NOAA-Fisheries Advanced Sampling Technology Working Group (ASTWG) FY 07 Annual Report

EXECUTIVE SUMMARY

The long-term goals of the Advanced Sampling Technology Working Group (ASTWG) are 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 for the ASTWG in FY07 were to continue development of an alternative sampling platform (AUV), to improve acquisition and analyses of underwater images, to improve accuracy and precision of acoustic estimates, and to initiate efforts towards improving tagging technologies.

The NOAA Fisheries AUV underwent a series of field tests and modifications making the vehicle capable of depth holding and conducting single-leg deployments. Plans for the coming year are to replace current AUV buoyancy with syntactic foam, integrate multiple sensors for mission decision making, achieve multi-leg deployments and begin testing the AUV at deeper depths. The ASTWG funded 6 grants that addressed needs and knowledge gaps in assessments of living marine resources. These projects included developing an in-situ means to validate acoustic target strength, a towed high speed optical validation camera, a low cost device for broad scale sampling of marine sound and development of receiving stations for tracking animal movement using cell phone technology. Two grants were awarded for workshops, one on modeling fish and zooplankton acoustic scattering and the other on fisheries applications for the ME70/MS70.

This report consolidates the annual reports of the Science Centers advanced technology initiatives to highlight accomplishments of the Science Centers through funding by the ASTWG. Also appended in the back of the report are progress reports of technology projects supported by the ASTWG grant program.
Regional Support of FY07 ASTWG: Northeast Fisheries Science Center

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GOALS
The goal of ASTWG supported efforts at the Northeast Fisheries Science Center (NEFSC) is 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 FY07 were to develop the technical infrastructure required to improve fish stock assessments, participate in ASTWG national initiatives, complete the ASTWG-supported research FY06 project “Broadband discrimination between anatomical groups of fish and zooplankton-demersal and pelagic regions” with Woods Hole Oceanographic Institution, and begin ASTWG-supported research FY07 projects “Multibeam (Simrad ME70/MS70) users workshop for fisheries applications”, “Workshop on modeling fish and zooplankton acoustic scattering” and “Remote detection and identification of marine animals to improve fish and habitat assessment using a Dual Frequency Identification Sonar (DIDSON)”.

A FY07 priority for the NEFSC Advanced Sampling Technologies group was the continued 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 provided engineering support for various advanced sampling technology projects; fisheries acoustics, seafloor and habitat mapping, underwater video, and survey gear performance.

We hosted two summer undergraduate students for 10 weeks this summer. The first was a Hollings Scholar who assisted with calibration of underwater stereo cameras. The second was an EPP scholar who worked on integrating acoustic and trawl data in GIS.

Effort was devoted to developing NEFSC’s acoustic capabilities aboard the FSV H B BIGELOW. The capabilities include split-beam scientific echo sounders (EK60) and multibeam (EM3002) sonar.
The NEFSC is continuing its efforts at 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 of 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.

A research cruise was conducted during September 2007 on the R/V ENDEAVOR to continue development of the broadband acoustic system in conjunction with scientists at WHOI. We collected broadband acoustic data on Atlantic herring, haddock, silver hake, and Acadian redfish to begin to build an acoustic library on these species. During this cruise, the DIDSON sonar was deployed to observe herring behavior acoustically.

We have also participated in meetings to discuss progress on the ME70. The objectives of these meetings are to maintain communication among the Science Centers and the manufacturer on development of the ME70 multibeam and initiate collaborations among the Science Centers and academia.

RESULTS

Fish were imaged in the Georges Bank region of the Gulf of Maine using the optical capabilities of the AFTV (Fig. 2)

The DIDSON sonar was deployed on the northern flank of Georges Bank during the first two weeks of the NEFSC’s annual acoustic survey of Atlantic herring in September 2007. These deployments were the first on Atlantic herring in the Gulf of Maine. We are initiating efforts to utilize the DIDSON sonar for identification and classification of acoustic backscatter, length measurements, and behavioral observations. The DIDSON has high spatial resolution and can be used to detect fish near the bottom (Fig. 3).
Figure 2. Images of fish from the AFTV. The fish in the image on the left is possibly an Acadian redfish and the fish in the image on the right is probably a haddock. The AFTV frame and lead weights are visible in the lower portion of the images.

Figure 3. Echogram of single ping from a Dual-frequency IDentification SONar (DIDSON). The DIDSON was operating at 1.1 MHz, with 48 0.4° by 12.0° beams and 7 cm range resolution. Data were collected in the Georges Bank region of the Gulf of Maine on 10 September. The upper panel demonstrates detection of the sea bed (horizontal band of red/white/blue backscatter at 10 m) and a fish near the sea bed. The lower panel shows an enlarged view of the fish and sea bed. From the beam geometry, the fish length is estimated at 28 cm and the fish is approximately 7 cm off the sea bed. Historical trawl catch data have shown Atlantic herring (Clupea harengus) of this length range in this area.
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 (which were completed in FY07)
- 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) and three projects in FY07
- Multibeam (Simrad ME70/MS70) users workshop for fisheries applications by D. Demer (SWFSC), Chris Wilson (AFSC) and M. Jech (NEFSC)
- Workshop on modeling fish and zooplankton acoustic scattering by M. Jech (NEFSC) and J. Horne (U. Washington), and
- Remote detection and identification of marine animals to improve fish and habitat assessment using a Dual Frequency Identification Sonar (DIDSON) by C. Wilson (AFSC) and others from the Science Centers.

Progress reports for these projects are appended as separate documents.

PUBLICATIONS

PRESENTATIONS

**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 $110K. An additional tax was imposed on the $135K by the NEFSC ($25K) for a total salary and tax reduction of $135K.
Regional Support of FY07 ASTWG:
Southeast Fisheries Science Center

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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) and natural mortality within the US Gulf of Mexico, South Atlantic, and Caribbean regions.

APPROACH
FY07 activities addressed improving reef fish assessments. Fishery-independent surveys for reef fish are typically conducted using non-extractive visual methods, either by divers or video cameras, to estimate fish density and community structure. The value of these surveys can be improved through the use of stereo imaging systems to obtain accurate measurements of fish length without the necessity of capture. A camera system has been developed that incorporates both video and stereo still cameras to image reef fish that will be used during field surveys in FY08.

WORK COMPLETED AND RESULTS
Development of stereo video camera systems was continued during FY07. The system is composed of color video and stereo monochrome still cameras controlled by a PC104+ computer and installed in an underwater housing. In FY07 the housings were reconfigured to accept auto-iris video cameras and the CPU’s were upgraded to improve download speed. Four complete camera systems have been built and are being used during a reef fish survey in the first quarter of FY08. A companion computer system was built that can download data from all four camera systems simultaneously and archive the data on Blue-Ray discs. These hardware changes have reduced the total time required to download all four systems to approximately half the acquisition time.
for VMS software for analysis of the stereo images was acquired and a server is being networked to provide data access to multiple analysts.

The Harvesting Systems Branch of SEFSC Mississippi Laboratories evaluated a Dual Frequency Identification Sonar (DIDSON) and its ability to image marine mammals and sea turtles during interactions with shrimp trawls and Turtle Excluder Devices (TEDs.) Results were promising, and future use of the DIDSON may reveal how dolphins become entangled in trawls, leading to possible design changes or usage techniques to reduce the likelihood of dolphin drowning.

The ASTWG-supported FTE participated in various projects during the year. He conducted a survey of part of the Florida Keys National Marine Sanctuary using side-scan sonar and underwater video to locate material illegally dumped as artificial habitat to attract lobster, and he collected bottom sediment samples as part of the 07 Small Pelagics survey. He was responsible for calibrating the stereo camera systems and measuring fish lengths in the collected images during development and testing of the systems. He also developed and submitted a proposal to the ASTWG to automate processing and analysis of images from underwater cameras such as the stereo cameras SEFSC is using for reef fish assessments.

**IMPACT / APPLICATIONS**
Stereo camera systems represent a significant advance in SEFSC’s ability to assess reef fish stocks. These systems will provide more accurate length measurements on a greater number of individual fish than was possible with previous techniques (paired laser arrays or viewer estimation).

**TRANSITIONS**
Four stereo video camera systems with the same design as the SEFSC’s but slightly different hardware were constructed for the Florida Fish and Wildlife Conservation Commission for use in their reef fish research.

**RELATED PROGRAMS**
Development of the stereo camera system is expected to benefit several programs, including on-going monitoring of reef fish communities in Marine Protected Areas (MPAs) in the NE Gulf of Mexico and in the South Atlantic Bight as well as the newly implemented State-Federal West Florida Shelf reef fish survey. Each of these programs requires more accurate methods to measure the size of animals captured or observed.

