

NOAA-Fisheries Advanced Sampling Technology Working Group (ASTWG) FY06 Annual Report

Regional Support of FY06 ASTWG: - Alaska Fisheries Science Center

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Goals

The goals of the Alaska Fisheries Science Center (AFSC) are to work in concert with the ASTWG to improve the accuracy and precision of living marine resource assessments by identifying information needs for existing and new stock assessments, identifying new and innovative uses of sampling technologies, and facilitating and conducting research to advance our understanding of the marine environment.

Priorities

The FY06 priorities for AFSC projects were: 1) to develop sampling technologies using a DIDSON imaging sonar shared among all NMFS Science Centers, and 2) to attach light meters to bottom survey trawls to determine how inter-annual and spatial variation in water clarity influences availability of walleye Pollock to the bottom trawl survey

Approach

Project 1. Innovative use of a Dual Frequency Identification Sonar (DIDSON) system has provided critical observations to assess the potential net selectivity of the AFSC pelagic trawl. The DIDSON sonar will now be applied to a variety of sampling questions from other AFSC Science Centers. Project 2. Ambient light levels will be collected on survey bottom trawls and related to the vertical distribution of walleye pollock determined simultaneously using ES60 echosounders.

Work Completed

DIDSON imaging sonar

The ASTWG DIDSON was received in mid-September, tested and accepted by AFSC (Figure 1). The accessories needed for autonomous deployment are in the final stages of assembly and will be ready by the end of December. These include 1) a battery case, 2) batteries and chargers, 3) a simple circuit board and pressure switch to trigger data recording, 4) cables and connectors 5) a deployment frame and a 6) deck download cable. Issues remaining include a communication problem with the 50 ft underwater cable and identification of an additional shipping box for the non- DIDSON components. A protective cage for the unit is available and has been used successfully for mounting and protection of a DIDSON when deployed on bottom and midwater trawls. Procedures for receiving requests for DIDSON use, prioritizing, scheduling, training and shipping are being developed. Input from co-PIs has been solicited for DIDSON scheduling in 2007-08.

Light Measurements on bottom trawls

Ambient light was measured with Wildlife computers MK-9 archival tags attached to the headrope of survey trawls in order to measure water column vertical profiles of light during approximately 400 tows collected on the 2006 bottom trawl surveys. In addition, the vertical distribution of walleye Pollock was determined on the bottom trawl surveys using ES60 echosounders aboard all 5 of the survey vessels. Using ATSWG funds to buy the light meters, extends the prior work completed on 1 vessels to all vessels participating in the AFSC summer bottom trawl survey.



Figure 1. DIDSON components including Pelican case for DIDSON (black device). Also shown is cylindrical battery pressure housing, two battery packs, charger, deck download cable, and protective metal cage. Long (50 ft) underwater cable not shown. Ruler (12 in.) shown for scale.

RESULTS

DIDSON imaging sonar

No results are available, as proposed studies have not started because of unavailability of DIDSON in FY06.

Light Measurements on bottom trawls

Near-bottom light intensity in 2006 differed from previous observations in that there was an extensive region in the southern part of the survey area where light levels were low enough that pollock were expected to be visually impaired (Figure 2). The areas in which light levels are low enough to impact pollock depend on the year, and cannot be explained by depth gradients alone, indicating that temporal and geographic differences in light attenuation are the primary factor controlling near-bottom light intensity.

Initial comparisons of pollock water column distributions indicate that pollock in the areas where light levels are low are less likely to be close to bottom (Figure 3).

Although the analyses are very preliminary, these results appear to be consistent with our proposed hypothesis that when light intensity is low, pollock will tend to be distributed higher in the water column, where they are not visually limited.

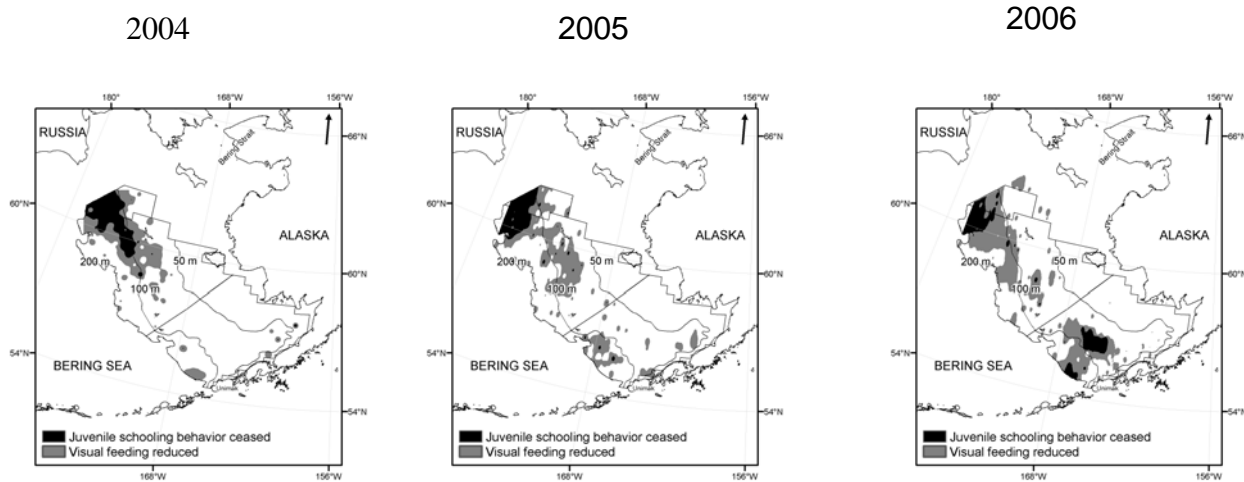


Figure 2. Daytime near-bottom light levels in the context of pollock visual capabilities. Shaded locations at which near-bottom light levels are predicted to limit the ability of juvenile pollock to maintain schools ($2.8 \cdot 10^{-6} \mu\text{E} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, Ryer and Olla, 1998), and feed using vision ($5 \cdot 10^{-5} \mu\text{E} \cdot \text{m}^{-2} \cdot \text{s}^{-1}$, Ryer and Olla, 1999) are indicated in black and dark gray, respectively. Light data were collected during the 2004, 2005 and 2006 BT surveys. Outline of the survey area and depth contours (50m, 100m and 200m) shown to illustrate variability in light conditions along the same depth.

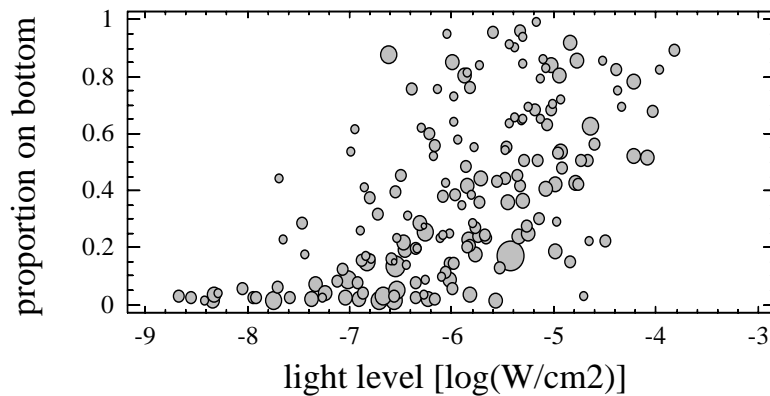


Figure 3. Proportion of pollock on bottom in relation to light levels. This value indicates a fraction of pollock from entire water column, which was present in the path of the trawl, used for EBS bottom trawl survey.

IMPACT/APPLICATIONS

DIDSON imaging sonar

N/A as proposed projects have not started because of unavailability of DIDSON in FY06.

Light Measurements on bottom trawls

Currently in the stock assessment model for Bering Sea walleye Pollock, the population projections are tuned, independently; with both acoustic and bottom trawl estimates of relative abundance. However, these two time series are clearly not independent, because this study has shown that availability of Pollock to either survey, due to the near bottom vertical distribution, depends upon light level, which varies spatially and temporally. A better index of relative abundance would be one that combined both estimates utilizing environmental, spatial and demographic to capture variations in availability. This work provides data to allow this to be done.

TRANSITIONS

N/A as proposed projects have not started because of unavailability of DIDSON in FY06.

PUBLICATIONS

N/A as proposed projects have not started because of unavailability of DIDSON in FY06.

PRESENTATIONS

N/A as proposed projects have not started because of unavailability of DIDSON in FY06.

HONORS/AWARDS

N/A as proposed projects have not started because of unavailability of DIDSON in FY06.

Expenditures

The Alaska Fisheries Science Center was allocated \$93K in FY06 for ASTWG activities, including \$82.5K for the DIDSON sonar and \$10.5K for the light meters.

