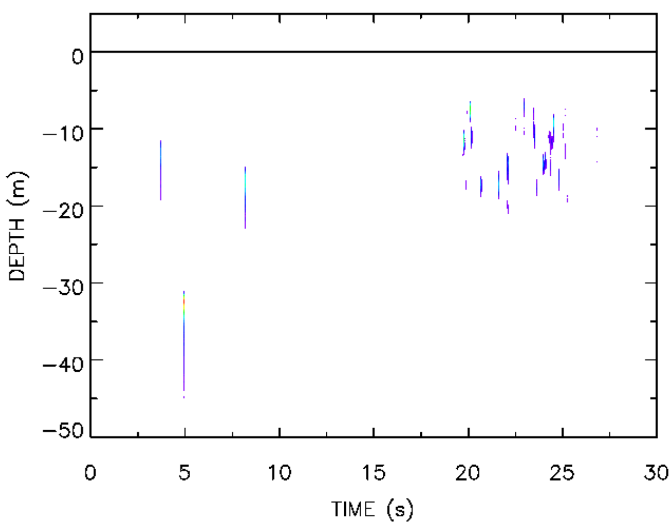
B.

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.

In the summer of 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 ten 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 ten-degree angle from a camera port and window port in a twin-engine aircraft (Figures 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 Geographical Information System (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.

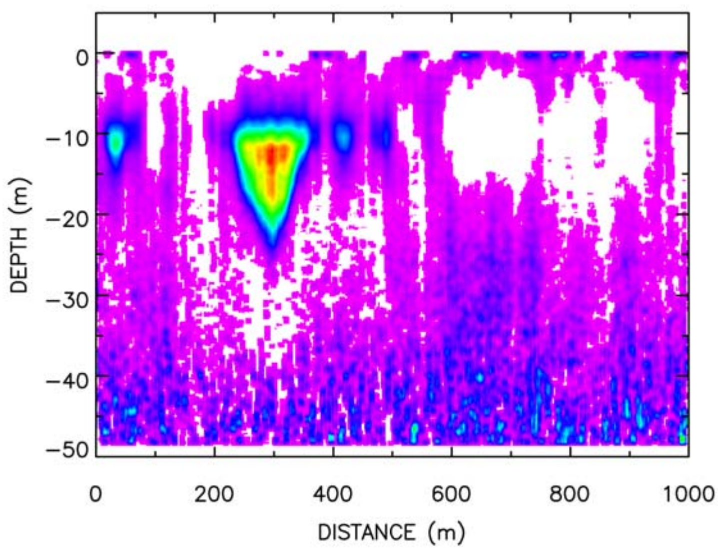


Figure 5. A raw data file output (displayed by shot number or distance with the background signal removed) of a school of fish in the Gulf of Alaska (attenuation depth here was approximately 40 m).

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 North Pacific Marine Research program (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 shipboard 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 time 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 originally provided for FY03.

As part of the evaluation, we will fuse the data from the various instruments, add shipboard 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 zooplankton 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.

NEED FOR THE PROJECT

A. Statement of Problem (duplication from FY02 proposal)

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 those of 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. Human activities in the areas also will be surveyed.

B. Rationale/Link to Restoration (duplication from FY02 proposal)

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 (revised from FY02 proposal)

In 2002 at the EVOS Workshop, we developed a cooperative working agreement with the Sea Life Center and the GLOBEC program, both conducting research in the Northern Gulf of Alaska. We decided to perform the aerial evaluation within the Chiswell Island sea lion foraging region south of Resurrection Bay and over the GLOBEC Long-Term Ecological Research (LTER) monitoring stations overlapping and east of the Chiswell area. This survey will take place in July 2002 and will complement similar surveys that we are conducting in S.E. Alaska, Kodiak, and the Aleutian Chain funded from other sources. Therefore, the results from this study can be combined with those from the other areas for a comparison of ecological features over a broad range in the Gulf of Alaska. The choice of survey location was based on this potential for a broad scale comparison of areas. In addition, we have the opportunity to compare between years since we collected data in 2000 over the same GLOBEC sites.

COMMUNITY INVOLVEMENT AND TRADITIONAL KNOWLEDGE (duplication of FY02 proposal)

There will be very little physical or direct interaction with spill community residents because we will 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 two or three 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 (revised from FY02 proposal)

The objectives for this project, established in 2002, are:

1. Using remote sensing instrumentation, sample waters in the Gulf of Alaska and Prince William Sound 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.