**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.

**PRESENTATIONS**
No presentations were made during FY07.

**EXPENDITURES**
The Southeast Fisheries Science Center was allocated $135K in FY07 to support the FTE position, ASTWG participation (travel to the May 2007 meeting), and field activities described above.
Regional Support of FY07 ASTWG: Southwest Fisheries Science Center

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GOALS
The Advanced Survey Technologies Group (AST) in the Fisheries Resources Division (FRD) at the Southwest Fisheries Science Center (SWFSC) supports ecosystem-based fisheries management through new or innovative uses of sampling technologies.

PRIORITIES
During FY07, the priorities of AST were manifold. The group:

- Identified new, promising topics for research within the SWFSC and with collaborators;
- Conducted research and development on advanced technologies for improving the accuracies, precisions and efficiencies of fisheries surveys;
- Analyzed, interpreted and reported data and results from research and development pertaining to advance survey technologies and their applications;
- Communicated research results in various professional venues such as presentations at professional meetings and publications in peer reviewed journals;
- Provided service and leadership outside of NOAA and served on domestic and international scientific working groups, advisory panels, formal and ad hoc groups; and
- Provided professional and scientific expertise through manuscript reviews, scientific editing, and participation in formal academic teaching.

APPROACH
AST characterizes measurement and sampling uncertainties, defines gaps in existing data, and develops, refines, and employs advanced survey technologies to improve the accuracies, precisions and efficiencies of fisheries surveys and thus resulting stock assessments. To maintain an emphasis on the scientific objectives, rather than on the instrument or instrument platform being developed, AST also conducts fisheries research and surveys using the instrumentation and methods it develops. Examples of advanced survey technologies being developed by AST include: instrumented buoys, instrumented small craft, and autonomous underwater vehicles (AUVs).

WORK COMPLETED
During FY07, AST has:

- Tested and refined the NOAA Fisheries AUV, and prepared it for operational deployments.
- Refined a large-ship AUV recovery device;

• Made operational the Collaborative Optically-assisted Acoustic Survey Technique (COAST) for estimating the distributions and abundances of rockfishes in the Southern California Bight;

• Surveyed coastal pelagic and rockfish species off the west coast of the United States;

• Refined SM20/SM2000 multi-beam sonar to survey fish and bathymetry;

• Led the design, construction and deployment of a micro echosounder, underwater stereo camera system, low-cost passive acoustic logger, and deepwater echosounder;

• Coordinated surveys of zooplankton, predators, and bathymetry in Antarctic nearshore;

• Orchestrated a second small-boat multi-beam sonar survey in the Southern Ocean;

• Directed the calibration, collection and analysis of PRD acoustic survey data;

• Made total target strength measurements of juvenile salmon for remote detections; and

• Developed specifications for ME70 broad bandwidth multi-beam sonar data processing.

RESULTS
Progress reports for projects funded by ASTWG are provided as separate documents. Results of other AST projects are documented in Publications below.

IMPACT/APPLICATIONS
Fisheries resources must be understood and managed in the context of ecosystems. NOAA Fisheries and its Advanced Sampling Technologies Working Group aim to meet this challenge with development and increased use of instrumented small craft, buoys, satellites and autonomous underwater vehicles as critical components of our nation’s ocean observation system.

TRANSITIONS
AST served on NOAA/NMFS teams, task forces, and ad hoc groups:

• SWFSC Representative to NMFS Working Group on Advanced Survey Technologies

• NMFS Representative to the NOAA Working Group on Autonomous Underwater Vehicles

• Committee member for the SWFSC Ocean Ecosystem Observing Task

• Chair of the ICES Working Group on Fisheries Acoustic Science and Technology (WGFAST)
• U.S. Representative to the Working Group on Environmental Monitoring and Management reporting to the Scientific Committee of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR)


AST advised students including:
  • Post-Doctoral Advisor to Ana Sirovic, Ph.D., Oceanography, UCSD / Scripps Institution of Oceanography.
  • Hollings Fellowship Advisor to Jason Eckstein, B.S., Engineering, Columbia University, NY.
  • Undergraduate internship advisor to Conrad Salinas, B.S., Electrical Engineering, University of California, San Diego

RELATED PROJECTS
AST applied for and received funding from the ASTWG for the following projects:


• G.R. Cutter, Jr. and D.A. Demer, “Optical validation of acoustical targets using a high-speed underwater camera system,” NOAA/NMFS/ASTWG, $61.7k.


• C. Wilson, D.A. Demer and J.M. Jech, “Multibeam (Simrad ME70/MS70) users workshop for fisheries applications,” NOAA/NMFS/ASTWG, $20.6k
• C. Wilson, D.A. Demer and J.M. Jech and others, “Remote detection and identification of marine animals to improve fish and habitat assessment using a Dual Frequency Identification Sonar (DIDSON)”.

AST was also a co-recipient of a grant from the Gordon and Betty Moore Foundation:
• T. Koslow and D.A. Demer, “The Role of Mid- and Upper Trophic Levels in the California Current: Toward Ecosystem-Based Fishery Management,” $660.5k. This money is to outfit a Scripps ship with multi-frequency echosounders, hull-mounted transducers, and data collection and processing equipment. Additionally, a portable multi-frequency echosounder array will be fabricated for use on other vessels; and multiple researchers and technicians will be trained to collect, process and interpret the acoustic data.

PUBLICATIONS
Papers published and submitted for peer-reviewed publication in FY07:


Published Abstracts:


Reports:


AST was invited to speak at the following fora:

• Pacific Islands Fisheries Science Center, Honolulu, Hawaii; D.A. Demer presented “Collaborative Optically-assisted Acoustic Survey Technique (COAST) Applied to Rockfish in the Southern California Bight.”

• Workshop on Climate effects on the California Current Ecosystem, Scripps, Institution of Oceanography, La Jolla, CA; D.A. Demer presented “Acoustic observations of biological populations”.
• NMFS Science Board Meeting, La Jolla, May 3, 2007; D.A. Demer presented “The Collaborative Optically-assisted Acoustical Survey Technique”.

PRESENTATIONS
AST participated in the following presentations:


• D.A. Demer presented “Acoustic-optical techniques for surveying demersal fish,” and “Target strength models and multi-frequency measurements of Antarctic krill, myctophids and squid,” at the CCAMLR WG-EMM’s Study Group on Acoustic Survey and Analysis Methods; and

• M.J. Cox, D.A. Demer, J.D. Warren, G.R. Cutter, and A.S. Brierley presented “Characterizing the three dimensional structure of Antarctic krill (Euphausia superba) swarms,” at the 4th International Zooplankton Production Symposium, Hiroshima, Japan.

EXPENDITURES
In addition to the grant moneys from ASTWG, the SWFSC was allocated $135K in FY07 to support one FTE position (G.R. Cutter).
Regional Support of FY07 ASTWG: 
Northwest Fisheries Science Center

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GOALS
The goals 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 and expand the information gathered for use in integrated ecosystem assessments (IEAs). These goals will be accomplished by identifying information and technology needs for existing and new assessments, improving these assessments, and advancing our understanding of the marine environment. By identifying new and innovative uses of sampling technologies and advancing these technologies, we will facilitate acquiring the necessary information for ecosystem-based management decisions.

PRIORITIES
Priorities during FY07 included participation in ASTWG national initiatives, attending the ASTWG semi-annual meeting, comparison testing the Seabed AUV with the DFO ROV, deploying a larger number of the improved DNA sampling hooks, and developing a portable and autonomous GPS logger for use by groundfish observers.

APPROACH
Our approach was to develop and employ state-of-art 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
Comparisons between AUV and ROV surveys of inshore rockfish
Dr. Elizabeth Clarke and Mr. Stan Tomich (NWFSC) and Dr. Hanumant Singh Woods Hole Oceanographic Institute (WHOI) participated on a Cruise with Canadian colleagues at Department of Fisheries and Oceans (DFO) Canada onboard the CCGS Vector April 14 - 23, 2007. The objective of the cruise was to compare the abilities of the SeaBED Autonomous Underwater Vehicle (AUV) and the DFO Remotely Operated Vehicle (ROV) to conduct inshore rockfish surveys. The DFO ROV was fitted with video cameras and used a DIDSON system to assist in navigation within rock areas. The SeaBED AUV collects high-resolution digital still images and navigates at a pre-programmed distance from the bottom. This is part of the ongoing work with Hanumant Singh (WHOI) to develop the SeaBED AUV to survey groundfish in untrawlable areas on the West Coast.

Portable and Autonomous GPS Logger
There is a need to capture independent and accurate tow track information aboard commercial trawl vessels operating off the west coast. Current Vessel Monitoring Systems (VMS) that are deployed on these fleets provide only a rough estimate (based on vessel speed) of fishing location and effort. Over the summer and winter of 2007, a prototype GPS logger, a "black box" which can autonomously log fine resolution ship track information during a trawling event, was developed. The GPS logger is designed to be carried to a vessel by a groundfish observer, easily mounted above the wheelhouse and operated remotely from deck to activate the logging of the ship's track during trawling. This device will give a more detailing picture of trawling activity than is recorded either in logbooks and or by VMS and will be used for analysis of bycatch “hotspots”.