Regional Support of FY06 ASTWG: Northeast Fisheries Science Center

(Representatives: Michael Jech, 508-495-2353, Michael.Jech@noaa.gov; William Michaels, 508-495-2259, William.Michaels@noaa.gov)

GOALS

The goal of ASTWG supported efforts at the Northeast Fisheries Science Center (NEFSC) to implement advanced sampling technologies to improve survey operations with integrated sensor deployment and analytical tools to obtain more accurate, precise, cost-effective, and synoptic measurements for monitoring our Nation's living marine resource and their habitat using ecosystem-based management approaches.

PRIORITIES

Priorities during FY06 were to develop the technical infrastructure required to improve fish stock assessments, participate in ASTWG national initiatives, and continue the ASTWG-supported research project "Broadband discrimination between anatomical groups of fish and zooplankton-demersal and pelagic regions" with Woods Hole Oceanographic Institution. Another FY06 milestone was the delivery and successful field testing of the Advanced Fisheries Tow Vehicle (AFTV) which provides our agency with a unique horizontally stable towfish platform that readily integrates and deploys new technologies in support of efforts to improve NOAA's Stock Assessment Improvement Plan (SAIP), Essential Fish Habitat (EFH), and Integrated Coastal and Ocean Mapping (ICOM) research.

APPROACH

Our approach for developing NEFSC's advanced sampling technologies have been to develop collaborative efforts for research, evaluation, and implementation of new technologies aboard existing Atlantic Herring Acoustic Surveys, Bottom Trawl Surveys, and Gear Performance Studies. This collaborative effort also included mentorship for academic students through NOAA's Undergraduate Scholarship Program and Education Partnership Program.

WORK COMPLETED

The Electronics Engineer hired with the ASTWG Center funds has continued development of an electronics lab and provided engineering support for various advanced sampling technology projects (fisheries acoustics, seafloor and habitat mapping, underwater video, and survey gear performance). We hosted an EPP undergraduate student for 10 weeks during the summer who assisted with calibration of underwater stereo cameras. The NEFSC supported participation of one scientist to the ASTWG Habitat Technology Workshop. Effort was also devoted to developing NEFSC's multibeam (EM3002) capabilities.

A major advanced sampling technology project completed this year at the NEFSC was the successful design, construction and field testing of the Advanced Fisheries Tow Vehicle (AFTV) system (Fig. 1). The AFTV was constructed in collaboration with Deep Sea System International and was delivered and successfully tested at the Northeast Fisheries Science Center during September 2006. The AFTV provides novel capabilities to NOAA in that this towfish is designed as a horizontally stable platform and improves upon measurements during either drifting or steaming operations from research vessels. The AFTV is designed with state-of-the-art Ethernet-based electronics providing network-ready data from integrated acoustical, optical, and environmental sensors. This Ethernet-based capability allows real-time viewing of acoustical and optical data during field operations as well as straightforward

configuration the AFTV as new sensors become available. The AFTV is presently configured for verifying acoustic targets in the water column. Future plans are to configure the AFTV for video mosaics and acoustic seabed classification for assessing scallop populations and habitat. Contact William.Michaels@noaa.gov for further details.

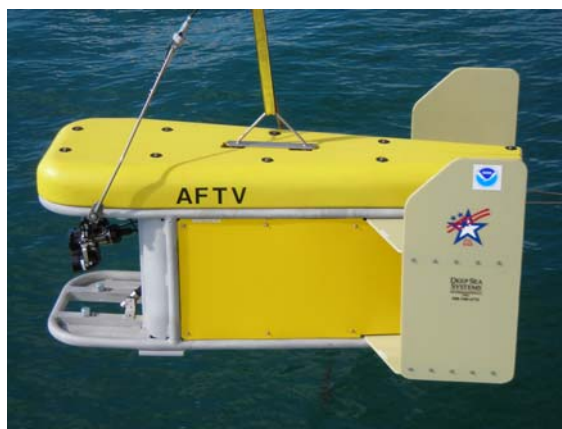


Figure 1. The AFTV being deployed on the NOAA ship FRV DELAWARE II during the annual Atlantic herring acoustic survey in the Gulf of Maine during September 2006.

RESULTS

In situ target strength and volume backscatter data (Fig. 2) and underwater video images were collected on Atlantic herring during September 2006 with the 38-kHz EK60 echo sounder on the AFTV. When aggregations of herring were located with the hull-mounted EK500, the AFTV was lowered to within 10s of meters of the acoustic backscatter. These data will improve our ability to determine the target strength of Atlantic herring as well as other scatterers (e.g., euphausiids, haddock, redfish) in the Gulf of Maine and Georges Bank regions.

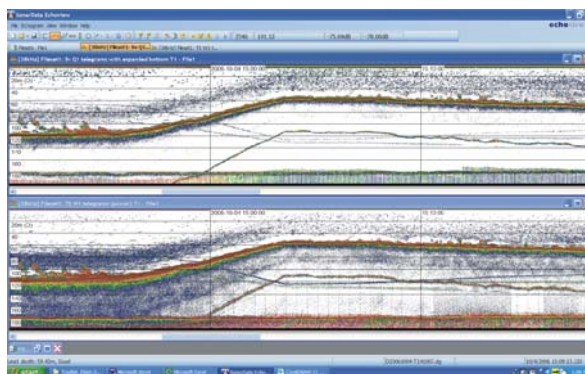


Figure 2. Volume backscatter (upper echogram) and target strength (lower echogram) echograms of Atlantic herring (backscatter near the sea floor) and euphausiids (dispersed backscatter above the sea floor) at 38 kHz with the AFTV.

IMPACT/APPLICATIONS

NEFSC efforts in support of the national ASTWG initiatives and regional projects will improve our ability to monitor economically and ecologically important living marine resources in a more accurate and cost-effective manner. Support has also fostered increased collaboration with academic partners and other governmental agencies.

TRANSITIONS

The development and continued improvement of our electronics support to the NEFSC has allowed the advanced sampling technology group to augment our acoustic sampling as well as enhance and further our efforts towards optical measurements and implementing advanced technologies for improving gear mensuration and on-board fish measurements.

RELATED PROJECTS

The ASTWG funded three projects in FY06 through its competitive proposal process: “Broadband discrimination between anatomical groups of fish and zooplankton-demersal and pelagic regions” by M. Jech (NEFSC) and T. Stanton and D. Chu (Woods Hole Oceanographic Institution); “A generic advanced image processing package for benthic habitat characterization and measurement of sea scallop abundance and size distribution” by D. Hart (NEFSC) and S. Gallager (Woods Hole Oceanographic Institution); and “Application of RAFOS tags to yellowtail flounder on Georges Bank” by S. Cadrin (NEFSC) and J. Miller and T. Rossby (University of Rhode Island). Progress reports for these projects are provided as separate documents.

PUBLICATIONS

Jech, J.M. and W.L. Michaels. A multifrequency method to classify and evaluate fisheries acoustics data. *Can. J. Fish. Aquat. Sci.* 63: 2225-2235.

Overholtz, W.J., J.M. Jech, W.L. Michaels, L.D. Jacobson, and P.J. Sullivan. 2006. Empirical comparisons of survey design in acoustic surveys of Gulf of Maine-Georges Bank Atlantic herring. *J. Northw. Atl. Fish. Sci.* 36: 1-18.

PRESENTATIONS

Gamble, R. and J. M. Jech. 2005. “Improving Atlantic herring (*Clupea harengus*) Population Estimates Using in situ Measures and Acoustic Models”, AFS, Anchorage, AK, September 2005.

Jech, J.M., R. Gamble, R.H. Towler, and J.K. Horne. 2006. “Towards a standardized data format of digital anatomy and morphometry for acoustic scattering models”, ICES WG-FAST, Hobart, Tasmania, March 2006.

Jech, J.M. 2006. “Using objective classification methods to evaluate fisheries acoustics data”, ASLO/AGU, Honolulu, HI, February 2006.

Stanton, T.K., D. Chu, J.M. Jech and J.D. Irish. 2006. “Statistical behavior of echoes from swimbladder-bearing fish at 2-10 kHz”, OCEANS/IEEE 2006, Boston, MA, September 2006.

Expenditures [\$135K]

The Northeast Fisheries Science Center (NEFSC) was allocated **\$135K** in FY06 to support the FTE position and ASTWG participation. The FTE salary and overhead costs totaled **\$104K**. An additional 20% tax was imposed on the \$135K by the NEFSC (**\$27K**) for a total salary and tax reduction of **\$131K**. The remaining **\$4K** was used to fund travel for participation at the ASTWG meeting in May 2006 and miscellaneous computer supplies.

Regional Support of FY06 ASTWG: Northwest Fisheries Science Center

(Representatives: Stan Tomich, 206-860-3361, Stan.Tomich@noaa.gov; Earl Prentice, 206-842-5434, Earl.Prentice@noaa.gov)

The goal of the Northwest Fisheries Science Center (NWFSC) is to work in concert with the ASTWG to improve the accuracy and precision of living marine resource assessments. This goal will be accomplished by identifying information and technology needs for existing and new stock assessments, improving these assessments, and advancing our understanding of the marine environment. By identifying new and innovative uses of sampling technologies, advancing these technologies, facilitating and conducting research, and openly sharing information we will be able to provide necessary information for ecosystem-based management decisions.

