

SCOMM

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Airborne LIDAR & Digital Imagers For Fisheries Management and Research

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Airborne Technologies Inc.

ABSTRACT – Using recent advancements in technology, a new tool is being developed that can be used to locate and track fish movement from an airborne platform. Daily fish survey flights are now possible that can cover hundreds of miles in a matter of hours. We believe that the **Bristol Bay Sockeye fishery** is the perfect place to introduce the use of this new tool. Both management and industry could benefit from daily accurate reports of fish school size and movement. We believe that this technology will prove that a lidar/imaging unit in an airborne platform is a viable and preferable alternative to traditional fishery indices and/or ship surveys. The implementation of this technology would have a **positive economic impact on the State of Alaska.**

INTRODUCTION -

LIDAR is an acronym for **L**ight **D**etection And **R**anging. In essence, "Lidar" is a laser range finder that sends out a short pulse of laser light towards a target. The return signal is received and the time lapse calculated into a range measurement to the target. The strength of the return pulse can provide additional information about the target. Advancements and commercial applications in this technology are growing daily. An application still under development by the Environmental Technology Laboratory (ETL) is that of developing an **airborne lidar for fisheries surveys** (named **FLOE**, for Fish Lidar, Oceanic, Experimental). ETL is a division of the National Oceanic and Atmospheric Administration (NOAA). The system they have developed uses a pulsed lidar to **profile fish density from an airborne platform**. The system has proven to work best on the upper ocean fishes, such as pacific herring, Pacific sand lance, and caplin. The cost is less than **10% of a ship survey per survey kilometer**, and the depth penetration is more than 3 times that of a visual survey. Airborne Technologies desires to use FLOE lidar technology to locate concentrations of fish and/or marine mammals in the water column.

Additional imaging sensors work in conjunction with the lidar system to provide surface and near sub-surface data including seabird activity, sea mammals, ocean frontal changes and visually observable fish schools. The sensors include:

- **Infra-Red imager**
- **Multi-spectral imager**

- **Hi resolution Digital video**
- **Intensifier equipment for night surveys**

Airborne Technologies Inc. (ATI) has teamed up with both Dr. Jim Churnside from NOAA's ETL and Evelyn Brown from the **School of Fisheries and Ocean Science at the University of Alaska Fairbanks** to bring this technology to Alaska. ATI was awarded a grant from the **Alaska Science and Technology Foundation (ASTF)** last summer to integrate and develop the image sensors with the lidar technology. ASTF's mission is to "promote and enhance" technological development and help establish a commercial base for economic development and growth. Establishing the use of this technology in Alaskan fisheries will serve the people of this state through its' commercial applications as well as the management and research studies of Alaska's natural resources.

Lidar Information

Lidar is a remote sensing technology developed by the military. It was only recently, in the mid 90's, that this technology has found its way into the commercial markets. This is due, in part, to the advances in digital and computer technologies. Airborne lidar first saw commercial application in the land survey industry. Commercially available units are now available that can perform topographical mapping rapidly and cost-effectively. Changing the wave length of the laser pulse, results in different characteristics of the laser light. Operation in the blue-green spectrum will allow the laser to penetrate the surface of water. A few very expensive lidar systems have been developed by government agencies that are capable of performing bathymetric surveys.

The low cost FLOE lidar system, still in development, locates and identifies fish schools in the upper water column of the ocean. The laser beam in this system is capable of penetrating the water to a depth of 50 meters. The penetration depth varies according to surface conditions and water turbidity. Typically, 20-30 meter penetration can be expected. The lidar was initially designed by the military to detect objects in the water column. NOAA's Environmental Technology Laboratory has taken the basic system and is using it to located and help identify fish species, zoo plankton and other marine creatures in the water.