New Hook for DNA Sampling

The 2007 FRAM Hook and Line Survey for Shelf Rockfish in the Southern California Bight was conducted from September 25 through October 7 aboard two chartered sportfishing vessels - the F/V Mirage and F/V Aggressor. In addition to annual population monitoring operations, survey personnel deployed custom-engineered hooks designed to collect tissue samples of important rockfish (Genus: Sebastes) species without the barotrauma and other stresses associated with capture with traditional fish hooks. During a fish strike, the hook is designed to trip from a cocked position to a triggered position where a metal sheath is forced down over the exposed tip, preventing multiple fish from striking the same hook. DNA from these specimens is analyzed in the laboratory and identifies the fish's species and provides a unique combination of genetic markers that effectively "fingerprints" the fish for identification in subsequent genetic sampling operations. This becomes a “genetic tag” and genetic tag and recaptures can be analyzed similarly to more traditional tag recapture data to provide population estimates.

RESULTS

AUV and ROV Comparison for inshore rockfish surveys

The AUV and ROV comparison cruise was conducted in April 2007 on a Canadian vessel, CCGS Vector (Department of Fisheries and Oceans) in the Georgia Strait north of Vancouver Island. The AUV performed well despite the challenges of both high tidal current and high turbidity. The AUV could be deployed in similar areas to the ROV and several “side by side” comparison tows were
conducted. Data have been extracted, fish counting is continuing and comparisons between ROV and AUV are being conducted.

New Hook for DNA Sampling
During the 2007 survey, a total of 372 DNA hooks were deployed during three separate sampling sessions conducted at 14 Mile Bank. Operations included the testing of two separate hook tip designs for differences in hook performance and differences in the amount of tissue collected during deployment. 99 hooks outfitted with newer flat tips were compared with 273 round tips used during genetic sampling in previous surveys. Final results on tissue capture are still being processed, however hooks with the newer flat tips were approximately 15% more likely to trigger than hooks with the round tips.

Portable and Autonomous GPS Logger
In 2007 GPS loggers were deployed with several senior observers on a pilot basis. Needed improvements in battery power were identified. These improvements are being made.

IMPACT / APPLICATIONS
Our efforts have improved 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 academic institutions, as well as having impact within NMFS.

TRANSITIONS
The cruise comparing AUV and ROV as tools for inshore rockfish surveys in untrawlable areas provides important and useful scientific and technical information and experience to help the transition of AUV surveys methods from research to operation. The AUV methods are being further refined during surveys off Puerto Rico to be conducted in April 2008. In addition, the project on the DNA Sampling Hook contributes our effort in developing a cost-effective and non-lethal monitoring technology for fisheries application. The GPS tracking of trawling patterns will be used to further define areas where bycatch of overfished groundfish is high and will provide more detailed scientific advice to implement rockfish conservation areas.

RELATED PROJECTS
N/A for the FY2007.

PUBLICATIONS

**EXPENDITURES**

The Northwest Fisheries Science Center (NWFSC) was allocated $135K in FY07 to support the FTE position and ASTWG participation. Salary and travel costs for this FTE exceeded 135K and were supplemented from other Groundfish research funds. The FTE supported has assisted in these projects described above.
Regional Support of FY07 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 existing sampling technologies, and facilitating and conducting research to advance our understanding of the marine environment.

PRIORITIES
The FY07 priorities for AFSC projects, which involved some ASTWG-support were: 1) continue research with ASTWG DIDSON imaging sonar and a large midwater trawl to investigate net selectivity of walleye pollock to this trawl, 2) begin development of an autonomous lowered target strength (TS) system to refine estimates of walleye pollock in situ TS, 3) participate in a Simrad ME70 multibeam workshop and several web-conferences to evaluate performance characteristics and to develop research strategies for the ME70 in conjunction with other researchers within NOAA, other research institutes (e.g., IFREMER, UNH) and the private sector (Simrad), 4) develop various innovative software and hardware tools for use primarily during stock assessment surveys.

APPROACH
Our approach in developing AFSC’s advanced sampling technologies has been to allocate efforts for research, evaluation, and implementation of new technologies during the course of routine survey operations. The approach can be a collaborative (e.g., ME70, lowered TS system) or an individual effort (e.g., net selectivity) although in all cases, the products will have widespread applications within NOAA and elsewhere.

WORK COMPLETED

Net selectivity based on DIDSON imaging sonar

The DIDSON along with its autonomous deployment accessories was deployed on the midwater survey trawl in various locations successfully 25 times in 2007 during acoustic abundance surveys for walleye pollock in March in the Gulf of Alaska and June-July in the eastern Bering Sea. Based on information collected with other samplers (i.e., pocket nets) attached in numerous locations on the trawl, efforts were concentrated to optimize the Didson attachment mechanism for the bottom trawl panel. Consequently, most Didson data for FY2007 provide a view of the bottom panel of the trawl ahead of the codend (Figure 1). Small “pocket” nets designed to capture animals passing through the larger meshes of the trawl were used during many of the tows with the Didson. Because existing target tracking software was found to be inadequate, customized software was developed in Matlab to remove the background trawl signature in the DIDSON data and automatically track fish targets. This software was developed jointly with Dr. N.O. Handegard (Institute of Marine Research, Bergen Norway). The software will be used to analyze data collected during trawl deployments.
Figure 1. Position of Didson inside large midwater trawl.
Lowered target strength (TS) system

The lowered TS system (Figure 2) is a collaborative effort between SWFSC and AFSC. Researchers at SWFSC completed phase 1 of the project, which included the design, manufacture, testing and design refinement. The system was deployed off the coast of Southern California to measure target strengths of rockfish near the seafloor. The system can operate autonomously and logs data internally. Alternatively, the system can be connected to a Cat5 Ethernet cable for long-range (>500 m) control and communications. Further tests were conducted, and a rigging arrangement to decouple the motion of the vessel from the deployed TS system was finalized aboard the Oscar Dyson in Puget Sound in January. Plans are underway to use the system to collect TS measurements on pre-spawning walleye pollock during the March 2008 AFSC Shelikof Strait acoustic survey. Efforts to integrate an acoustic modem with the system to allow wireless remote control and communication are anticipated to be completed by late spring, and will be followed by additional tests during the AFSC eastern Bering Sea acoustic survey in June-July.

ME70 multibeam workshop and related activities

Several different activities focused on the newly acquired Simrad multibeam ME70 and served to increase our understanding on the fundamentals of operation and performance capabilities of the ME70. This knowledge greatly facilitated efforts to identify fisheries-related research questions that could be best addressed with the ME70. The work included: 1) participation in two ME70 web conferences with NOAA Fisheries scientists and Simrad ME70 representatives including the ME70 project manager; 2) Field-training of two NOAA Fisheries scientists (Chris Wilson (AFSC), David Demer (SWFSC) by IFREMER scientists experienced in the use of the ME70, during an IFREMER cruise aboard the vessel, Thalassa; and 3) collaborative work with Tom Weber (University of New Hampshire) aboard the Oscar Dyson while the vessel transited north from Seattle to Alaska. Although the primary objective during the transit was to explore the performance capabilities of the ME70, particularly with regard to water-column backscatter, other features of the instrument were also evaluated, including the use of seafloor scattering to map the bathymetry (Figure 3).
AFSC Advanced Technology Hire (Rick Towler) Activities

Hardware projects
In early 2007 hardware prototypes for an electronic fish measuring board (EFMB) based on magnetostrictive technology were evaluated and a final design was developed (Figure 4). Environmental tests were successfully completed verifying operation at extreme temperatures. Two boards were built and readied for the AFSC summer 2007 field season where they performed extremely well. Minor deficiencies in the cases were noted and corrected. Two additional boards are currently being assembled for use in the 2008 field season. The two employees responsible for the design and construction of the EFMB (Rick Towler, Kresimir Williams) received a NOAA Bronze medal for this work.

The “Pea Pod” camera is a very low-cost stereo camera prototype, which was originally developed to look at in-situ fish behavior in a large midwater trawl as part of the AFSC Net Selectivity project (see above). The Pea-Pod system uses two off-the-shelf digital SLR cameras, a salvaged dive strobe, and a custom controller housed in inexpensive housings machined from trawl floats (Figure 5). The system was repeatedly deployed very successfully during the entire 2007 field season (Figure 6). Plans are currently underway to modify the system to include gyroscopic sensors and an inertial measurement unit to enable improved estimates of animal orientation, length, and location in the trawl.
A project requiring the simultaneous collection of ADCP data and EK60 data in 2007 initiated development of the “Trigger Jigger” programmable sonar trigger delay (Figure 7). Complex triggering sequences can be programmed and the device can also alter trigger sequencing based on an external input (i.e. SCS DBS telegrams). Although hardware development is complete, software and firmware development continues as research into EK60 and ME70 triggering sequences advances. The trigger-jigger is currently used aboard the NOAA ships Oscar Dyson and Miller Freeman and a unit has been requested for the Henry Bigelow.