Priorities

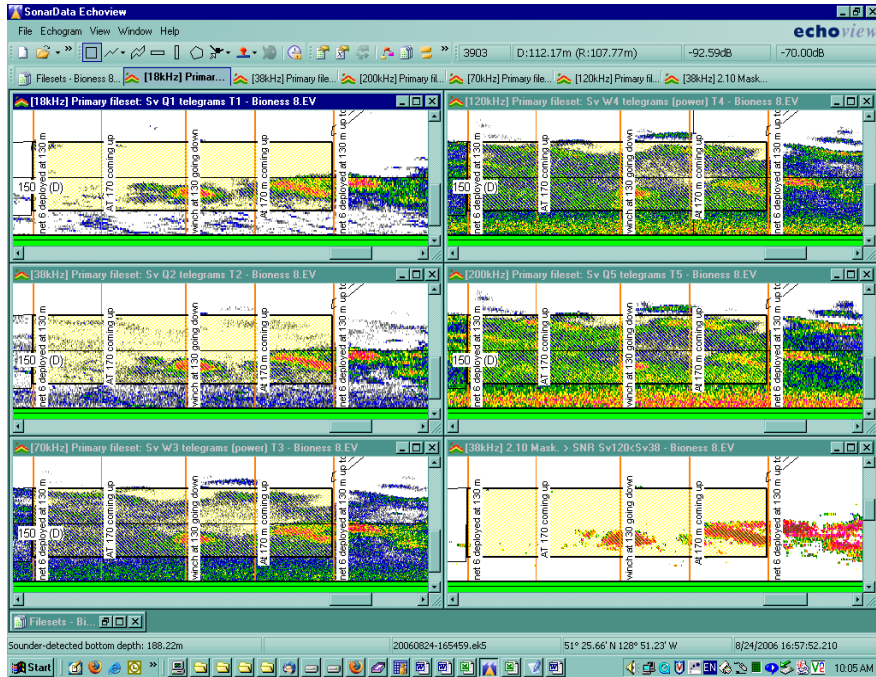
Priorities during FY06 included the integration of the newly hired advanced technology FTE into the Advanced Technology Programs at the Center. Other priorities included participation in ASTWG national initiatives, conducting an ASTWG workshop, determining the source of backscatter for Pacific hake surveys using the multi-frequency EK60 echo sounder, advancing the use of the Digital Video Plankton Recorder (DVPR), designing an improved DNA sampling hook, and collaborating on modifications on the WHOI AUV camera system for use in monitoring groundfish.

Approach

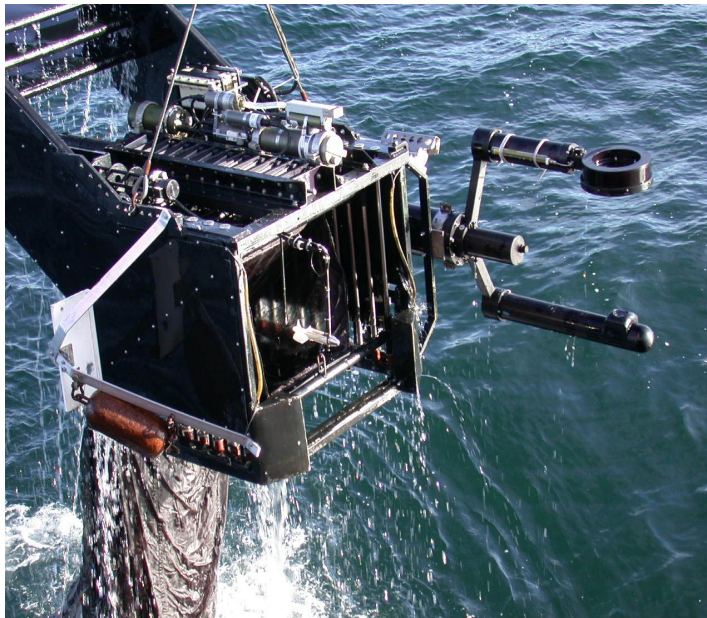
Our approach was to develop and employ technologies to improve and expand data collected on existing surveys and to develop new technologies that could be used to initiate new surveys for groundfish and salmon. The development of new surveys for groundfish is an action recommended to the agency in GAO report 04-606 "Pacific Groundfish - Continued Efforts Needed to Improve Reliability of Stock Assessments".

Work Completed

During the joint US/Canadian survey performed in August over a large area of Queen Charlotte Sound backscatter data (supply a figure - pix of multi-frequency echogram) were collected during the month of August in Queen Charlotte Sound (pix of map of survey). During the survey data were collected on 18-, 38-, 70-, 120-, and 200-kHz EK60 echo sounder simultaneously aboard the CCGS Tully. Concurrent with the Tully, the CCGS Ricker fished representative fish schools for stock assessment using midwater trawling. An example 5-frequency echogram:



Also on the joint US/Canadian survey the Canadian BioNess (a multi-net variable depth plankton and CTD sampler) and Bongo tows, were used in conjunction with the NWFSC DVPR. The use of both plankton nets and the DVPR will give a complete picture of the plankton community and including gelatinous zooplankton not identifiable from net tows. The goal of this work is to identify plankton that affect acoustic backscatter during hake surveys. The BioNess sampler and DVPR (far right) are shown below and are followed by some sample zooplankton images.

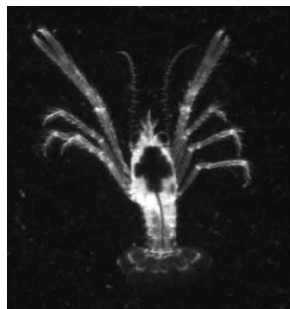




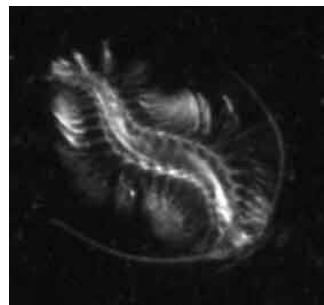
Aegina citrea



Limacina helicina



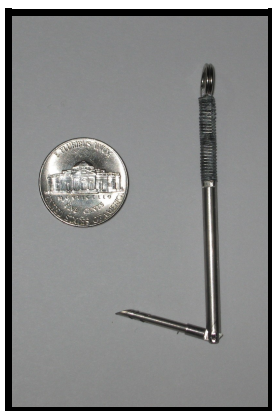
Munida quadras



Polychaete

Experiments were performed using the two types of passive integrated transponder (PIT) tag technologies used in fisheries to identify specific individuals by a unique code, full duplex (FDX) and half duplex (HDX). Both technologies are considered radio frequency identification systems and historically have not been considered practical for use in either estuarine or marine environments for fish identification applications. This assumption is changing because of work performed in 2006 by researchers from the Fish Ecology Division of the NWFSC. The tag read range is limited to centimeters or meters depending upon the system, environment where it is used, antenna configuration, tag size, and transceiver used with the system. A first attempt at using the HDX PIT-tag technology in the marine environment will occur in early 2007.

During the early part of 2006 the new biopsy sampling hook was designed. Tank testing on captive live rockfish using several prototypes found that 97% of the hooks had ample tissue for DNA analysis. After tank testing, fabrication of 30 hook bodies and 400 replaceable tips of the new design was completed for field work. These parts were used in a hook and line survey in October 2006 and resulted in 47% of the hooks triggering with DNA tissue samples, analysis of these samples continued into 2007.



The DNA Sampling Hook in the ready position (left) and the triggered position (right).

Results

The workshop in Seattle on Advanced Sampling Technologies to Improve the Classification and Monitoring of Marine Habitats for NOAA Strategic Goals in August was successful.

Approximately, 40 individuals representing NMFS Headquarters, five fisheries science centers, two NMFS regional offices, and seven other academic institutions and agencies participated in the workshop.

The joint US/Canadian survey lasted 14 days and resulted in 23 transects with over 1200 miles of fishing and other operations. Data were collected on 18-, 38-, 70-, 120-, and 200-kHz EK60 echo sounder, as well as fishing hauls for 7,722 kg consisting of 67% hake, 13% yellowtail rockfish, and 10% yellowmouth rockfish as the top three by weight along with 14 CTDs casts.

The combination Bioness and DVPR were deployed for 10 tows in areas where acoustic backscatter was significant on the echo sounder. These deployments resulted in physical collection of zooplankton with the Bioness nets, and in hundreds of thousands of digital pictures of individual zooplankton.

AUV testing planned for 2006 could not be completed because mechanical failures on the vessel scheduled to be used for testing. This required cancellation of the cruise. Testing was rescheduled and will be conducted April 2007 on a Department of Fisheries and Oceans, Canada research vessel.