An additional objective, not covered by this study but included in complementary studies being conducted over the same time period, will be:

7. Compare indices of production, including ocean color, relative density, and size of patches of zooplankton and fish aggregations, sea bird and mammal occurrence, scale of foraging patches, and SST, at four areas in the Gulf of Alaska (Northern S.E. Alaska, Prince William Sound-Northern Gulf of Alaska, Kodiak, and the Aleutians) over two time periods (May and July).

8. Compare the information collected in 2002 in the Northern Gulf of Alaska with that collected in 2000 in the same region (GLOBEC LTER sites) and the same time period (late summer).

B. Methods (revised from FY02 proposal)

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 to a maximum of 50 m, 2) a gated, high resolution, high speed B/W video to image features illuminated by the lidar at specified depths, 3) an infrared radiometer to map SST day (analogous to AVHRR satellite data), 4) a high resolution RGB imager to map ocean color (chlorophyll), ocean fronts, near-surface fish schools, and seabird or mammal aggregations, 5) a thermal Infrared high resolution imager for mapping sea surface thermal patterns and locations of birds and mammals at night. The instruments are deployed to maximum overlap of captured area on the surface. Instrument settings and use vary from day to night. During the day, all five instruments are deployed. During the night, only the Red-Green-Blue (RGB) imager is shut off.

The components and settings of the FLOE lidar system are described in detail by Churnside *et al.* (2001a) and summarized here. The FLOE system is a non-scanning, radiometric lidar with three major components: 1) the laser and beam-control optics, 2) the receiver optics and detector, and 3) the data collection and display computer. The laser is linearly polarized and the beam diverged, using a lens in front of the laser, to meet eye safety standards established for marine mammals (Zorn, *et al.*, 2000). During the day, a narrow divergence filter is used compared to the nighttime filter, which is three times wider. The narrow filter minimizes the amount of background light entering the receiver but effectively limits the penetration depth of laser light. (Gordon, 1982). A polarizer in front of the telescope selects the cross-polarized component of the reflected light thus maximizing contrast between fish and smaller light-scattering particles (Churnside, et al., 1997; Lewis, et al., 1999). The telescope collects the light onto an interference filter to reject background light. As with the divergence filter, a narrow interference filter is used during the day and a wider one at night. An aperture at the focus of the primary lens also limits background light by limiting the field of view of the telescope to match the divergence of the transmitted laser beam. The resulting light is incident on a photomultiplier tube (pmt), which converts the light into an electrical current. For the nighttime receiver, the active area of the pmt is the field-stop aperture. During the day, separate aperture is used, and the light is transferred to the pmt by a second lens. The combination of divergence lens size, field of view setting, interference filter width, and altitude flown in 2000 determined the spot diameter or sampling swath at 5 m during the day and 15 m at night. The pmt output is passed through a logarithmic amplifier to increase the dynamic range of the signal. A 50-Ohm load resistor converts the current into a voltage, which can be digitized in the computer.

A new feature in the lidar system will be a gated video camera. This camera allows snap-shots of lidar returns at specified depth levels in 0.1 m increments. This will allow a more detailed examination of optical targets within a given data bin (5–7 m by 0.1 m). Military applications of airborne lidar have used this technology, along with shape recognition software, to locate sub-surface mines as small as a dinner plate. For our purposes, images from this video will allow us to allocate signal data between large and small objects (e.g. fish within a zooplankton layer or predators within a fish school). Processing of this data is intensive and we will, therefore, selectively sample desired mixed species layers.

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 receives infrared emissions from the ocean surface. It monitors thermal emissions near the wavelength of 11 microns and the Infrared brightness temperature is approximately equal to the physical temperature of the ocean surface. The Infrared brightness temperature is calibrated in the laboratory prior to and following field data collection.

A high resolution, RGB imager will be used for capturing images used to produce ocean color data as well as sea bird and marine mammal counts and spatial configurations. The image swath width was altitude- and focal length-dependent ranging from 150–200 m at 305 m in altitude with a pixel resolution of approximately 6 cm. The imager is set up to capture the blue, green, red, and near infrared bands. Both an analog output and digital output are recorded. The analog output is recorded onto digital tape at 7.5 fps during the course of the flight. Global Positioning System (GPS) information was recorded onto one of the available sound tracks and later retrieved through post-process to create a dbf file of GPS points along the flight track. The digital signal is captured via a frame grabber at a pre-determined distance along the flight track. In this case, we captured an image every 1000 meters. These images were then batch processed to create a database file of RGB color values for each image at its given location. From this database file the following algorithm was run that gave us a value of green for each image:

$$V_n = G_{(An)}/G_{(An)}+R_{(An)}+B_{(An)}$$

Where:

V_n is calculated green value for n^{th} image in the set of images
G is the mean green value of the histogram of A_n
B is the mean blue value of the histogram of A_n
R is the mean red value of the histogram of A_n
A_n is an area of interest centered on the n^{th} image in order to mask the outer pixels to keep them from being included in the calculation. This was done in order to eliminate a vignetting effect from the lens and camera port.