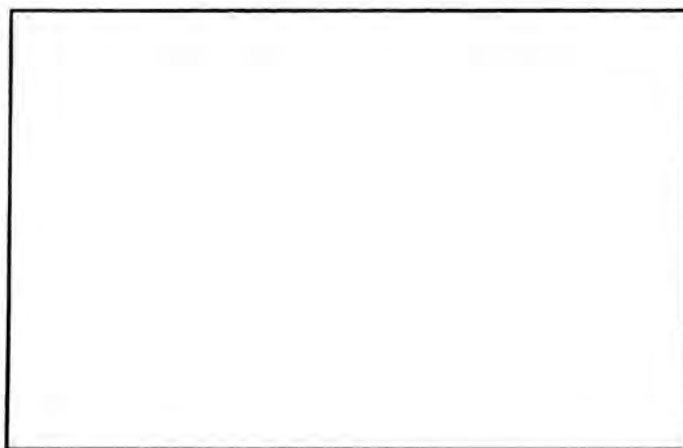
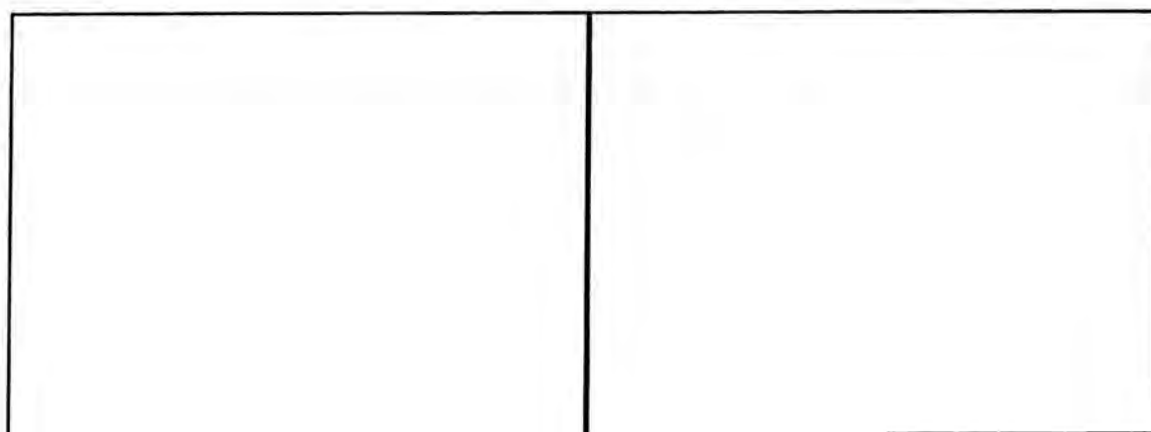


Figure 1 - Block diagram of FLOE lidar system

In this Fish Lidar System, a laser emits a short pulse (~15ns) of green (532nm) light toward the ocean surface. Some of the light is reflected from the surface and some continues down to be reflected back from a school of fish. A **20-cm telescope** is pointed in the same direction as the laser and collects the reflected light. This telescope is a simple refractor that uses a condensor lens. A 10-nm wide interference filter filters out most of the background light and lets only the laser light through to the photomultiplier tube. The **photomultiplier tube (PMT)** detects the reflected laser light and converts it into an electrical signal. In some cases, a logarithmic amplifier compresses the electrical signal. The signal is routed to an analog-to-digital converter (ADC) in a personal computer where it is digitized and saved to the hard disk. In other cases, two ADC boards with different gains are used to increase the dynamic range of the receiver.

Two different displays are available on the aircraft computer. The first is a line plot of the return signal as a function of time for each shot. Since time can be related to distance through the speed of light, this is equivalent to a plot of the return energy as a function of depth for each laser pulse. At 30 pulses per second, this display produces 30 plots per second, which can be hard to follow. Therefore, we have another display that shows depth in the vertical axis, shot number in the horizontal axis, and encodes return power as a gray level. This is similar to the display in a conventional echo sounder. Fish schools show up as regions of more return power. We have the option to identify the surface in each shot and relate the vertical axis to actual depth. Another option is to estimate the background water return and subtract it from each shot to make fish schools easier to see.