Impact/Applications

Our efforts have are improving the data collected during surveys and expanded the survey activities in a cost effective way. This work has also expanded our collaborations with the fishing industry, Department Fisheries and Oceans Canada and academia institutions.

Transitions

The addition of engineering support to the NWFSC has improved, and will continue to improve, our ability to monitor important marine resources. Continued advancements in the AUV capability, use of the DVPR, and developments like the DNA Sampling Hook contribute to cost-effective methods of non-lethal monitoring and survey activities.

Related Projects

The ASTWG funded one project in FY06, “ASTWG Workshop on Advanced Sampling Technologies to Improve the Classification and Monitoring of Marine Habitats for NOAA Strategic Goals”. This workshop was organized to identify the most effective and promising approaches and technologies for identifying, mapping, and monitoring essential offshore habitat for demersal fish species. This successful workshop was held in Seattle during August and the report on this project is provided as a separate document appended here.

Publications

Chu, D., L. C. Hufnagle Jr. 2006. Time varying gain (TVG) measurements of a multibeam echo sounder for applications to quantitative acoustics. Proceedings MTS/IEEE Oceans 2006.

Presentations

Burke, B. J., M. A. Jepson. 2006. Performance of passive integrated transponder tags and radio tags in determining dam passage behavior of adult Chinook salmon and steelhead. *North American Journal of Fisheries Management*, 26(3):742-752.

Chu, D., L. C. Hufnagle Jr. 2006. Time varying gain (TVG) measurements of a multibeam echo sounder for applications to quantitative acoustics. *Proceedings MTS/IEEE Oceans 2006*.

Hufnagle, L., N. Tolimieri, S. de Blois, R. Thomas, Kelly Andrews, G. Williams 2006. Advancements in fisheries acoustics: from splitbeam to multibeam. Poster at 2006 NWFSC Science Symposium.

M. Elizabeth Clarke, Hanumant Singh, Nicholas Tolimieri, Chris Goldfinger, Kelly Andrews, Guy Fleischer, Lawrence Hufnagle, Stephen Pierce, Christopher Roman, Christopher Romsos, W. Waldo Wakefield, Keri York, Julia Clemons 2006. Integrated Mapping of West Coast Groundfish and their Habitat Using the SeaBED AUV and the ROPOS ROV. *Proceedings 2006 14th Western Groundfish Conference*.

Expenditures

The Northwest Fisheries Science Center (NWFSC) was allocated \$135K in FY06 to support the FTE position, set up costs, and ASTWG participation. An additional \$23K was received from the ASTWG for FY06, "ASTWG Workshop on Advanced Sampling Technologies to Improve the Classification and Monitoring of Marine Habitats for NOAA Strategic Goals".

Regional Support of FY06 ASTWG: Pacific Islands Fisheries Science Center

(Representatives: Michael Seki, 808-983-5393, Michael.Seki@noaa.gov; Frank Parrish, 808-983-5391, Frank.Parrish@noaa.gov)

Assessment of Biomass, Distribution, and Movement Patterns of Nekton and Micronekton in the American Samoa Longline Fishing Grounds

Based on results of the previous year (Domokos et al., manuscript submitted to Fisheries Oceanography), a second cruise was conducted to the American Samoa longline fishing grounds from 15 February to 2 March 2006 to assess the effects of physical characteristics on nekton and micronekton in the region, focusing on the effects of the seasonally varying South Equatorial Counter Current (SECC). To obtain information on the distribution, composition, movement patterns, and abundance of nekton and micronekton, active acoustic surveys were conducted in physical environments of interest using the dual frequency (38 & 120 kHz) hull-mounted split-beam echosounder system on board the NOAA ship *Oscar Elton Sette*.

The acoustic data from the cruise show that the daytime scattering layer typically extends from 500 to 900 m in depth and consists of two prominent layers – one in the 500 – 650 m range and a less prominent layer in the 750 – 900 m range (Fig. 1). The nighttime scattering layer extends from the surface to about 200 m and contains organisms migrating from the 750 – 900 m layer, indicating the possible importance of organisms and the physical characteristics at that depth on nekton such as the economically important albacore tuna which dominates the catch in the region. Nekton typically occupy the 150 – 400 m depth range and were seen predominantly during daytime, apparently feeding on a thin scattering layer than persist at approx 250 m during day- and nighttimes (Fig. 2). Area scattering coefficients were calculated for nekton and micronekton separately, based on TS values at 38 & 120 kHz. Micronekton composition will be estimated by the comparison of Sv values at the two frequencies, aided by trawl samples collected during the cruise. Preliminary results indicate that micronekton biomass is significantly higher in waters of the SECC than those of the South Equatorial Current (SEC; compare Figs. 1 & 3), with nekton biomass seemingly as high as in waters of the SECC. Preliminary results were presented at the 57th International Tuna Conference in Lake Arrowhead, May, 2006, by Dr. Reka Domokos. Data analysis will be completed in FY07, with results prepared for publication in a peer review journal.

Assessment of Juvenile Pink Snapper Population at a Hawaiian Nursing Ground

As a continuation of the project developing a method to monitor the stock of juvenile pink snapper in Hawaiian nursery grounds using active acoustics (reported in the ASTWG FY05 report), TS values of snappers with known sizes were collected at various depths (10 – 90 m) in the field, with the orientation of the fish monitored concurrently with an underwater video camera with a live feed (Fig. 4, top panels). Acoustic recordings we obtained using a portable Simrad split-beam system aboard a small NOAA vessel, the *Kumu*, operating at 38, 120, and 200 kHz frequencies. In an effort to be able to distinguish the acoustic signatures of pink snappers from those of the only other primary fish in the nursing ground at depths occupied by snappers, a puffer (*Torquigener florealis*), TS measurements in the field were obtained from three individual puffers with known sizes and orientations and were compared to those obtained from pink snappers (Fig 4, bottom panels).

To monitor the juvenile pink snapper population over time, a survey grid was designed over an area of the nursery ground previously determined to have relatively high population of snappers, and transects have been conducted over the grid. In addition, data from 20 tagged aquacultured juveniles released around two listening station in the nursery grounds indicate that most of the animals stayed around the nursery grounds throughout the life of the stations, approx. 2 months. In the future, both validation of bioacoustic signals and the monitoring of population density of juveniles will be continued in the nursing ground, with plans of investigating neighboring adult habitat. The first investigation to test the feasibility of using

the portable EK60 system down to 400-m depths has been conducted, with encouraging results. Preliminary results and work in progress were summarized in a presentation by R. Boland at the Workshop to Evaluate Fishery Independent Approaches for Assessment of Hawaii Bottomfish Resources in Honolulu, Sep 2006.

Development of a Fisheries Independent method of Biomass Estimation of Bigeye Tuna at Cross Seamount, Hawaii

Based on results of a preliminary study during FY05 (reported in the ASTWG FY05 report), a proposal was submitted (PI R. Domokos) to the Pelagic Fisheries Research Program (JIMAR, Univ. of Hawaii) to develop a fisheries independent method of estimating bigeye tuna biomass at Cross seamount, located approx. 290 km south of the island of Oahu. Funding was obtained for a 2-year period during which two cruises, one in FY07 and one in FY08, will be conducted to Cross and the biomass, composition, movement patterns, and distribution of both bigeye and its forage will be studied using the 38 & 120 kHz active acoustic instrument on the NOAA ship *Oscar Elton Sette*. Identification of micronekton will be aided by trawl samples while individual bigeye will be double tagged with continuously active and with individually coded intermittent transmitters and tracked concurrently to obtain information on the movement of individuals and to aid in the interpretation of the acoustic data. Double tagging will allow both for active tracking of individual tuna and passive tracking of multiple individuals via listening stations deployed over the plateau of the seamount. The physical environment will be monitored to obtain information on its effects on micronekton and — directly or via forage — on nekton.