The thermal imager captures images of features emitting heat in the mid-Infrared range. This camera is linked to the same control system as the RGB imager but records to a separate digital tape. Intricate thermal patterns on the ocean surface as well as heat emitted from sea bird beaks, whale exhalations, and other marine mammals are captured in the images. We are building a validation and identification index of thermal signatures during separately funded work in Kodiak in cooperation with our research partners there.

We will base our flight plan around the July GLOBEC LTER survey in the Northern Gulf of Alaska and the acoustic forage fish target strength survey conducted within the Chiswell Island sea lion colony foraging region (about 20 n mi radius around the Island). We will coordinate flights to overlap ship transecting in the same regions. 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 shipboard data to obtain sub-surface oceanographic structure (especially salinity, pycnoclines, location/size of fronts, and information of stratification) used to ecologically frame our spatial observations.

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.

Lidar files are large, representing an array with 1000 depth bins of 0.1m extent multiplied by 2000 shot returns. The laser pulsed light 30 times s^{-1} and a file contains 66 s of data representing about 4.5–5 km explored distance (airspeed dependent). A typical flight can acquire several hours of data yielding approximately 150–200 data files. Files are first corrected by the surface echo and then the median return per bin; slope of background backscatter was estimated in order to calculate signal over noise. The backscatter signals are normalized to the background backscatter or median backscatter for comparison with other bins. The background signal, the total received averaged signal (root-mean-square averaged; RMS), and the median signal were often plotted geographically to aid in batch processing using geo-referenced notes or auxiliary data collected during a survey.

A threshold depth below which meaningful signals cannot be discriminated from noise determines penetration depth. Because light attenuates in the water column, the return signal is weaker with increasing depths and, therefore, a threshold is selected to be above the signal produced by noise alone. Using the plotted median of the lidar return over several hundred shots of the data, threshold noise can be easily identified and the depth at which this curve crosses the threshold is the penetration depth. This is illustrated in Figure 3b where the return signal becomes noisy, corresponding to a penetration depth of about 30m. This depth occurs at a signal current of $1x10^{-9}$ A, which is the threshold signal, used to filter the data from shots associated with the estimated median.

A general treatment of remotely 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 an 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 ratio (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, and 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 collected 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 work for this project is part of a larger array of related tasks that are being performed by a remote sensing team that was established in 2000. Members of this team include personnel from the Institute of Marine Science (IMS) and Geophysical Institute (GI) at UAF, the NOAA Environmental Technology Laboratory at Boulder Colorado, Airborne Technologies, Inc (ATI)., and Scientific Fisheries, Inc. See "Personnel" under the Principal Investigator Section for a complete list of responsibilities. Instruments are provided by IMS, ETL, and via a contract with ATI; the aircraft is chartered by ATI. In the field, we will coordinate with Chuck Baker (SeaLife Center) and Ken Coyle (UAF IMS) who will be conducting acoustic surveys in the Northern Gulf of Alaska aboard the R/V *Pandalus* and R/V *Alpha Helix*.

SCHEDULE

A. Measurable Project Tasks for FY03

Nov 15, 02	Completed compilation of processed instrument data Evaluate need for possible rebinning/rescaling of LIDAR data
Dec 15, 02	Compile shipboard and satellite data needed for interpretation Begin qualitative and quantitative comparisons or aircraft-ship-satellite data

Jan 03:	Attend EVOS workshop and present preliminary findings
Mar 15, 03	Begin spatial analysis of mapped biological and physical features (from airborne, ship, and satellite data)
Apr 15, 03	Complete spatial analysis and begin evaluation of methods
May 1, 03	Begin report and publication preparation

B. Project Milestones and Endpoints

FY03

Jul 2002:	Objective 1–2 completed during FY02 phase
Mar 15, 2003	Objective 3; distribution descriptions completed
Apr 15, 2003:	Objective 4; spatial analysis completed
Apr 30, 2003:	Objective 5; evaluation of cost-effectiveness of information
	Objective 6; evaluate usefulness and limitations for GEM
May 31, 2003:	Manuscript draft submitted; final report completed
Aug 31, 2003:	Manuscript revised and finalized

C. Completion Date

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

PUBLICATIONS AND REPORTS

For the NPMR pilot study, the following publication was produced:

Brown, E.D., J.H. Churnside, R.L. Collins, T. Veenstra, J.J. Wilson, and K. Abnett 2002. Remote sensing of capelin and other biological features in the North Pacific using lidar and video technology. ICES Journal of Marine Science, XXX:000–000.