**Software projects**

Significant development has been made in the automated acoustic data processing MATLAB library, which was originally developed for an on-going MACE project to semi-autonomously process quantitative acoustic data (i.e., Simrad ES60) collected aboard vessels of opportunity such as commercial fishing vessels. Additions to the Matlab library include a generalized filter framework, new plotting routines, and automated triangle wave correction of the ES60 data. Currently, we are identifying the acoustic data processing needs of researchers outside of the MACE Program at AFSC to expand the software capabilities of the library, as well as exploring strategies to create these general processing tools that are deployable without a MATLAB license (e.g., Matlab Compiler toolbox).

In support of the lowered TS system project (see above), two Matlab libraries have been developed for working with the system’s ER60 system. The first is an ER60 client for MATLAB that provides an interface to the ER60 remote control and data subscription server. Thus, the operator of the TS system can easily subscribe and unsubscribe to data streams and send commands to control the operation of the sounder. This library is not specific to the lowered TS system and can be used in any application that requires monitoring, control, or specialized logging of EK60 data. The second library is a message passing system optimized for low bandwidth, high latency, half-duplex connections such as the acoustic modem that is currently being incorporated into the lowered TS system. A GUI based application is being built using these libraries to provide monitoring and control of the TS system while deployed via the acoustic modem data link.

![Figure 7. The trigger-jigger is a microcontroller-based device that accepts a single trigger input and generates 4 outgoing trigger pulses with programmable delays.](image-url)
RESULTS

*Net selectivity based on DIDSON imaging sonar*

Preliminary results show potential differences in fish behavior based on fish size composition, trawling depth and survey season. An analytical procedure for quantifying these differences is being developed. Distinct individual fish reactions to the trawl have been observed, and will provide the basis for examining the fish escapement process in detail. The analysis will consist of comparing observed behavior patterns among trawls with different pollock size composition, while incorporating potential effects of environmental variables such as temperature and light level. Examples of the type of behavior patterns observed are given in Figure 8.

![Figure 8. Several different types of fish trajectories and inferred behaviors based on Didson data collected from a large midwater trawl during March 2006.](image)

*Lowered target strength (TS) system*


Currently, minor repairs to the unit are being made based on results of recent tests. Additional results are anticipated based on successful deployments of the TS system during the AFSC March, 2008 acoustic survey of walleye pollock in the Gulf of Alaska.

*ME70 multibeam activities*

See ASTWG FY07 Progress Report on, “Workshop on the Simrad ME70 broad bandwidth multi-beam for fisheries applications.” In addition, preliminary results based on ME70 data collected during the upcoming AFSC Shelikof acoustic survey in March 2008 are anticipated and will be presented at the April-May ME70 web-conference meeting.
IMPACT/APPLICATIONS
All of the projects described above are designed to improve survey estimates of abundance by quantifying and reducing sources of bias and uncertainty. This is accomplished in two ways. First, by providing methodological and technological advances to acoustic survey efforts, and secondly by testing assumptions inherent in acoustic survey methodologies.

TRANSITIONS
Many of the technological developments described above are currently used during the routine stock assessment survey efforts conducted at AFSC by the acoustics program (MACE). Examples would include the electronic measuring board and trigger-jigger instrument control box. Transition from other work is more long term (e.g., net selectivity and lowered TS system) but the results of these studies will be used to refine and improve the stock assessment efforts when appropriate.

PUBLICATIONS
Handegard, NO and Williams, K. accepted. Automated tracking of fish in trawls using the DIDSON (Dual frequency IDentification SONar). ICES J. Mar. Sci. 65.

PRESENTATIONS

HONORS/AWARDS
Rick Towler and Kresimir Williams received a NOAA Bronze award for their work on the Electronic Fish Measuring Board.

EXPENDITURES [$170K]
The Alaska Fisheries Science Center (AFSC) was allocated $135K in FY07 to support the FTE position and ASTWG participation. Funds were also received in support of two ASTWG proposals: $31k for the project entitled, “Development of an autonomous lowered acoustic system for improved in situ target strength measurements”, and $4k for the project entitled, “Workshop on the Simrad ME70 broad bandwidth multi-beam for fisheries applications.”
Regional Support of FY07 ASTWG:  
Pacific Islands Fisheries Science Center  
(Representatives: Frank Parrish frank.parrish@noaa.gov and Mike Seki michael.seki@noaa.gov)

GOAL
The Pacific Islands Fisheries Science Center (PIFSC) is focused on building infrastructure and expertise using emerging technology to improve stock assessment and monitoring of living marine resources.

PRIORITIES
Researchers at the PIFSC are evaluating the potential contribution of hydro-acoustics, and optical systems as a means of providing a reliable index of abundance is support of stock assessment. There is some work being conducted to reduce the error in telemetry movement data using cell phone GPS technology.

HYDRO-AcouSTIC INITIATIVE – Center ASTWG Core funding

Project 1) Environmental effects on albacore tuna (*Thunnus alalunga*) forage in the American Samoa Exclusive Economic Zone (EEZ):

During FY06, the seasonally and interannually varying South Equatorial Countercurrent (SECC) was identified as having an important effect on the fisheries performance for albacore tuna, the target species of the local longline fishery (Domokos, et al., 2007), with all other evidence pointing towards the hypothesis that the two are linked by the effects of eddies on the distribution and biomass of micronekton, followed by those of albacore. The goal for this year’s research was to document the effects of the SECC on micronekton distribution and biomass in the region using *in situ* bioacoustics data, CTD casts, and ADCP recordings, complimented by satellite altimetry as well as the Southern Oscillation Index (SOI). Acoustic data were collected on board the NOAA ship *Oscar Elton Sette*, equipped with a hull-mounted, dual-frequency (38 and 120 kHz), split-beam EK60 echosounder system.

The results of this work confirm the effects of the SECC and its associated eddies on micronekton. Strong SECC velocities are associated with a predominantly anticyclonic eddy field and with an increase in both micronekton biomass, forage for albacore, and in the performance of the local longline fishery. Enhanced SECC waters dominate the northern part of the EEZ and show distinct differences in micronekton composition from those in waters of the South Equatorial Current (SEC), occupying the southern part of the EEZ. Relatively stable anticyclonic eddies show an increase in chloropigment concentrations and micronekton biomass, apparently advected from neighboring SECC waters. High shear regions of neither anticyclonic nor cyclonic eddies correlate with increased micronekton biomass. Areas characterized by SEC waters correspond to areas with the lowest micronekton biomass and the highest number and biomass of aggregative structures, most likely small pelagic fish shoals. There is strong evidence that the seasonally intensified SECC carries chloropigment rich waters from upwelling regions at the north coast of New Guinea, transported to the SECC by the anomalously eastward flowing New Guinea Coastal Current (NGCC) and allowing for the increase in micronekton biomass before reaching the EEZ. During El Niño, exceptionally strong and long upwelling at the north coast of New Guinea results in a marked increase in micronekton biomass within the anomalous
NGCC, source of a proportional increase in micronekton biomass in the EEZ. Increased micronekton biomass in strong SECC waters presents enhanced foraging opportunity for albacore, most likely increasing their biomass and resulting in the observed increase in their CPUE.

Project 2) Development of a fisheries independent method of biomass estimation of bigeye tuna (*Thunnus obesus*) at Cross Seamount, Hawaii:

During the first year of a 2-year project, a cruise was conducted to Cross seamount in April, 2007, on board the NOAA ship *Oscar Elton Sette*, equipped with a hull-mounted, dual-frequency (38 and 120 kHz), split-beam EK60 echosounder system. Survey design was developed to best suit data analysis using multivariate statistics to study bigeye distribution and movement patterns. Identification of bigeye was aided by handlining, while micronekton samples were collected by a midwater trawl. The physical environment was monitored with CTD casts, equipped with redundant dissolved oxygen sensors and a fluorometer for chloropigment determinations, while currents were monitored with a 75 kHz ADCP.