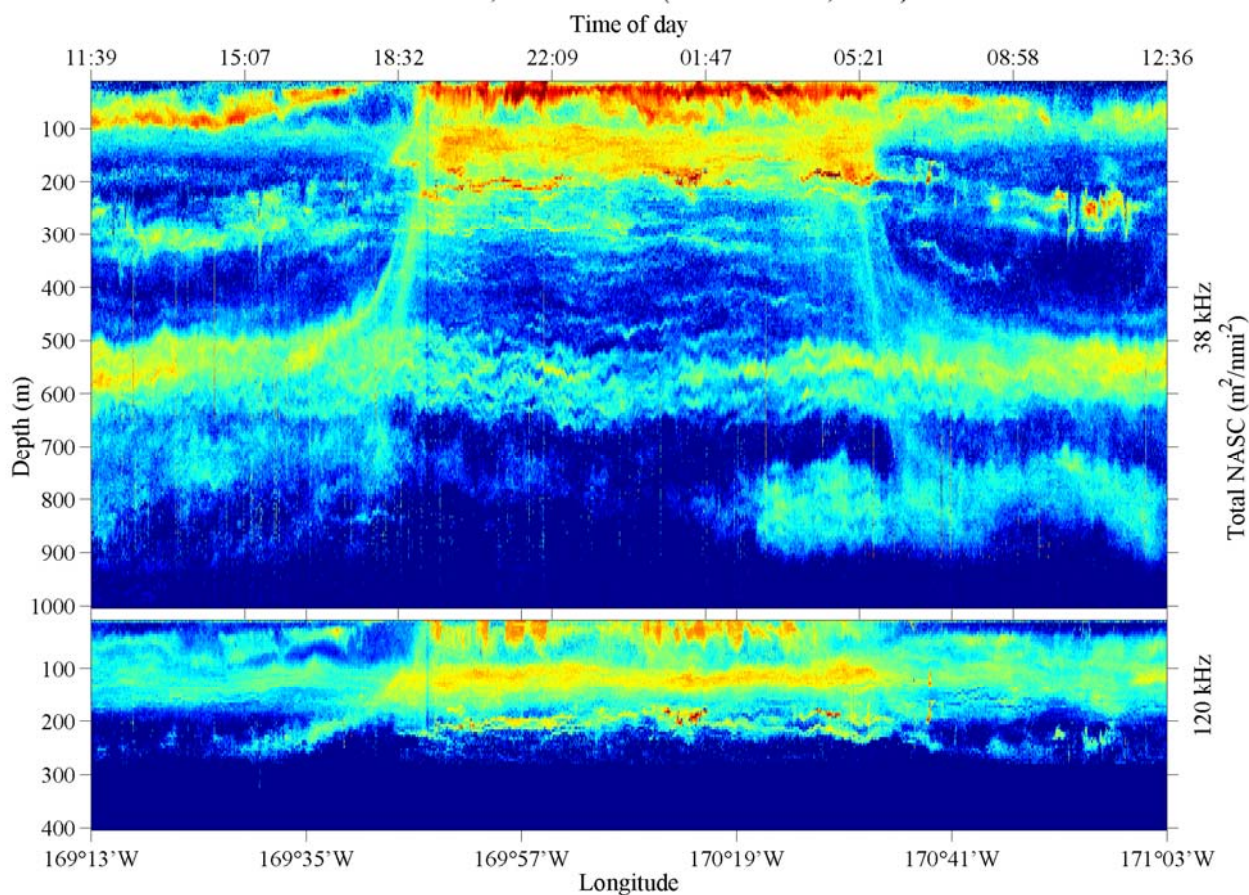


Figure 1. Daytime and nighttime area scattering coefficients in waters with characteristics consistent with those expected in the SECC. American Samoa fishing grounds.

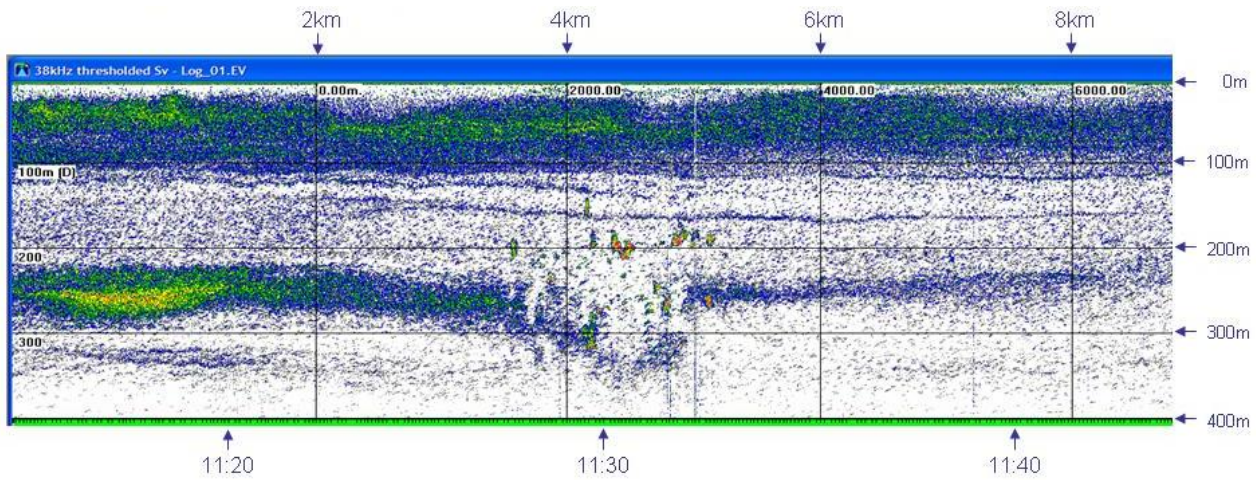


Figure 2. 38 kHz Sv echogram showing nekton apparently feeding on micronekton in the American Samoa fishing grounds.

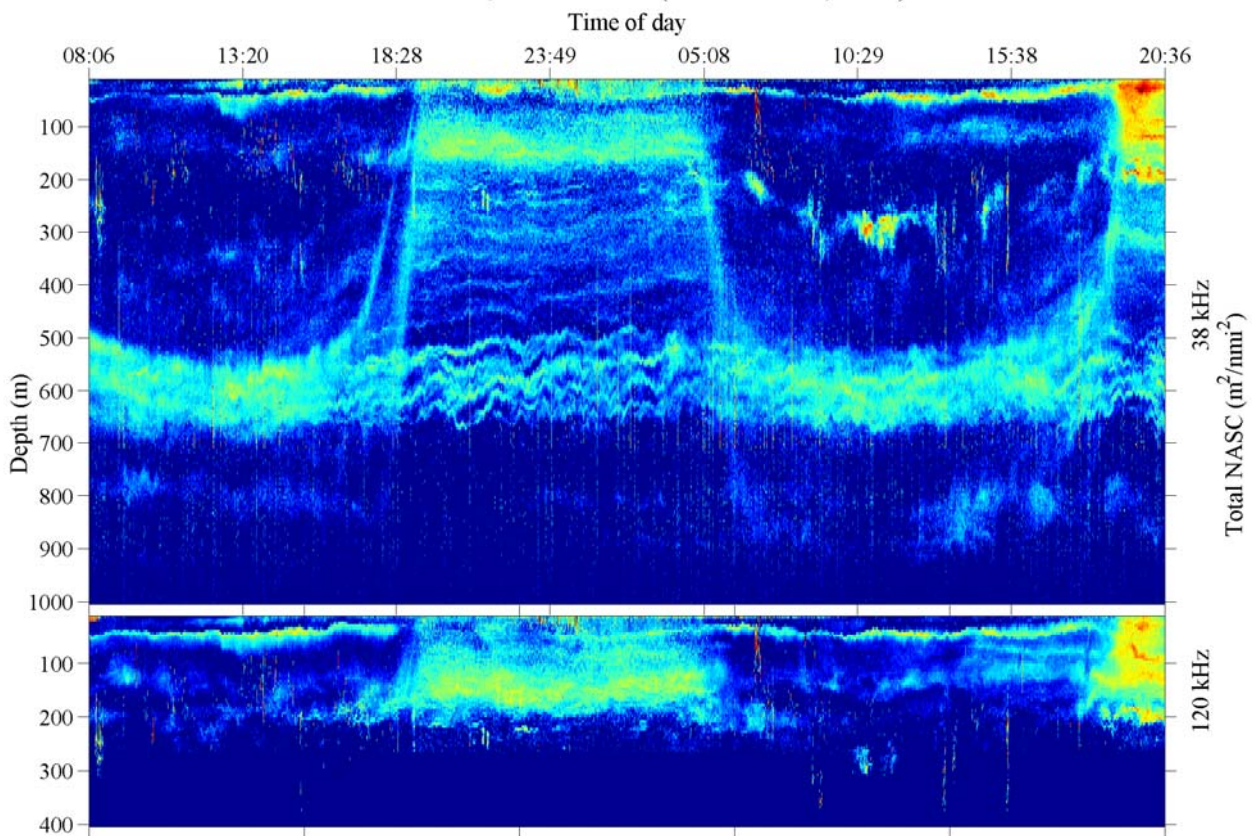


Figure 3. Daytime and nighttime area scattering coefficients in waters with characteristics consistent with those of the SEC. American Samoa fishing grounds.



Figure 4. TS values of a juvenile pink snapper (top panels) and a puffer (bottom panels) at the 38 (top), 120 (middle), and 200 (bottom) kHz frequencies. Juvenile pink snapper nursery ground, Hawaii.

Regional Support of FY06 ASTWG: Southeast Fisheries Science Center

(Representatives: Christopher Gledhill, 228-762-4591, christopher.t.gledhill@noaa.gov; Pete Sheridan, 850-819-8026, pete.sheridan@noaa.gov; Charles Thompson, 228-688-2097, charles.h.thompson@noaa.gov)

Goals

The goal is to develop the infrastructure for developing and deploying advanced sampling technologies required to improve stock assessments.