For this study, we will included a more in-depth analysis of target identification, instrument calibration, relative abundance or density indices, and spatial scale of features to complement our earlier publication. We will include some of the data collected in 2000 (during the NPMR study) for an interannual comparison in the Northern Gulf of Alaska region. This publication will be submitted to either Ecological Applications or Fisheries Research.

PROFESSIONAL CONFERENCES

Other than the EVOS workshop and scientific planning meeting, we have no plans to present the results formally in FY03. However, we may present some of the results from this study, combined with similar results from other studies, at scientific meetings covered by other funded projects.

COORDINATION AND INTEGRATION OF RESTORATION EFFORT

In 2002, we are conducting studies in other areas in the Gulf of Alaska, some within the spill region. Although these studies focus on sea lion issues, the data collected includes broad-based physical and biological parameters in near shore areas as well as the continental shelf. Data collected in Northern S.E. Alaska, Kodiak, and the Aleutian Chain will be directly comparable to the data collected under this project in the Northern Gulf of Alaska and Prince William Sound region. We are well connected and actively cooperating with researchers in Kodiak (UAF Fisheries Industrial Technology Center, National Marine Fisheries Service (NMFS)), Juneau (NMFS Auke Bay Lab), Seattle (NMFS Alaska Fisheries Science Center and National Marine Mammal Laboratory), University of California, Irvine (George Hunt), and Anchorage (United States Fish & Wildlife Service, University of Alaska Anchorage). Using funds from other studies, we are establishing a web-based browser that will enable other researchers to view, download, or order (in the case of very large data sets) useful data from our surveys. Databases compiled from aerial surveys (funded by EVOS and NMPR) since 1995 will also be available on-line.

EXPLANATION OF CHANGES IN CONTINUING PROJECTS

None

PROPOSED PRINCIPAL INVESTIGATORS

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PERSONNEL RESPONSIBILITIES

The list of responsibilities for the PIs and associated personnel in our research team is as follows:

UAF-IMS
PI – Evelyn Brown, Ph.D. candidate (defending 2002)
Background: Fisheries Biology and Marine Ecology, Airborne Surveys, Statistical Analyses
Duties: Chief Scientist during airborne surveys, instrument operation, oversee UAF signal processing tasks, signal validation, biological interpretation, spatial analysis, and reporting

Martin Montes, Ph.D.
Background: Ocean Productivity, Oceanography, and Remote Sensing
Duties: Research Analyst, signal processing and target identification, assistance with development of processing software, integration of airborne and satellite imagery, assistance with analysis and reporting

UAF-GI
Richard Collins, Ph.D.
Background: Electrical Engineer, Optics and Research Lidar, Atmospheric Science
Duties: (not funded by this project) signal analysis, instrument design and improvement, assist with software, and analytical algorithm development

Kevin Abnett, MS
Background: Software Engineer, Signal Processing
Duties: (not funded by this project); software development, web-based browser tools

NOAA-ETL
PI – James Churnside, Ph.D.
Background: Physicist, Optics, and Electrical Engineering
Duties: provide, operate, and calibrate LIDAR and Infrared Radiometer; assist with calibration and interpretation of other physical and biological measurements (e.g. ocean color from video), assist with signal processing algorithm development, analysis and reporting.

James Wilson, BS
Background: Electrical Engineer, Ocean Instrument Specialist
Duties: (funded by this project in FY02) install and maintain instruments, assist with field data collection, install and synchronize gated video (provided by UAF) with LIDAR.

Private Industry:
Tim Veenstra, President Airborne Technologies, Inc.
Background: Aircraft Charter and Configuration, Imaging Services
Duties: Provide, install, maintain, and operate imaging equipment; perform all image processing and data delivery tasks, assist with image interpretation, validation, and reporting

Pat Simpson, President, Scientific Fisheries, Inc.
Background: Scientific and industry acoustic instrumentation development and design and software development including neural networks.
Duties: (not funded by this project) development of acoustic-lidar integration and fusion software, instrument development and support of acoustic system used by coordinating project for target validation.