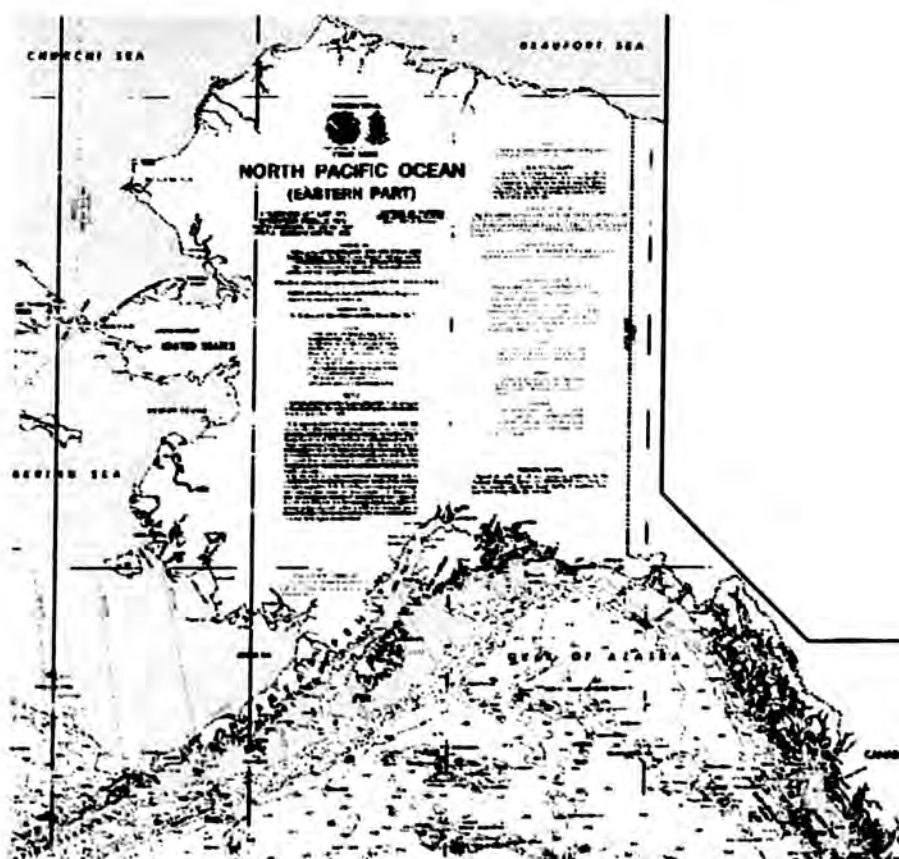
ECHOSOUNDER

LIDAR

The picture on the left shows the sonar data of a fish school gathered from a vessel on the water. The picture on the right is FLOE (lidar) data, collected at the same time. The vertical scales show depth in meters. The left sides of each picture are a single ping for the acoustic and a single laser pulse from FLOE. It takes 1800 laser pulses to give us one minute of data. While the details are different because the two instruments are not looking at exactly the same part of the school, the general features are very similar.

There is only one fishery lidar system available at this time. We just completed a short study with the Prince William Sound Science Center this past week. The lidar system is in Alaska now with the hopes that we can find other projects for this summer. There is no guarantee that the unit will be available in 2002 since there it has generated interest from Japanese and European countries. Jim Churnside from NOAA would like to see Alaska as one of the primary end users and hopes to continue the development of this system here in Alaska. I believe that Bristol Bay is the perfect place to take this technology beyond development and into application. We are searching for funding to enable us to provide a feasibility study and establish a base year of data in Bristol Bay this summer.

LIDAR/Imaging Technology for Alaskan Fisheries



Tim Veenstra
Airborne Technologies Inc.

Lidar/Imaging Airborne Surveys For Alaskan Fisheries

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Objective

- Introduce Airborne Technologies Inc.
- Introduction to technology
- Key players involved
- Examples of our past work
- The future

Airborne Technologies Inc.