Priorities

Priorities of the SEFSC include improving fishery-independent data on reef fish stocks, determining large-scale movement patterns of highly migratory species, and improving estimates of catchability (particularly for highly migratory species on longline gear) within the Gulf of Mexico, Atlantic, and Caribbean regions.

Approach

FY06 activities addressed improving reef fish assessments. Fishery-independent surveys for reef fish are typically conducted using visual methods. For example, surveys of the Florida Keys reef tract are conducted using SCUBA diver census, while surveys of shelf-edge banks along the continental shelf are conducted using baited stationary video cameras. Both of these surveys can be improved by the development of stereo camera methods to obtain accurate measures of fish length. A stationary stereo camera system is being developed specifically for mid-depth (<500 m) fixed location operation. The electronics package is suitably flexible to be incorporated into a portable design (i.e., diver or towed body), and the mechanical packaging and operating software is tailored for the high shock load expected during deployment and recovery.

Work Completed and Results

The system is composed of an underwater housing, a monochrome stereo still camera, a color video camera, and a disk drive-based recording package. The 30 frame per second color video can be used for species identification and for localizing a time segment for stereo analysis. Since the video is recorded in MPEG-2 format and the stereo images are bit-mapped, the frame rate of the stereo images controls the amount of hard disk space required to record a given time. The video and stereo images are loosely synchronized to allow data screening via the video only.

- Four underwater housings have been fabricated and pressure tested. Two stereo systems have been completed and tested in the field. The stereo camera and video camera used in the system are “off the shelf” and have already been delivered. The recording package is based on the PC104+ standard and is therefore composed primarily of “off the shelf” electronic boards, and it uses the Windows XP operating system. All of the electronic boards and disk drives, with the exception of the power control board, have been delivered. The power control board has been designed and is currently being prototyped. The software for the power control board was required to hold the system in a hibernation mode during deployment and retrieval to minimize the chance of disk drive damage due to

shock. This is the only fully custom software in the system. This software was developed in conjunction with the hardware prototyping. The other required software functions are to control capture and storage of the video and stereo images. The video capture/store function uses a modified demonstration program supplied by the manufacturer of the video capture board. The program modification is to allow command line operation rather than operation via the GUI. This modification was completed. The stereo image capture and store software is a modification to the operating program supplied with the stereo camera. This software also required modification to allow command line operation and has been completed and tested. The stereo processing software has been installed on a dedicated computer. Underwater calibrations were performed on the two stereo camera systems and the camera were field tested in March, 2006. Several problems were noted during the first deployment of the stereo cameras during the 2006 MPA survey. First was under and overexposure in MPEG videos caused by changing light conditions, video with dropouts, and slow downloads of data. These issues could be solved with the acquisition on new hardware including an auto-iris video camera, MPEG-4 boards, and Pentium 4 CPU boards with gigabit Ethernet. The Pentium 4 CPUs should be available in December, 2006. No hardware improvements have been made due to limited funding.

Related Programs

Development of a stereo camera system would benefit programs that monitor coastal and open-water sharks, deep-water groupers and snappers, and marine mammals. Each of these programs requires more accurate methods to measure the size of animals either captured or observed.

Presentations

No presentations were made during FY06.

Transitions

A stereo camera system is being constructed to be field tested in 2006. Software to process stereo images has been purchased.

Relation to national projects

Stereo camera development will support the effort to survey within boundary areas (near-surface, near-bottom, irregular topography) using the NMFS AUV or ROVs.

Expenditures

Total FY06 funds were \$188.5K. Of this, \$135K was used to support the advanced technology position, \$43.5K was spent on electronics and hardware to build 4 stereo camera systems for a stationary array, \$2.0K was spent for processing software, \$3.5K was spent for a dedicated processing computer, and \$4.5K was spent for travel to ASTWG meetings.

Workshop on advancing the state of electronic tagging technology and use

(Project Leaders: Pete Sheridan, 850-819-8026, pete.sheridan@noaa.gov; John Ferguson, 206-860-3270, john.w.ferguson@noaa.gov; Sandy Downing, 206-860-5604, sandy.downing@noaa.gov)

Goal

The goal is to assess the current use of electronic tagging technology and its derived data to improve stock assessments and ecosystem approaches to fishery management.

Priorities

Tagging and marking technologies are key methods used in addressing fishery management issues such as protecting or rebuilding stocks, allocating catches, or evaluating distribution, abundance and viability of fishery organisms or protected species.

Approach

The approach was to conduct a NMFS-wide workshop on electronic tagging technology and how tag-related data are, could, or should be used.

Work Completed

The NMFS workshop on advancing the state of electronic tagging technology and use was held during 23-25 August 2005 at the Northwest Fisheries Science Center.

Results

The co-chairs submitted the Technical Memorandum to NMFS Scientific Publications Office (F/SPO) in July 2006. Due to work load, F/SPO indicated publication was not expected until FY07.

Impact / Applications

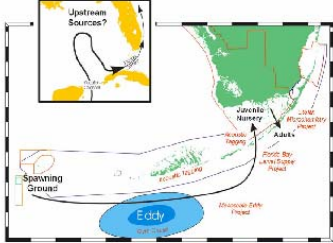
The workshop serves as a contact list, an information conduit to enhance the use of similar tags across NMFS, a means to compare and contrast to capabilities and utility of each tag type, and a venue to begin or extend cooperative efforts between field biologists and stock assessment biologists to better utilize tagging data.

Transitions

The Technical Memorandum will serve as the foundation for both the suggested international tagging symposium.

**Report of the National Marine Fisheries Service
Workshop on Advancing the State of Electronic
Tag Technology and Use in Stock Assessments**
Seattle, Washington, 23-25 August 2005

Pete Sheridan, John W. Ferguson, and Sandra L. Downing (editors)



U. S. Department of Commerce
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
NOAA Technical Memorandum NMFS-XXXX



Related projects

A proposal to develop documents required for an electronic tagging funding initiative was prepared from the workshop report by representatives of all six Science Centers and was submitted to the ASTWG for potential FY07 funding.

Expenditures

FY07: \$5.0K (estimated), including production and distribution costs for a color Technical Memorandum to serve as a contact file for NMFS personnel involved in tagging and to disseminate results to a broad constituency.

Measurements of the temperature-dependent performance of electro-acoustical transducers and quantification of resulting error in echo-integration surveys

(Project Leader: David Demer; SWFSC; 858-546-5603; david.demer@noaa.gov)

Goals

- Minimize uncertainty in echosounder calibrations due to changes in system performance versus changes in water temperature throughout a survey; and
- Reduce uncertainty in measurements of scattering spectra used for species identification, and target strength and volume backscattering strength used to estimate their biomass and dispersion.

Priorities

- Precisely characterize performance versus temperature in 10 echosounder transducers;
- Develop methods to account for these changes; and
- Minimize this component of uncertainty in acoustical surveys of aquatic life.

Approach

In addition to changes in the properties of the transducer materials versus water temperature T , the transmitting current response (S_0 ; $\mu\text{Pa}\cdot\text{A}^{-1}$), the receiver free-field voltage response (M_0 ; $\text{V}\cdot\mu\text{Pa}^{-1}$), and the mechanical resonance frequency (f_r ; kHz) can vary with T . These changes can be characterized using a self-reciprocity calibration, where a transducer projects a pulse of sound at a near perfect reflector (e.g. an air-water interface). Both S_0 and M_0 can be determined from separate measurements of the

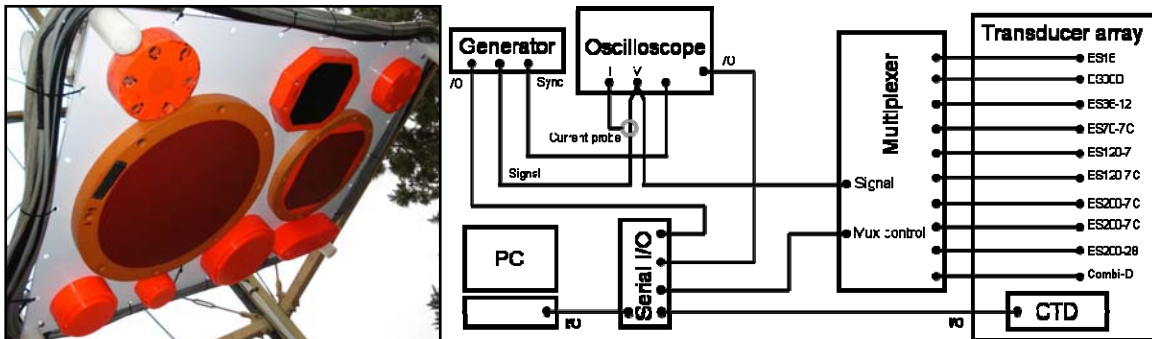


Figure 1: Diagram of impedance measurement apparatus including a custom-made transducer array and multiplexer. Measurements were made in a temperature controlled tank and room.

transmitter current (I_t , A), and the open-circuit voltage (V_r , V), due to the received reflected sound. The ratio of V and I has units of electrical impedance (Z ; Ω). Both Z and the electrical admittance (Y ; S) are derived from measurements of complex voltage (V ; V) and current (I ; A):

$$Z = V/I = R + jX, \quad \text{and} \quad Y = I/V = G + jB,$$

where R is the resistance (Ω), X is the reactance (Ω), G is the conductance (mS), B is the susceptance (S), and $j = \sqrt{-1}$. G is maximum (G_{\max}) at f_r . The quality factor Q (unitless) is a measure of the width of the resonance peak relative to its maximum. S_0 and M_0 can be solved with measurements of the reflectional impedance Z' measured when the transmitted signal overlaps with that from a total reflection (e.g. using a self-reciprocity calibration configuration, during the superposition of a transmitted pulse and its echo from an air-water interface).