The main focus of the cruise was to develop a technique to acoustically identify bigeye and to obtain information on their movement patterns and distribution, as well as study the effects of the seamount environment on both bigeye and its forage, micronekton. Results obtained from the acoustic data indicate that the biomass of micronekton and tuna at the seamount --- as well as that of other fish --- are higher than those away from it. Higher tuna biomass is evident over the shallow plateau, while higher micronekton biomass is seen both over the plateau and at the flanks. The composition of the nighttime shallow scattering layer (SSL), composed mainly of micronekton, differs over the plateau than away from it (Fig. 1), with the differences in backscatter characteristics at the two frequencies indicating relatively high biomass of fish with gas bladder, other gas bubble containing organisms, and possibly squid, at the seamount. Dense micronekton patches, at depths of approximately 700-800 m, were observed at the flanks, predominantly in the up-current directions. Dense, large aggregations (~3 km long, 50 m high) of bottom fish were observed directly over the plateau floor only during nighttime, predominantly over the southwestern area of the plateau. Acoustic signatures of bigeye tuna were separated from other nekton, as well as from other tuna species, using their positional, morphological and energetic acoustic descriptors, taking into account previous knowledge of the composition and depth distribution of species fished at Cross seamount. The results of fishing efforts during the surveys, although not numerous enough for statistical significance, collaborate the acoustic identification of bigeye, yellowfin, and skipjack tunas over the plateau.

Two types of acoustic objects, with characteristics consistent with those of bigeye tuna, were observed over the plateau of Cross seamount: single fish described by their Target Strength (TS) values and tuna aggregations. All tuna aggregations were observed in daytime in the central and southwestern part of the seamount plateau. These aggregations were large (111 m high, 189 m long on average), loose, and deep, with a mean depth of 200 m. The depth distribution of tuna aggregations reasonably match those of bigeye tuna equipped with archival tags, spending a substantial amount of time at around 400 m near the depth of the seafloor. These results seem to indicate that bigeye tuna shoal during their deep excursions over the seamount plateau (Fig. 2). Generally speaking, most of the tuna targets were aggregated in daytime in the central and southwestern part of the plateau with individuals dispersing at sunset --- seemingly leaving the plateau area --- then congregating again into large aggregations at sunrise. Besides this diel cycle, daily variability in relative tuna biomass was also observed.
The information obtained on the distribution and movement patterns of bigeye tuna will be used to develop a survey design for the second cruise (April, 2008), aimed at obtaining acoustics data to estimate bigeye tuna biomass, preferentially aggregating over the plateau of the seamount. To aid in the identification of organisms, a third split-beam transducer, operating at 70 kHz, has been installed on the *Oscar Elton Sette*. Inversion algorithms will be used and tested with micronekton sampling to better estimate the composition of scattering layers and their differences between regions over the plateau and away from it.

**Project 3) Assessment of juvenile pink snapper (*Pristipomoides filamentosus*) population at a Hawaiian nursing ground**

As a continuation of a project to develop an acoustic method to monitor stocks of juvenile pink snappers in a Hawaii nursery ground, regular surveys are conducted over a predetermined grid to obtain a time series of bottom fish distribution and biomass. The grid is designed to cover an area known to contain high number of juveniles, in waters from 80 to 110 m deep. Acoustic data are collected using a portable side-mounted, split-beam echosounder system with a maximum of 3 frequencies (38, 120, and 200 kHz) on a small (~ 7 m long) NOAA boat, the *Kumu*. To obtain biomass estimates, TS values are thresholded based on *in situ* TS measurements conducted during FY06, down to 80 m depth on both juvenile pink snappers and puffers (*Torquigener florealis*, the only other bottom fish in the region) with known sizes. Since juvenile pink snappers do not aggregate, fish tracks with acceptable TS values within 20 m of the bottom are counted from each survey (Fig. 3., left panel). Preliminary results of data obtained during surveys indicate that on temporal scales of orders of hours and months, the distribution of bottom fish with TS values compatible with those of juvenile pink snappers is relatively steady (Fig. 3., right panel). The survey area is also occupied by thick aggregations of organisms near the bottom, changing position within the scale of minutes.

To aid in the identification of pink snapper targets, a stereo video camera equipment has been obtained and a winch system installed on the Kumu (Fig. 4). To test the feasibility of collecting simultaneous video and acoustic recordings, the system has been successfully tested on fish (juvenile pink snappers and puffers) secured to a line and held at depth. The stereo system, able to estimate sizes of organisms, will become fully operational within FY07 and will be used in the nursery ground to obtain TS measurements of fish identified with the video camera. Once the method is developed, it will require only slight modifications to apply it to adult populations or to monitor other bottom fish stocks.

**PUBLICATIONS:**


Domokos, R. (submitted to Fish. Oceangr.) Environmental effects on forage and longline fishery performance for albacore (*Thunnus alalunga*) in the American Samoa Exclusive Economic Zone.
PRESENTATIONS:


Figure 1: Differences in the composition of the nighttime shallow scattering layer away from Cross seamount (top panel) and at Cross seamount (bottom panel), as revealed by the differences in the mean volume backscattering strengths ($S$, in dB re 1 m$^{-1}$) at 120 and 38 kHz frequencies. x axes show
distance and time, while y axes indicate depth. Note that at Cross seamount negative values dominate, indicating relatively higher abundances of fish with swim bladder, other gas bubble containing organisms, and possibly squid.

Figure 2: Echograms showing an aggregation identified as bigeye tuna from the shape, looseness, and depth of the aggregation, as well as from the target strengths of the individuals within. x and y axes are as in Fig. 1. The upper and lower panels display the mean volume backscattering strengths (Sv in dB re 1 m$^{-1}$) at the 38 and 120 kHz frequencies. Note that the aggregation extends vertically from almost the surface to the 400 m deep plateau, indicating that bigeye can shoal during their deep diving behavior.
Figure 3: Echogram showing bottom fish detections (left) and histogram showing the mean number of tracks per 0.1 nmi over 3 consecutive surveys (right), approximately 45 minutes apart from each other. Differences in the number of detections per survey are not significantly different from each other.

Figure 4: The winch system for the underwater camera on the *Kumu* (left), and the deployed camera with its housing (right).
BAITED CAMERA TECHNOLOGIES – Progress since initial ASTWG grant funding

The Pacific Islands Fisheries Science Center (PIFSC) developed a stereo-video equipped baited camera system (BotCam) as a fisheries independent method of monitoring Hawaii’s bottomfish complex (http://www.pifsc.noaa.gov/cred/botcam.php). Design, testing and development of the system from 2004 through 2005 led to a collaborative effort with Dr. Chris Kelley of the Hawaii Undersea Research Laboratory and the State of Hawaii’s Division of Aquatic Resources to run a pilot study of a restricted fishing area off Penguin Banks, Hawaii. The pilot study included a total of 82 independent 30 minute drops. 40 drops were made inside the RFA, and 42 were made outside the RFA.

Drops sites were selected prior to sampling using a stratified random design methodology. Sites were stratified by depth, bottom hardness (based on multibeam backscatter values), and bottom slope, which were all determined from multibeam data.

Data are currently being collected from BotCam surveys to assist the State of Hawaii Division of Aquatic Resources in assessing the efficacy of recently implemented Bottom Fish Restricted Fishing Areas (BRFA) throughout the main Hawaiian Islands. The project is led by Dr. Jeff Drazen from the University of Hawaii. The project will utilize BotCam’s to estimate relative bottomfish density and length-frequency distributions from 6 of the state’s 12 newly defined BRFA’s over a 5 year period. Sampling follows a random stratified sampling design similar to the initial Penguin Banks study. 32 drops occur in each BRFA and 32 in the fished areas adjacent to the BRFA. Since June of 2007, approximately 200 stations have been sampled successfully demonstrating that the technology has moved to a fully operational phase. Video analysis is time consuming but 75 stations have been analyzed to date.

Future work will require cross calibration studies between these non-extractive video techniques and traditional fishing surveys to relate relative densities to conventional CPUE indices. Further, studies are planned to use BotCam’s to test non-extractive DNA sampling hooks being developed by the NWFSC, to develop a bait plume model, and to develop and test both red and UV lights to potentially extend the depth range of BotCam’s without further effecting fish behavior.
Figure 1. Restricted Fishing Area 9 off Penguin Bank, Hawaii. Shown are total snapper maximum number counts per drop both inside and outside of RFA 9. This RFA has since been opened to bottom fishing. Maximum number is a statistical parameter that uses the maximum number of a given species seen in a single frame of video as an index of total fish on a given site.
Figure 2. Shown are the average maximum number of onaga (Etelis coruscans) and opakapaka (Pristipomoides filamentosus) sorted by depth. The depth distribution data obtained from BotCam surveys correlates well with the known depth stratification of these two species.
Figure 3. This figure shows variability of fish counts based on the multibeam derived bathymetry (slope and hardness). The top plot shows that snapper and grouper species are present at most high slope and/or hard bottom environments. The bottom plot shows that the average maximum number of snappers and groupers seen is significantly higher in high slope areas.


Advanced Sampling Technology Working Group
2007 Grant Progress Report to
The Office of Science and Technology

TITLE: Development of GSM remote receiving stations for the enhancement of ecological assessments of protected species.