- Located in Meadow Lakes, Alaska
- Alaska business since 1983
- Fish survey work since 1987
- Fixed wing & helicopter
- ASTF grant in 2000



Key Personal

- Tim Veenstra - Airborne Technologies Inc.
- Evelyn D. Brown – University of Alaska Fairbanks School of Fisheries and Ocean Science Institute of Marine Science
- Dr. James Churnside – NOAA Environmental Technology Laboratory Boulder, CO

Marine Survey Platforms

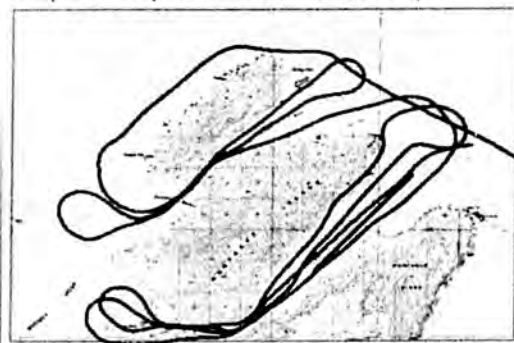


Vessel Surveys

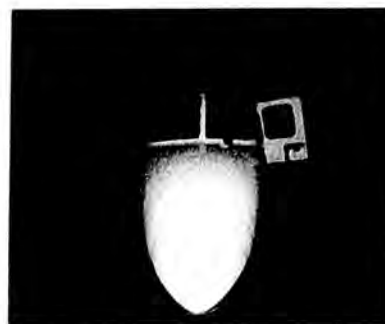
Airborne Surveys



Ship Survey Vs. Airborne Survey



Aircraft Surveys



Aircraft Surveys

- Human observation
 - Note taking
 - Laptop w/ GPS
- Remote sensing
 - Passive sensors
 - Active sensors

Human Observation

Disadvantages

- Bias
- Fatigue
- Limited spectral range
- Observer error
- Impossible to archive



Remote Sensing

Advantages

- Repeatability -temporal
- Wide spectral response
- All digital format
- Both passive & active



Remote Sensors

- Lidar
- Thermal imager
- Multispectral imager
- High resolution imager
- 3 chip digital video

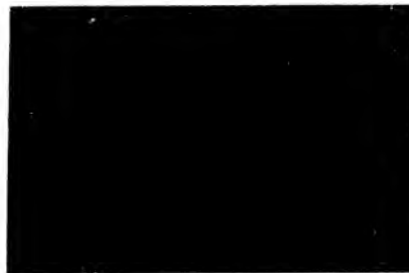


Multispectral Imager

- Ocean temps & color change
- Chlorophyll concentration
- IR imagery -- vegetation
- Fish schools
- Seabirds and Mammals



Herring in Knowles Bay PWS 21 March 2001



Herring in Knowles Bay PWS 21 March 2001



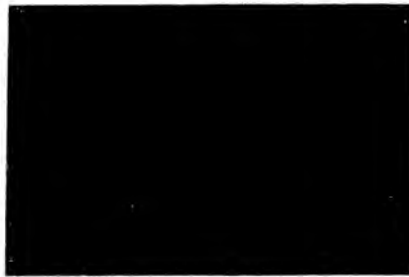
Herring in Knowles Bay PWS 21 March 2001



Herring in Knowles Bay PWS 21 March 2001



Herring in Knowles Bay PWS 21 March 2001



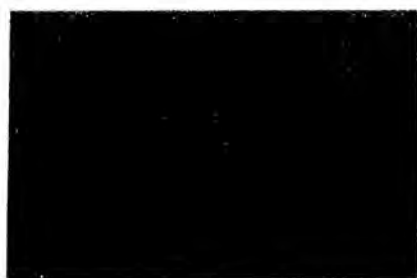
Herring in Knowles Bay PWS
21 March 2001



Herring in Knowles Bay PWS
21 March 2001



Herring in Knowles Bay PWS
21 March 2001



Thermal Imager

- Ocean Temperature
- Sea mammals
- Oil spills
- IR imagery – vegetation
- Night or day



Fish LIDAR



Fish LIDAR

- **L**ight **D**etection **A**nd **R**anging
- Used to assess fisheries stock abundances
- Comprises a laser, a telescope with photo-detector, and a computer
- Flown over survey area in small aircraft

Fish LIDAR

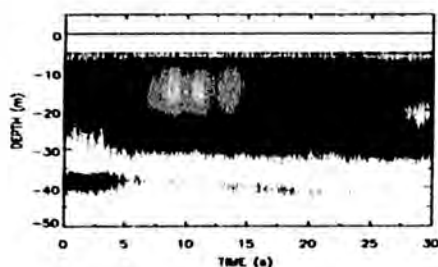
- Works like an echosounder using short pulses of laser light rather than pulses of sound
- Safe for marine mammals
- Covers large areas of ocean quickly at a few percent of the cost of a ship
- Complements surface surveys in spatial and temporal coverage

Fish LIDAR – Is It Eye Safe?