Principle measurements of echo sounders are the backscattering cross-sectional area of an individual target (σ ; m^2):

$$\sigma = \frac{P_r 64 \pi^3 r^4 10^{2\alpha r}}{P_t g_0^2 \lambda^2},$$

and the volume backscattering coefficient (s_v ; m^{-1}):

$$s_v = \frac{P_r 32 \pi^2 r^2 10^{2\alpha r}}{P_t g_0^2 r_0^2 \lambda^2 c \tau \psi},$$

which is the backscattering area (m^2) per unit volume of seawater (m^3). P_t is the transmitted power (W), P_r is the received power (W), r_0 is the reference range of 1 m, and ψ is the equivalent two-way solid beam-angle (steradians). Both P_t and P_r are functions of the transmitted voltage V_t and V_r , and the impedance:

$$P_t = V_t^2 / Z(T), \quad \text{and}$$

$$P_r = V_r^2 / Z(T).$$

Changes in $SNR(T) = 10 \log(snr(T))$ are proportional to changes in the transducer impedance divided by the square of the impedance. Changes in $SNR(T)$ will change the effective precisions and maximum detection ranges of the echo sounder measurements.

The accuracy of σ and s_v will be affected by changes in $g_0(T)^{-2}$. The on-axis system gain is a function of the temperature dependent transducer directivity ($d(T)$; unitless), and electroacoustic transducer efficiency ($\eta(T)$; unitless):

$$g_0(T) = d(T)\eta(T).$$

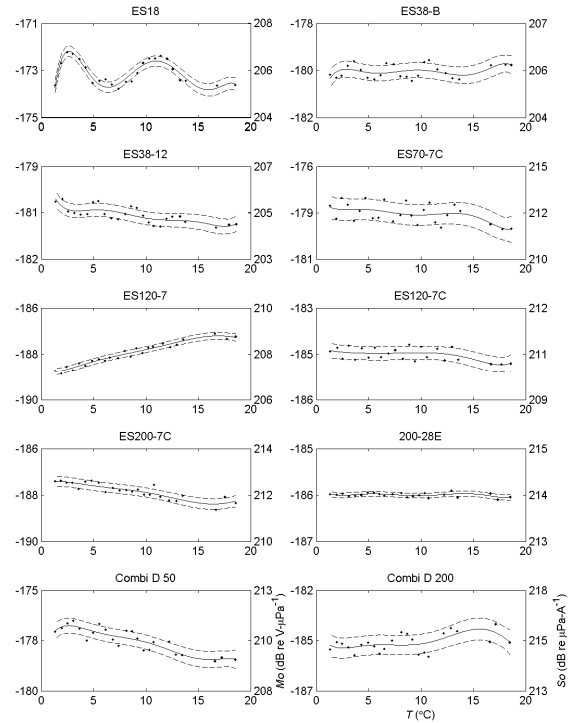


Figure 2. Transmitting current and receiving voltage responses for 10 Simrad transducers. The ES120-7 transducer exhibits the largest dynamic while the ES38-B and 200-28E are relatively stable.

A change in the $d(T)$ due to a change in T is approximately equal to the change in sound speed (e.g. 4.0% or 0.17 dB for a 16 °C change in T), because the effective aperture is inversely related to the acoustic wavelength (λ ; m). Changes in $\eta(T)$ can be more appreciable. At the transducer resonance frequency, $\eta(T)$ can be determined from measurements of $Y(T)$ made with the transducer loaded and unloaded:

$$\eta = \frac{D_W (D_A - D_W)}{D_A (G_{\min} + D_W)},$$

where D_A and D_W are the widths of the unloaded (in air) and loaded (in water) admittance circles (G versus B as a function of f), respectively; and G_{\min} is the minimum conductance in the admittance circle.

Work Completed

The performance characteristics of ten survey transducer models (ES18, ES38-B, ES38-12, ES70-7C, ES120-7, ES120-7C, ES200-7C, ES200-28E, CombiD-50, and CombiD-200) were measured versus water temperature T ranging from approximately 1 to 18 °C. The transducers are split-beam, except for the single-beam ES200-28E and the Combi D 50 and 200. Measurements of the split-beam transducers were made with the four quadrants in parallel.

Four experiments were conducted:

(A) $Z(T)$, $f_r(T)$ and $Q(T)$ were determined from measurements of $V(T)$ and $I(T)$; the corresponding $\Delta snr(T)$ were estimated from changes in $Z(T)$;

(B) $M_0(T)$ and $S_0(T)$ were measured from the vector differences in $Z(T)$ and $Z_{ref}(T)$;

(C) $\eta(T)$ were estimated from measurements of $Y(T)$ when the transducer was loaded and unloaded; and

(D) $g_0(T)$ and $G_0(T)$ for the Simrad EK60 echosounder was evaluated from measurements of $P_r(T)$ in a tank, for five of the most commonly used Simrad transducer models.

Results

The Z , f_r , Q , M_0 , S_0 , and η were measured versus T for ten Simrad transducers. The Simrad EK60 system gain was measured versus T for 18, 38, 70, 120, and 200 kHz

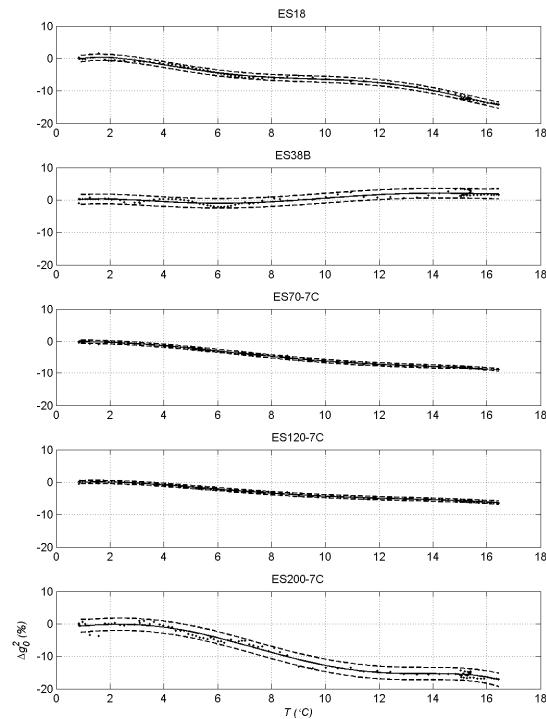


Figure 3. Changes in two-way system gain versus water temperature for five commonly used Simrad transducers. The ES200-7C exhibits the largest dynamic while the ES38-B is relatively stable.

transceivers fitted with ES18, ES38-B, ES70-7C, ES120-7C, and ES200-7C transducers, respectively. All of these parameters change appreciably over the measured range of potential operational temperatures (~1-18 °C). In general, the directions of these changes are not consistent or monotonic. Changes in SNR versus T will appreciably affect both detection ranges and measurement precisions. Also, the on-axis EK60 system gains change appreciably versus T due to changes in the transducer efficiency versus T . The changes in $SNR(T)$ and $G(T)$ are predictable. Changes in the frequency-dependent detection ranges must be considered when using scattering spectral information for species identification, and when calculating insonified volumes. Also, adjustments should be made to the echo sounder system gains during surveys (using e.g. **Fig. 3**), using measurements of transducer or seawater temperature.

Impacts / Applications

Probabilistic comparisons between the shapes of the measured spectra and those predicted by the models may identify acoustic targets. However, the effectiveness of these methods for remote target identification depends on both the accuracies of the scattering spectra predictions and the accuracies and precisions of the measurements at each f . The results of these experiments can be used to reduce uncertainty in measurements of frequency-dependent detection ranges and scattering used for species identification, and target strength and volume backscattering strength used to estimate their biomass and dispersion.

