A Novel Technique to Detect Epipelagic Fish Populations and Map their Habitat

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LONG-TERM GOALS

The ultimate goal of this project is to substantially improve our understanding of the relation between ecologically important key fish species (e.g. sardine and albacore) and the physical environment by collecting synoptic measurements with improved spatial and temporal resolution of observations.

OBJECTIVES

Our partnership program is striving to develop a new method for detection of fish and synoptically mapping their environment at nested spatial and temporal scales. This new technique involves employing aerial data collection techniques (which are able to collect data at a much larger range of temporal and spatial scales than traditional methods) and coupling them with directed and coordinated ship-based observations, buoy data, and satellite-derived information. The nested array of observations are being analyzed and modeled in a GIS-based environment to provide qualitative and quantitative views of habitat- and behavioral-induced fish distribution patterns.

APPROACH AND WORK PLAN

1) The overall objective of this work is to develop a new technique to detect epipelagic fishes and map their habitat and to test this technique in the EEZ of Oregon and Washington. The secondary objective is the analyze the array of spatial data collected to better understand the connection and affects of habitat and fish behavior on fish detection and distribution. The technique combines data from satellites, aircraft, ships, and moorings. Each platform covers a unique set of spatial and temporal scales, and each instrument has its own advantages and disadvantages. A technique combining data from multiple platforms can be much more powerful than any one alone.

2) James Churnside of NOAA ETL will be responsible for overall coordination of this project. He will also be responsible for the LIDAR component and for the investigation of automatic species identification from airborne video. An engineer (James Wilson) and a part-time undergraduate student (Holly Sewell) will work on the LIDAR effort. Richard Brodeur of NOAA Fisheries will be responsible for the coordination of this effort with the ship surveys, including obtaining data from those surveys, and for contibuting to the synthesis effort. Evelyn Brown of the University of Alaska, Fairbanks will be responsible for obtaining satellite data, coordination with the fishing industry, including spotter pilots, and contributing to the geostatistical analysis and synthesis efforts. Kelly Benoit-Bird of Oregon State University will be responsible for the acoustic moorings and processing of all acoustic data. John Horne of the University of Washington will be responsible for development of techniques for optimally combining LIDAR and acoustic data.

3) In the upcoming year, we will: process all data from the previous year's effort; report the results at the Ocean Sciences 2006 Conference in February; plan the second field test using lessons learned from the 2005 test; perform the second field test at a different time of year in order to get a variety of oceanographic and biological conditions; begin processing of the second field test; and begin the synthesis effort with the first year's data.

WORK COMPLETED

Prior to the field season, we had several meetings with commercial sardine fishermen and industry representatives to coordinate our activities with fishing operations. We presented two talks at a sardine workshop held in Astoria, Oregon in May to present our plans and we received an enthusiastic response from the fishing community. We completed the first field experiment by the end of August, and each investigator has done some preliminary data processing. Spotter pilot reports and catch reports were obtained from the sardine fishing industry. Satellite data were collected to identify temperature and color fronts. Ocean color and sea-surface temperature were also measured with much higher spatial resolution from the NOAA Twin Otter aircraft. LIDAR and visual observers on the same aircraft provided distributions of fish, birds and marine mammals. Acoustic data, underway physical sampling and surface trawl and subsurface plankton sampling were obtained from the fishing vessel Frosti and the NOAA ship Miller Freeman. Fixed acoustic moorings provided data on fish and plankton distributions at 2 locations. Time did not allow for full processing of results or of comparison of results in this reporting period.

RESULTS

Daily reports from the industry spotter pilots suggest that schools were concentrated in hot spots on the continental shelf. The locations of these hot spots varied greatly from one day to the next. The pilots reported large number of schools right at the surface. A typical example of a school group from the air (Figure 1) shows how close some of the fish were to the surface. The LIDAR flights verified that most

Figure 1. Photo of sardine schools (dark patches) around a commercial fishing vessel from the NOAA Twin Otter.

of the schools were very close to the surface, both during the day and at night. Figure 2 shows a typical LIDAR "echogram", showing small schools almost evenly spaced along the flight track and very close to the surface