LITERATURE CITED

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

Budget Category:	Authorized FY 02	Proposed FY 03						
Personnel		$18.6						
Travel		$1.2						
Contractual		$0.2						
Commodities		$0.4						
Equipment		$2.6	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$23.0	Estimated FY 04					
Indirect		$5.8						
Project Total	$47.5	$28.8	None					
Full-time Equivalents (FTE)		0.3						
	Dollar amounts are shown in thousands of dollars.							
Other Resources								

UAF COMPONENT $28.8
A DF&G 9% GA 2.6
NOAA COMPONENT 7.9 (includes 9% GA)

PROJECT TOTAL $39.3

FY03

Prepared: 4/2/02

Project Number: 030584
Project Title: Evaluation of Airborne Remote Sensing Tools for Gulf Ecosystem Monitoring and Research (GEM) Monitoring
Name: University of Alaska Fairbanks

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

Personnel Costs:				Months	Monthly		
	Name	Position Description		Budgeted	Costs	Overtime	
	Brown, E.	PI, Chief Scientist		1.5	6.8		
		Research Analyst		1.5	5.6		
			Subtotal	3.0	12.4	0.0	
						Personnel Total	

Travel Costs:		Ticket	Round	Total	Daily	
	Description	Price	Trips	Days	Per Diem	
	EVOS workshop & planning (air and per diem)	0.2	2	4	0.2	
					Travel Total	

FY03

Prepared: 4/2/02

Project Number: 030584
Project Title: Evaluation of Airborne Remote Sensing Tools for Gulf Ecosystem Monitoring and Research (GEM) Monitoring
Name: University of Alaska Fairbanks

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

Contractual Costs:	
Description	
Communications, copy/reproductions	
Contractual Total	

Commodities Costs:	
Description	
Software upgrade-ESRI-ArcView/Info. Splus	
Hardware, Printer Supplies, data storage	
Commodities Total	

FY03

Prepared: 4/2/02

Project Number: 03584
Project Title: Evaluation of Airborne Remote Sensing Tools for Gulf Ecosystem Monitoring and Research (GEM) Monitoring
Name:University of Alaska Fairbanks

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

New Equipment Purchases: Description	Number of Units	Unit Price	
Computer partitioned to run Linus and windows for signal, image processing algorithms, data visualization			
Those purchases associated with replacement equipment should be indicated by placement of an R.		**New Equipment Total**	

Existing Equipment Usage: Description	Number of Units	

FY03

Prepared: 4/2/02

Project Number: 030584
Project Title:Evaluation of Airborne Remote Sensing Tools for Gulf Ecosystem Monitoring and Research (GEM) Monitoring
Name: University of Alaska Fairbanks

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

Budget Category:	Authorized FY 2002	Proposed FY 2003						
Personnel		$6.0						
Travel		$1.1						
Contractual		$0.0						
Commodities		$0.1						
Equipment		$0.0	LONG RANGE FUNDING REQUIREMENTS					
Subtotal	$0.0	$7.2	Estimated FY 2004					
General Administration		$0.7						
Project Total	$0.0	$7.9	$0.0					
Full-time Equivalents (FTE)		0.0						
	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) were provided in 02 at no cost to the project. This represented substantial savings over having to rent or purchase this equipment. Personnel time involved with processing costs were also provided in-kind. This represents an approximate 50% match of the total personnel time. The personnel time here is for analysis of processed data and assistance with report and publication preparation.

FY03

Submitted: 8/5/02

Project Number: 030584
Project Title: Evaluation of Airborne Remote Sensing Techniques for GEM Monitoring
Agency: NOAA Environmental Technology Laboratory

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

Personnel Costs:		GS/Range/	Months	Monthly		
Name	Position Description	Step	Budgeted	Costs	Overtime	
James Churnside	Supervisory Physicist	ZP 5	0.3	20.0		
	Subtotal		0.3	20.0	0.0	
					Personnel Total	

Travel Costs:	Ticket	Round	Total	Daily	
Description	Price	Trips	Days	Per Diem	
RT Denver to Anchorage - EVOS Workshop	0.5	1	3	0.2	
				Travel Total	

FY03

Prepared:

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

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

Contractual Costs:	
Description	
4A Linkage	
When a non-trustee organization is used, the form 4A is required. **Contractual Total**	
Commodities Costs:	
Description	
Data Storage/Hardware/Printer supplies/repair	
Commodities Total	

FY03

Prepared:

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

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

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

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

FY03

Prepared:

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