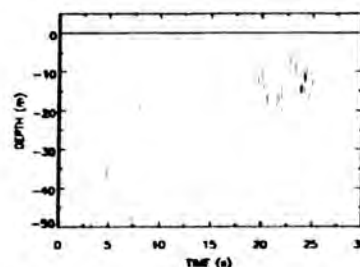
- Our laser beam meets ANSI Z136.1-1993 standard for occupational exposure at the surface
- We have calculated equivalent standards for various marine mammals
- Our laser beam is a fraction (1.3% to 16.7%) of that standard for all marine mammal species investigated



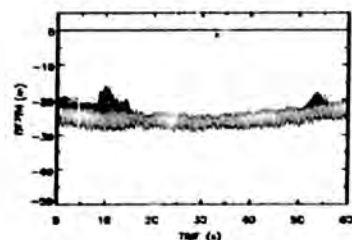
Anchovy Schools in Plankton



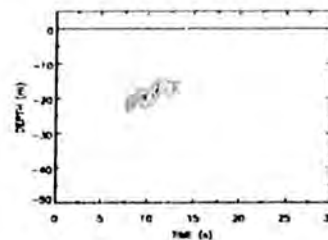
Dolphins



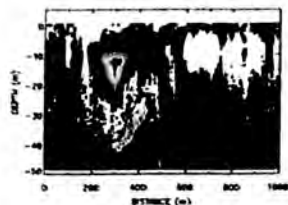
Squid (blue) on Bottom (green)



Sardine School



Krill Rising in Evening



Water Color Limitations



The Future

- Bristol Bay Sockeye Fishery
- Sea Lion research
- Herring stock assessment
- Smolt out-migration
- Salmon fisheries management