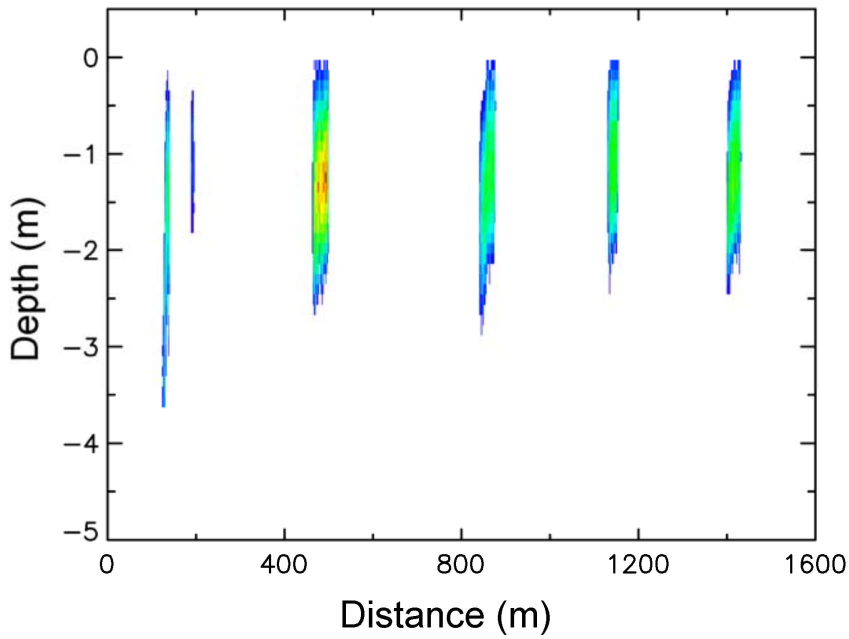

Figure 2. Typical group of sardine schools observed by the airborne LIDAR. The figure shows 6 small schools extending from the surface down to about 3 m along 1600 m of flight track. The length of the schools ranges from about 10 m to about 40 m.

Preliminary analysis of the 120 kHz acoustic buoys reveals strong diel patterns in acoustic scattering (Figure 3). Animals were seen much shallower at night and in more diffuse aggregations with many animals migrating right to the surface. During the day, animals were seen immediately on top of the mooring (about 1 m from the bottom) to approximately 30 meters above the bottom at both sites. Animals were more highly aggregated during the day than at night. These results suggest that LIDAR should be detecting more targets near the surface at night though we have yet to analyze these relationships. More than 100 passes of the LIDAR over the 2 moorings were flown during the experiment, both during the day and at night.

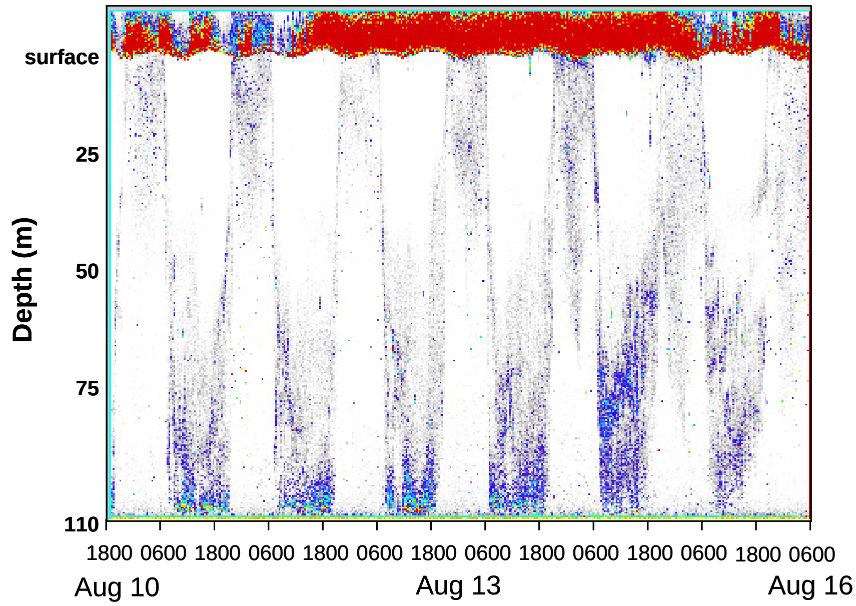

Figure 3. Six days of data from the sonar buoy placed 15 miles off the mouth of the Columbia River, Astoria Oregon (CR15). Strong diel patterns were present at both sites.