Transitions

By adopting temperature-dependent calibration procedures, survey bias can be minimized. To do this, each transducer must be characterized, or enough transducers of the same model must be tested to define model-specific $G_{\theta}(T)$ with respect to T , including estimated uncertainty.

Related Projects

This project has direct relevance to a multi-frequency drop target strength system proposed to the ASTWG. In addition to changes in transducer performance versus water temperature, the changes versus pressure must be characterized.

Publications

David A. Demer and Josiah Renfree, "Variations in echosounder transducer performance versus water temperature," *J. Acoust. Soc. Am.* (submitted).

Presentations

D.A. Demer and J. Renfree, "Variations of echosounder transducer performance versus water temperature," *J. Acoust. Soc. Am.* 120, 3016 (2006), presented at the 4th Joint Meeting of the Acoustical Society of America and Acoustical Society of Japan, Honolulu, Hawaii, 28 November--2 December 2006.

Expenditures

The \$57k budgeted for this project was spent in the following categories: vector impedance analyzer, \$40k; Deep Tank, \$4k; contract labor, \$10k; and overhead \$3k.

NMFS AUV for Economical Ecosystem Investigations

(Project Leader: David Demer; SWFSC; 858-546-5603; david.demer@noaa.gov)

Goals

NOAA Fisheries acquired a small, inexpensive, portable, multi-instrumented AUV (Autonomous Underwater Vehicle). It can be deployed from or independent of a survey vessel, in a variety of marine ecosystem investigations. The Fisheries AUV will facilitate, possibly for the first time, simultaneous *in-situ* measurements of acoustic target strength and fish species, size, and orientation from stereo images. AUVs will allow essential measurements be made in boundary areas: near the sea-surface (e.g. mapping of epi-pelagic fish schools); the sea-floor (e.g. rockfish or coral reef fish); and in coastal areas inaccessible from a large vessel. There are numerous other applications.



Figure 1. The Fetch 3.5 AUV on the back deck of SWFSC/AST's *R/V D.V. Holliday* during acceptance trials. The AUV includes a 38 kHz split-beam echo sounder, stereo imaging cameras and strobe, a CTD, Doppler velocity log, GPS, and 900 MHz ethernet telemetry. The AUV was tested off San Diego from July to December, 2005. Since then, procurement issues have halted its use.

Priorities

The AUV should include a sensor suite appropriate to concurrently explore biological, physical, chemical, and geological aspects of the oceans and to elucidate their interrelationships. The AUV platform should improve the efficiencies of many routine studies, expand some to more critical time- and space-scales, and make other investigations feasible for the first time.

Approach

Procure and use a commercial Autonomous Underwater Vehicle (AUV), customized with Fisheries instrumentation and conforming to the following general specifications: small, three-man-deployable, modular payload, COTS design; 0.35 m diameter; 2.03 m long, 130 kg; speeds up to 5 knots; duration of 20 hours at 2.2 knots; maximum depth of 150 m; and fisheries instrumentation including a 38 kHz split-beam echosounder, 300 kHz ADCP, CTD, and stereo imaging system with illumination.

Work Completed

The following is a synopsis of the difficulties encountered with the AUV acquisition:

- Sias-Patterson, Incorporated (SPI) underestimated the task of integrating the fisheries sensors into their Fetch 2.9 AUV. A larger Fetch 3.5 AUV was necessary to accommodate the sensors and SPI underestimated these costs.
- Lab Training on Fetch I AUV (Fetch 3.5 partially constructed): 8-10 September 2004; Sias-Patterson, Incorporated Yorktown, VA (Sessions, Needham, and Demer); Field Training on Fetch I AUV (Assembly and disassembly training on partially completed Fetch 3.5): 8-12 November 2004; SWFSC San Diego, CA (Patterson, Sias, Sessions, Needham, Jech, Thompson, Wong, Demer, Ressler, and Furnish)
- SPI restructured as Sias-Patterson, Limited Liability Corporation (SP-LLC); After constructing Fetch 3.5, SP-LLC hired a new CEO, Bob Mckisson. He directed SP-LLC to shelve the Fetch 3.5. After much discussion, SP-LLC delivered the AUV to SWFSC and essentially began testing.
- System Characterizations: July-August 2005; SWFSC, San Diego, CA (Sessions, Needham, Paterson, Arnold, Renfree, and Demer)
- The AUV and accessories were returned to SP-LLC for repairs, fitting of a new aft hull section, and pressure testing.
- SP-LLC fired CEO Bob Mckisson.
- System Acceptance Testing: November-December 2005: SWFSC, San Diego, CA (Paterson, Arnold, Sessions, Needham, Paterson, Renfree and Demer). The AUV requires further refinements to maximum speed and stability specifications, and to achieve predictable unattended operations.
- SP-LLC sells all assets to Prizm Advanced Communications;
- The final payment of \$16.3k was withheld from SP-LLC and the contract was terminated for default. NOAA/NMFS maintained custody of the AUV. In December, 2005, DOC/GC Terry Hart Lee advised not to use the AUV, indefinitely.
- January-May, 2006, a sole source contract was prepared for Prizm to refine the AUV for predictable unattended operations; Prizm responds to the solicitation with a proposal to evaluate the AUV at a cost of ~\$30k. NOAA does not return the unobligated \$16.3k to SWFSC; spending deadlines have past; and Prizm's proposal is considered improper.
- June-December, 2006, a written agreement with Prizm is imminent.

Results

A novel lifting cradle for deploying and recovering the AUV from large ships was developed and tested from the pier at Scripps Institution of Oceanography (**Fig. 2**). Testing of the cradle with the Fetch 3.5 AUV was not possible due to procurement issues.

Following the intense efforts to test the AUV during acceptance trials in Q1, SWFSC/AST focused Q2-Q4 efforts on gaining familiarization with the numerous AUV subsystems, and the navigation and control software.

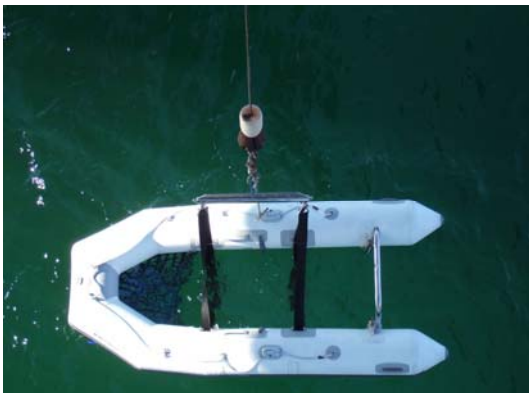


Figure 2. AUV lifting cradle (a) floating on the water with slack given to the support straps (b); and lifted from the water to recover the AUV (c).

Impacts / Applications

Concurrent assessments of multiple marine trophic levels, their essential habitats, and ecosystem variability due to natural and anthropogenic causes are increasingly necessary for fisheries management. Most of these studies would benefit from more observations than can be accommodated by the fleet of NOAA research vessels. Therefore, to economically and physically conduct such multidisciplinary studies on the most appropriate time- and space-scales, NOAA Fisheries is developing and acquiring a suite of alternative survey platforms including instrumented small-craft, buoy arrays, and autonomous underwater vehicles (AUVs) to augment the NOAA fleet. Some of the AUV projects discussed for 2007 include improved target strength estimation of west coast rockfish, Bering Sea pollock, and Atlantic herring; and characterization of fish avoidance reaction to traditional versus the new quiet survey vessel.

Transitions

Following AUV characterization experiments during FY07, west- and east-coast demonstration projects will be conducted. The system for sharing this asset is to be developed, tested and refined using proposals from Centers collaborating on the demonstration projects.

Related Projects

The ASTWG plans to add the following sensors to the AUV: a passive acoustic array; obstacle avoidance sonar, and sidescan sonar.

A white paper was prepared for an OAR/NMFS AUV collaboration. The white paper may be considered at a management retreat in January, 2007. The proposed workshop and demonstration projects (NURP large AUV and NMFS small AUV) would be collaboratively conducted to improve communications and cooperation between the agencies and thereby improve the efficiencies of technology development for fisheries surveys and research.

Publications

The San Diego Union Tribune highlighted the AUV training operations (http://www.signonsandiego.com/uniontrib/20041111/news_1m11remote.html), which were hosted at SWFSC in November, 2004. The Fisheries AUV was also showcased in a NOAA Report, and included in NOAA's WG-AUV's Strategic Plan and Report. The Collaborative SWFSC/U.S.AMLR/VIMS AUV investigations in the Antarctic were included in the U.S. AMLR Program's Field Season Report.

Expenditures

The FY06 budget for maintaining, developing, and deploying the Fetch AUV (\$200k) was spent in the following categories (travel, 3.45k; transportation, 1.26k; contract labor 171.64k; materials and supplies 8.26k; and overhead, 15.39k. Besides the labor and the overhead, the expenses were incurred during the extensive field trials in Q1. A portion of AUV-related labor is pre-funded for FY07.