INVESTIGATORS:
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Pacific Islands Fisheries Science Center
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GOALS
The goal of ASTWG supported efforts at the Pacific Islands Fisheries Science Center (in partnership with the Alaska and Southwest Fisheries Science Centers) is to develop a portable, autonomous GSM archival node to study populations of seals and sea lions in remote areas outside of commercial network GSM coverage.

PRIORITIES
The priorities for FY07 were threefold:
1) Complete the field testing of the GPS/GSM transmitters on free roaming animals to ensure the devices were fully functioning and delivered the high resolution data expected prior to developing a PAGAN prototype,
2) Continue research and receive feedback to ensure that GSM was the most cost effective method of data transmission for this type of system or whether modification of the tag and creation of alternate PAGAN system would be better,
3) Develop clear statement of work for developing a PAGAN prototype, and
4) Solicit bids, reward contract and begin development of the system.

WORK COMPLETED AND RESULTS
The first GPS/GSM dive recorder to be used in the U.S. was deployed on an adult female Hawaiian monk seal in October 2007. The tag has functioned flawlessly and is continuing to transmit high resolution dive and location data. The data to date more than demonstrates and justifies the utility of applying these tags in and developing these stations for remote locations.

Figure 2: All GPS location fixes from an adult female monk seal on the south coast of Kauai. The record is from October 3 - January 7 and represents over 5000 GPS quality locations and clearly demonstrates near shore habitat use by a monk seal.
Figure 3: The top image is a 7 day record of GPS locations for an adult female monk seal. The bottom graph is the dive record for the seal during that time. The x-axis is time in days and the y-axis is depth in meters from (0 - 200).

We conducted market research with various universities and commercial enterprises to determine how to best utilize existing commercial technology and what method of transmission would best accomplish our goals. We are currently working on cost-benefit analyses for using either GSM technology or UHF.

We have developed a collaborative relationship with the University of St. Andrews (producers of the GPS/GSM tag) and engineers at Duke University to investigate working together to develop the PAGAN system and reduce costs.

Due to the lateness in receiving funds for conducting this work and subsequent issues in developing a contract, the money was obligated but we continue to refine the contract. The core issue was whether the development of the PAGAN would fall under a R&D type of contract or, since we are using mostly existing technology, a standard task order would be sufficient.

**IMPACT/APPLICATIONS**

PIFSC/AFSC/SWFSC efforts in support of the national ASTWG initiative will improve NMFS’r ability to monitor protected marine resources with much greater accuracy, increased data returns and in a more cost-effective manner.

**EXPENDITURES [$100K]**

The Pacific Islands Fisheries Science Center was allocated $100K in FY07 to support the development of the PAGAN system. The money has been obligated to a contract but not yet solicited or awarded. We expect to release a request for bids in early March.
TITLE
Remote Detection and Identification of Marine Animals to Improve Fish and Habitat Assessment, and Reduce By-Catch using the ASTWG Dual Frequency Identification Sonar (DIDSON)

INVESTIGATORS
Kresimir Williams and Christopher Wilson (NMFS/AFSC/RACE, 7600 Sand Point Way NE, Seattle, WA 98115 chris.wilson@noaa.gov), D. Hataway and J. Gearhart (NMFS/SEFSC/MSLAB, 3209 Fredric St. MS 39567 bret.d.hataway@noaa.gov), Mike Jech (NMFS/NEFSC/FEMAD/ESB, 166 Water St., Woods Hole, MA 02543 michael.jech@noaa.gov)

GOALS
Considerable research is directed at in situ experiments designed to understand the sources of variability of fish population estimates and reduction in by-catch. Underwater video is often utilized by scientists to investigate sources of variability in these estimates through direct verification of acoustic fish backscatter, observations of fish behavior, and avoidance reaction and escapement from sampling gear. However, the range of conventional underwater optics is typically limited to only a few meters resulting in its inability to adequately address behavioral reactions to sampling gear. For example, fish often avoid the lighting from underwater cameras, and even low-light CCD cameras require some degree of lighting during the night or at deeper depths. Recently, the Dual Frequency Identification Sonar (hereafter DIDSON; Ocean Marine Industries, Inc.) was developed to reduce this problem. The DIDSON provides high-resolution acoustic images for remote identification of individual fish and other marine animals well beyond the range of conventional optics without the need for lighting. The DIDSON is a portable, self-contained sensor that can be deployed on a wide variety of platforms or gear such as an AUV, towed bodies, and fixed or mobile fishing gear (e.g., fish traps, trawls). A Didson was purchased with ASTWG funds and delivered to AFSC in September 2006.

Three projects from three different Fisheries Science Centers were conducted during FY 2007 and are listed below with their respective project goals.

Project 1) Characterize selectivity of a large midwater research trawl to walleye pollock (K.Williams and C. Wilson, AFSC) The goal of this project is to describe the behavioral mechanisms underlying size-dependent escapement of fish from a midwater survey trawl. Didson data collected from the trawl can provide individual fish trajectories to determine whether escapement is primarily a passive process where fish are not actively “herded” by the trawl panels, or where the behavior is an active process where fish actively respond to the trawl meshes during the capture/escapement process. Information on these behavioral processes will potentially be used to modify the survey trawl design and/or alter fishing tactics to reduce selectivity.

Project 2) Evaluate the Potential for DIDSON to Identify Wild Sea Turtles in Turtle Excluder Devices and Shrimp Trawls (D. Hataway and J. Gearhart, SEFSC) The goal of this project was to
determine if the DIDSON sonar would be a useful tool that may replace and/or supplement video camera observations of wild sea turtles in turtle excluder devices and shrimp trawls when water conditions limit video observations.

Project 3) Acoustic Observations of Atlantic herring using the DIDSON Sonar (J.M. Jech, NEFSC)
The goals of this pilot project were to determine whether the DIDSON sonar was capable of detecting Atlantic herring in the water column (i.e., in the pelagic region) and near the sea floor (i.e., demersal region) and if they were detectable, to observe and monitor their behavior.

Progress reports for these three projects are presented below.

**PROJECT 1 – Characterize Selectivity of a Large Midwater Trawl (K. Williams & C. Wilson, AFSC)**

INVESTIGATORS
Kresimir Williams and Christopher Wilson, NOAA Fisheries, Alaska Fisheries Science Center, Seattle WA

PRIORITIES
Primary objectives in 2007 were to first establish and test deployment methods for the Didson at numerous sites on a large midwater trawl. Particular challenges included development of attachment strategies so that the particular position and orientation of the Didson on the trawl, when deployed, was less subject to chance and could be predicted with a high degree of certainty. A second objective was to develop target tracking software to process Didson data to quantify fish movements within the trawl to assess whether these behaviors could be considered mostly active or passive. This behavioral information will be valuable for developing strategies for modifying the trawl gear and/or changing fishing methods to potentially reduce selectivity of the trawl.

APPROACH
The DIDSON along with its autonomous deployment accesories was deployed on the midwater survey trawl in various locations. Based on information collected with other samplers (i.e., pocket nets) attached in numerous locations on the trawl, efforts were concentrated to optimize the Didson attachment mechanism for the bottom trawl panel. Consequently, most Didson data for FY2007 provide a view of the bottom panel of the trawl ahead of the codend (Figure 1).
WORK COMPLETED
The DIDSON was deployed successfully 25 times in 2007 during acoustic abundance surveys for walleye pollock in March in the Gulf of Alaska and June-July in the eastern Bering Sea. Small “pocket” nets designed to capture animals passing through the larger meshes of the trawl were used during many of the tows with the Didson. Because existing target tracking software was found to be inadequate, customized software was developed in Matlab to remove the background trawl signature in the DIDSON data and automatically track fish targets. This software was developed jointly with Dr. N.O. Handegard (Institute of Marine Research, Bergen Norway). The software will be used to analyze data collected during trawl deployments.

RESULTS
Preliminary results show potential differences in fish behavior based on fish size composition, trawling depth and survey season. An analytical procedure for quantifying these differences is being developed. Distinct individual fish reactions to the trawl have been observed, and will provide the basis for examining the fish escapement process in detail. The analysis will consist of comparing observed behavior patterns among trawls with different pollock size composition, while incorporating potential effects of environmental variables such as temperature and light level. Examples of the type of behavior patterns observed are given in Figure 2.
Figure 2. Several different types of fish trajectories and inferred behaviors based on Didson data collected from a large midwater trawl during March 2006.

IMPACT/APPLICATIONS
Data on fish reactions to the survey trawl gear will help evaluate gear effectiveness. The information will increase our understanding on how these sampling tools perform under different environmental conditions and will ultimately provide methods to quantify and potentially reduce this source of uncertainty (and bias?) in walleye pollock abundance assessment surveys.

TRANSITIONS
Deployment of the DIDSON on the large midwater trawl used during acoustic-trawl surveys of walleye pollock may continue at some level following the complete analysis of the current data so that net selectivity correction coefficients can potentially be derived for these nets under a wide variety of environmental situations.