Albacore were detected by the LIDAR, but only off the continental shelf and only at night. At night, they were very close to the surface (Figure 4). We suspect that they were too deep to be observed by the LIDAR during the day. We will confirm the species identification and the hypothesis of diurnal migration using ship data.

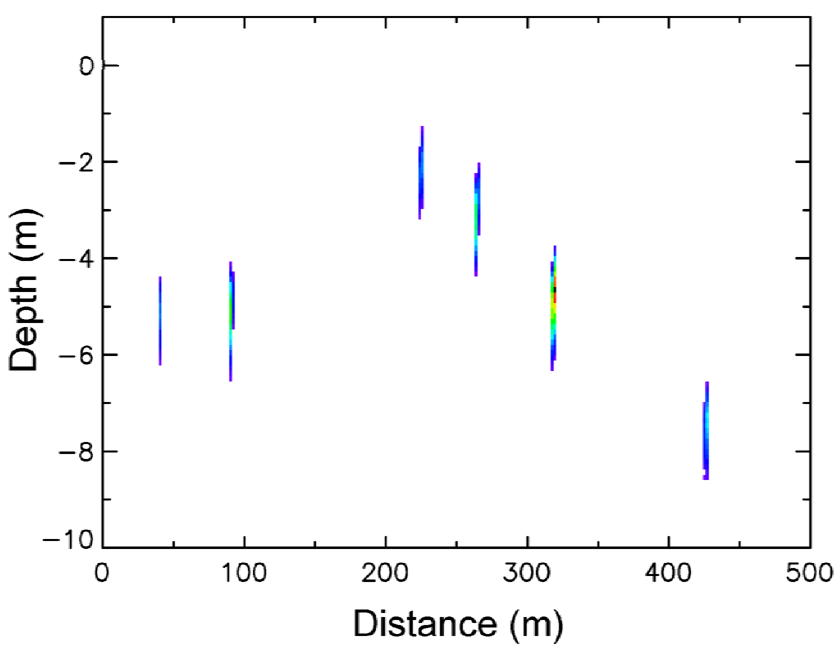

Figure 4. LIDAR echogram showing 6 individual fish targets at depths from 2 – 8 m over a distance of about 500 m along the flight track.

A total of 31 surface trawls were made along 6 transects from central Washington to central Oregon and the catches sardines were the dominant species caught, followed by northern anchovy and Pacific herring. The large number of surface schools is in qualitative agreement with the LIDAR results, although quantitative comparisons have not yet been done. Fewer sardine schools were observed by the echo sounder on the ship, which is probably because the echo sounder cannot pick up schools that are right at the surface. Again, a quantitative comparison has yet to be done.

IMPACT AND APPLICATIONS

Quality of Life

This program has strong support from the sardine fishing industry in the study area. The results from this study will be used to ensure the industry and resource managers have the best information possible on which to base resource allocation

Science Education and Communication

This project is partially supporting a post-doctoral position and a graduate student at Oregon State University and a graduate student at the University of Washington.

RELATED PROJECTS

This work is related to a North Pacific Research Board program involving Churnside, Horne, Brown, and others to investigate combined aerial and surface techniques to survey forage fish in the SE Bering Sea. That program does include a habitat component, and the different target species will require different techniques. Many of the general principles, however, are related.

This work is related to ongoing surveys by the Northwest Fisheries Science Center, NOAA, to estimate the abundance and distribution of the dominant pelagic commercial species, including sardines and tuna and their relationship to physical oceanographic factors such as upwelling and Columbia River plume fronts. Funding for these surveys comes from NOAA and the Bonneville Power Administration.

The comparison of LIDAR and acoustic sampling techniques for assessing biology in this work is strongly related to the collaboration between Benoit-Bird and Concannon and Prentice (NAVAIR). Concannon and Prentice are funded through ONR under the LOCO DRI and Benoit-Bird through the YIP program. This project seeks to compare airborne lidar and ship and moored acoustics, focusing primarily on fish as targets while the LOCO project compares ship based lidar with ship and moored acoustics primarily focusing on plankton as targets.