Stellar Sea Lions



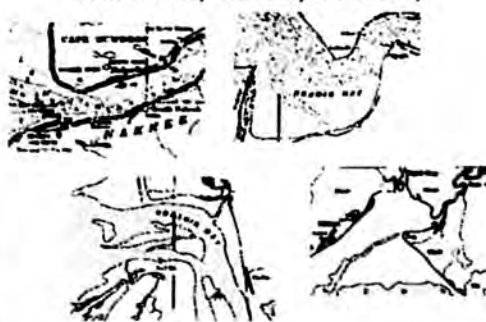
Stellar Sea Lions

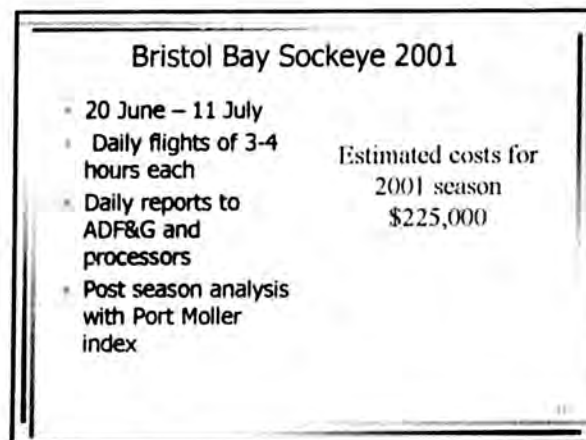
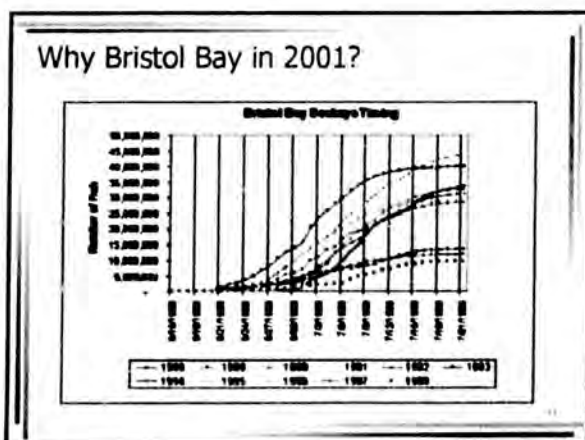
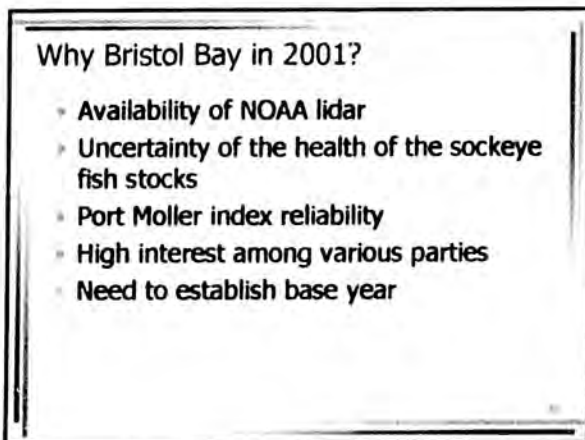
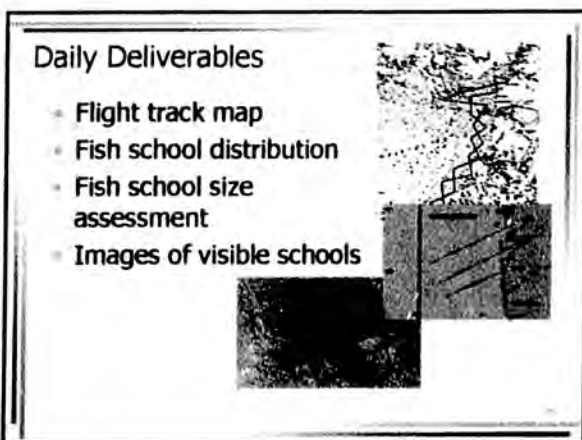
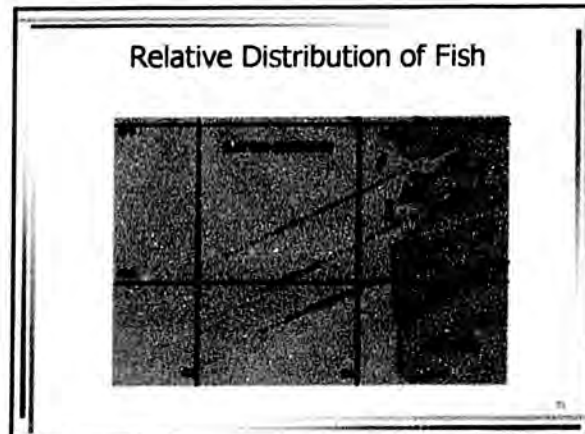
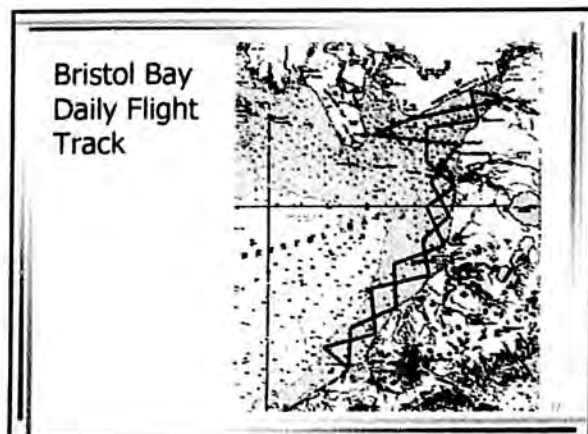


Lidar will ...

- extend fish survey coverage to shallow water
- extend fish survey coverage beyond immediate area of haul outs
- extend sea lion survey to animals in the water
- provide a quick response to immediate needs in other areas based on questions raised by the research, Native corporations, etc.

Bristol Bay Sockeye Fishery





Key Benefits

- New and more complete view of Alaska's fishery resource
- Wide spatial and temporal view of ocean ecosystem
- Lower cost than current method
- Compliments current methods

Questions?

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