RELATED PROJECTS
Software is being developed for the Didson, which may be useful to many researchers on other projects originally proposed for the ASTWG Didson. Dr. N.O. Handegard (Institute of Marine Research, Bergen Norway) is working in collaboration with AFSC researchers to finalize target tracking software for the Didson data. Once completed, the software will be available to others who may find it valuable for quite different Didson research applications.

A pilot study that used still cameras to identify DIDSON targets was completed in July 2007. The analysis of these data are currently underway. However, a procedure using customized software has been developed to provide a detailed look at the sea floor using the DIDSON. This has been accomplished by assembling DIDSON data frames into a single continuous image of the sea floor (Figure 3). This technique was incorporated in the procedure to analyze seafloor damage of caused by demersal trawls in a project headed by Craig Rose.
Figure 3. Sea floor mosaic of about 30 Didson data frames from a study to investigate the impact of trawling on the seafloor.

PUBLICATIONS

PRESENTATIONS
“Automated Tracking of Fish in Trawls Using the Dual Frequency Identification Sonar (DIDSON)”, by Kresimir Williams, Nils Olav Handegard, and Christopher Wilson was presented by KW at the Annual American Fisheries Society meeting in San Francisco, September, 2007

HONORS/AWARDS
None at this time
PROJECT 2 - Evaluate the Potential for DIDSON to Identify Wild Sea Turtles in Turtle Excluder Devices and Shrimp Trawls (D. Hataway and J. Gearhart, SEFSC)

INVESTIGATORS
Dominy Hataway and Jeff Gearhart, Southeast Fisheries Science Center, NOAA Fisheries, Harvesting Systems and Engineering Division, Pascagoula, MS Laboratory

GOALS
To determine if the DIDSON sonar would be a useful tool that may replace and/or supplement video camera observations of wild sea turtles in TEDs and shrimp trawls when water conditions limit video observations.

PRIORITIES
To use the DIDSON to count, identify, and measure sea turtles as they go into a shrimp trawl for the purpose of conducting an efficient in-water sea turtle population survey.

APPROACH
We planned to determine optimum placement of the DIDSON inside the trawl with regard to counting, identifying, and sizing wild sea turtles which enter the net. This would allow us to conduct a continuous sea turtle survey regardless of turbidity. Survey trawls could be outfitted with DIDSONs and TEDS allowing continuous trawling with minimal risk to the sea turtles.

WORK COMPLETED
We experienced an equipment failure soon after receiving the unit. The DIDSON flooded because the supplier left out a seal during assembly. Therefore we spent most of our time troubleshooting the equipment failure and only had a few days to work with the unit in the field.

RESULTS
As mentioned above we only had a few days to work with the unit, and all of that time was spent troubleshooting, mounting, positioning, and pointing the unit. NO sea turtles were imaged during this portion of the project. We later received a loaner unit from Soundmetrics and were able to successfully image a wild sea turtle and several bottlenose dolphins interacting with the trawl.

IMPACT/APPLICATIONS
We feel that once we have adequate time to use the unit in the field, the DIDSON should allow us to image megafauna such as sea turtles and dolphins effectively. This will allow us to document behavior in and around trawl gear without the limitations of light or visibility required by in-water camera systems.

TRANSITIONS
We found that it did take some time to float and point the unit properly for our application. But once aligned the images are a very useful supplement to video imaging.

RELATED PROJECTS
We plan to investigate the use of the DIDSON to image bottlenose dolphins interacting with shrimp trawls in an attempt to decrease these interactions.
PUBLICATIONS
No publications are in the works at this time.

PRESENTATIONS
No presentations have been made relating to DIDSON projects.

HONORS/AWARDS
No honors/awards have resulted from this project.

**PROJECT 3 - Acoustic Observations of Atlantic herring using the DIDSON Sonar (J.M. Jech, NEFSC)**

INVESTIGATOR
Mike Jech, Northeast Fisheries Science Center, Woods Hole, MA

GOALS
The goals of this pilot project were to determine whether the DIDSON sonar was capable of detecting Atlantic herring in the water column (i.e., in the pelagic region) and near the sea floor (i.e., demersal region) and if they were detectable, to observe and monitor their behavior.

PRIORITIES
Knowing the behavior of herring is important for scaling the relative index of herring to absolute abundance because of its effects on target strength. Underwater video measurements have had limited use in monitoring behavior due to its limited range. In this project, we investigated the capabilities of DIDSON sonar for monitoring and quantifying fish behavior and detecting fish near the sea floor.

APPROACH
The DIDSON sonar was deployed off the R/V ENDEAVOR during the first two weeks of Sept. 2007. Atlantic herring historically aggregate in pre-spawning and spawning groups on the northern edge of Georges Bank in the Gulf of Maine. The NEFSC annually surveys herring at this time for abundance estimates. Atlantic herring aggregations were detected using near-surface-mounted echo sounders (38- and 120-kHz Simrad echo sounders). The DIDSON was then deployed on these aggregations from the drifting vessel. During these deployments, different data acquisition parameters and instrument settings were set to determine optimal settings.

WORK COMPLETED
A field study was conducted in the Georges Bank region of the Gulf of Maine in September 2007. Analysis of the data are currently underway (e.g., Figure 4).
Figure 4. Echogram of a single ping from the ASTWG’s Dual-frequency IDentification SONar (DIDSON) processed with Echoview. The DIDSON was operating at 1.1 MHz, with 48 0.4° by 12.0° beams and 7 cm range resolution. The upper panel demonstrates detection of the sea bed (horizontal band of red/blue backscatter at 10 m) and a fish near the sea bed. The lower panel shows an enlarged view of the fish echo. From the beam geometry, the fish length is estimated at 28 cm and the fish is approximately 7 cm off the sea floor. Historical trawl catch data have shown Atlantic herring (*Clupea harengus*) of this length range in this area.

**RESULTS**
see Figure 4.

**IMPACT/APPLICATIONS**
Detecting and enumerating fish in the acoustic "dead zone" - i.e., near the sea floor - is an important component to accurate estimates of Atlantic herring stocks in the Gulf of Maine and Georges Bank regions. The DIDSON sonar was able to detect fish near the sea floor and observe the behavior of these fish. Future work will focus on quantifying these echoes and behavior.

**RELATED PROJECTS**
None at this time.

**PUBLICATIONS**
None at this time.
PRESENTATIONS
None at this time.

HONORS/AWARDS
None at this time.
TITLE: Development of an autonomous lowered acoustic system for improved in situ target strength measurements.

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GOALS
The aim is to make accurate estimates of target strength (TS) for the conversion of echo integration data to estimates of fish per unit volume and biomass. Although there are various methods for obtaining TS estimates, measurements on free-swimming fish in their natural environment are often considered most appropriate for survey applications. Ideally, these in situ TS measurements are from the target species under conditions that match the survey conditions as closely as possible because many aspects of the fish’s behavioral and physiological condition can strongly influence the TS and echo integration data.

PRIORITIES
The specific objectives of the one-year project are to design, construct, refine and test an autonomous lowered acoustic system for improved target strength measurements (DropTS), with the following specifications:

Sensors:
- Echosounder: Simrad EK60 38 kHz split-beam GPT;
- Transducer: Simrad ES38-DD 38 kHz deep-depth transducer;
- Motion: pitch-roll-bearing sensors (TBD) on transducer and main frames;
- Options: RS-232 interface (e.g. SBE19+ with DO, light, and pH)

Mechanical:
Materials: stainless steel, aluminum, e-glass, HDPE;
GPT pressure cylinder: reduced size via repackaged GPT;
Battery housing: separate and replaceable;
Transducer mount: gravity gimbaled and self-leveling;
Deployment options: any ship’s trawl or oceanographic instrumentation winches;
Maximum depth: 750 meters (2x safety margin);
Motion isolations: neutrally buoyant and linked to ship with weights and floats;

Electrical:
System control and data acquisition: PC104 single board computer system;
Minimum operational duration: 12 hours (2x margin);
Battery recharging: while installed, during and or between operations;
Activation: programmable depth/pressure switch;

I/O:
Autonomous operation: no electrical connection to surface vessel;
Telemetry: acoustic modem link for limited system control and data acquisition (e.g. ER60 TS and bottom depth; and transducer depth, tilt and bearing angles);
Optional interface: control and logging via ethernet and power-data cable.

Modes of operation:
Autonomous: pressure activated power, load configuration, and collect and store data;
Telemetered: add telemetry of depth, transducer orientation, TS, range and bearing angles; and
Cabled: full system control and complete data acquisition via power-data cable.

APPROACH
The DropTS has two development phases; only Phase 1 has thus far been funded. The Phase 1 system includes a gimbal-mounted single-frequency transducer and the operation is either autonomous, or via a Cat5E Ethernet cable. The Phase 1 system is complete and can be upgraded to multi-frequency operation with stereo cameras and stepping-motor stabilization.

WORK COMPLETED
The phase 1 system has been designed, manufactured, tested and refined. It has been deployed off the coast of Southern California to measure target strengths of rockfish near the seafloor. The system can operate autonomously and logs data internally. Alternatively, the system can be connected to a Cat5 Ethernet cable for long-range (>500 m) control and communications. Currently, efforts are underway to integrate an acoustic modem with the system to allow wireless remote control and communication.

RESULTS
The phase 1 system is has been completed (Fig. 1), tested, refined and deployed (Fig. 2). The components include a:

Deck system:
- Tut Systems XLP-6812 VDSL long range Ethernet modem 300VDC 1A PS
- Deck unit to underwater system connecting cable (for communications and charging)
- Deck unit to PC connecting cable (standard Ethernet cable)
- Mains lead
- PC with VNCTight remote desktop software

Underwater system:
Frame assembly:
- Stainless steel shackle lifting point
- Polycarbonate sea-current shield and rubber transducer endstop
- Gravity gimbaled and self-leveling transducer mounting plate
- Eight transducer mounting bolts, washers, nuts and black nylon spacers

Simrad ES38-DD transducer
PNI TCM2.6 transducer attitude sensor in 1000m s/s pressure casing
LinkQuest UWM2000 acoustic modem with two black nylon frame mounts
Seabird SBE 39 temperature and pressure sensor with two black nylon frame mounts

Electronic canister containing:
- PNI TCM2.6 attitude sensor
- Simrad EK60 38 kHz split-beam in compact housing
- Seavolt 12V 19Ah AGM lead acid battery
- Tut Systems XLP-6802 long range Ethernet hub
- Edgeport 4 USB to 4 port RS232 converter
- Chronos USB to 4 port RS232 converter
- IPTime 5 port Ethernet switch
- Microspace Epic MSEP800 single board computer (SBC)
- Western Digital 120GB HDD
- Control PCB with EK60 supercap PSU
- 300V power conditioning and protection PCB
- 15V regulator PCB
- Ethernet line protection PCB

Battery Canister:
- 5 x Seavolt 12V 19Ah AGM lead acid batteries Fuse (8A slow blow) and charging diodes

Underwater interconnecting leads
- Electronic canister to transducer attitude sensor
- Electronic canister to battery canister
- Electronic canister on/off switch lead
- Dummy plugs

**Figure 1.** Bottom end cap of electronic canister showing bulkhead connector assignments:
- SBC Com port Com 7 Frame attitude sensor; SBC Com port Com 8 Control board; USB to RS232 bulkhead connector 1 Com 1 Transducer attitude sensor; USB to RS232 bulkhead connector 2 Com 2 Acoustic modem; USB to RS232 bulkhead connector 3 Com 6 spare; USB to RS232 bulkhead connector 4 Com 24 CTD; USB to RS232 bulkhead connector 5 Com 5 Pitch and roll motors; and USB to RS232 bulkhead connector 6 Com 23 spare.
IMPACT/APPLICATIONS
Most of the species that are targeted by NOAA acoustic-trawl surveys are relatively deep (100-600 m), and the animals often exist in relatively dense aggregations -- conditions that are not conducive to in situ TS measurements from vessel-mounted transducers. The DropTS will provide data to validate or refute TS-to-body length relationships currently used in acoustic survey analyses and stock assessments. Improved measurement accuracies should result.

TRANSITIONS
The DropTS design is modular and upgradable. The system was designed so that it can be easily enhanced to include: a stepping motor system to replace the gravity gimbaled transducer mount; up to three more GPT’s (70, 120, and 200 kHz) and transducers (ES70-7CDD, ES120-7CDD, and ES200-7CDD); a synchronized stereo camera and strobe system; and increase operational duration to 24 hours.

RELATED PROJECTS
Modules of the DropTS system have been designed to be interchangeable with components of the FasTowCam system.

PUBLICATIONS

PRESENTATIONS
Provide citations of presentations (scientific conference, Fisheries Council meetings, public presentations, etc.) that were given or will be given for this project.

EXPENDITURES
Grant total = $94k; $63k to SWFSC for the design, construction, test, and refinement; and $31k to AFSC for integration of the acoustic modem, development of remote control and logging software, and shipping and travel for field testing.
TITLE: Autonomous Underwater Vehicle development ($55k)

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GOALS
The NOAA Fisheries AUV is intended to conduct ecosystem-based fish stock assessments, autonomously. This project’s immediate goals are for contracted labor, maintenance and supplies, transportation, travel, and training to develop the AUV to make it operational for surveys.

PRIORITIES
Gain permission to use the AUV, train personnel on operations, place the AUV in service, and accomplish missions in the ocean.

APPROACH
After receiving approval to use the AUV on 22 May, 2007, a team led by Cutter inspected the AUV code, bench tested the AUV and fixed mechanical problems prior to deployment. Field trials were then initiated to explore the capabilities and tune the behaviors of the AUV.

WORK COMPLETED
Inspection and bench-testing commenced in May, 2007. Field trials were initiated in June 2007 and once we were comfortable with the basic functions, the AUV was deployed on simple, single-leg missions, controlled from a base station on a pier, with a chase boat following the AUV. A tuning process was initiated for PID controller parameters that control the AUV dive behavior. Some code changes were required to accomplish stable depth-holding. We have overcome a variety of software bugs, and problems with code, mechanical and electronic components to accomplish field deployments in the Pacific Ocean and achieve reproducible behavior with the AUV.

RESULTS
The AUV has been deployed on field trials regularly since June, 2007. The AUV has proven capable of open ocean operation (Figure 1), and generally operates reliably. The AUV successfully completes single-leg dives, and swimming behavior has been tuned for precise depth-holding. Single-
leg missions are now reproducible and reliable. The EK60 echosounder, DVL, and CT sensor payloads are operational. The stereo camera system has not proven to be reliable. The cameras often do not initialize properly, and the strobe tends to not function.

Summary of field deployments of the NOAA Fisheries AUV

20070626 – Deployed the AUV from SIO Pier. Activated AUV. Established communications. Restarted AUV twice, once for modified flight code, once after losing contact with the payload computer. Telemetry became intermittent and unreliable. The reason was discovered to be a stuck dive plane. The port dive plane was stuck against the hull, and the AUV processor was becoming totally devoted to attempting to correct the dive-plane angle. Aborted deployment because of the potential catastrophic result if the dive-plane were to get stuck during swimming.


20070706 – Deployed the AUV from SIO Pier. Surface swam offshore to deeper water. Attempted eight missions. The AUV dove, but bailed out on every mission. The AUV was successfully recovered to SIO Pier. Reason for bailouts was later determined to be low voltage in one of the battery cells.

Figure 1. NOAA Fisheries AUV swimming prior to a dive in the Pacific Ocean off San Diego.
20070723 – Deployed the AUV from SIO Pier. **Seven AUV missions were successfully completed.** Each mission comprised a single-leg dive lasting from 1.0 to 2.5 min. On each mission, the AUV successfully dove and swam underwater, attempting to maintain the target depth of 6.0 m. There were no mechanical, electrical or software failures detected, except for one software bug caused by a recent change to the code which was remedied by reverting to the previous version of the 2 VIs that had been changed. The bug was noticed and fixed on the surface, prior to sending on any missions. EK60 echosounder data were successfully recorded on the last 4 of the 7 missions. The stereo-camera system did not operate. The AUV was successfully recovered to SIO Pier.

20070726 – Deployed the AUV from SIO Pier. **The AUV completed two missions successfully and safely,** and completed a third mission successfully, but was damaged upon surfacing. At the end of the third mission, the AUV surfaced directly beneath the chase-boat (*R/V Ernest*), and, despite evasive maneuvers by the boat, the AUV contacted either the transom or the dive ladder/step. The engine was out of gear at the time, and the AUV was going slowly in surfacing mode. Upon closer inspection of the AUV nose sensors, it was found that the conductivity cell sensor in the nosecone had been damaged. The AUV was towed back to SIO Pier, where it was safely recovered. Fortunately, there was no water intrusion into the AUV. No other damage to the AUV was found during inspection in the lab. The EK60 echosounder operated successfully when commanded on mission 3. Subsequently, the CT sensor was replaced.

20070802 – Deployed the AUV from SIO Pier. **The AUV completed 11 missions successfully and safely.** Each mission comprised a single leg dive lasting between 1.5 to 3.5 min. Missions were operated at 350, 450, 550, and 650 RPM. On each mission, the AUV successfully dove and swam underwater, except at 350 RPM, and attempted to maintain the target depth of 6.0 m. The parameters controlling depth-holding behavior were varied to accomplish PID tuning. These parameters were: proportional gain on depth, dive-plane neutral point angle, and dive plane deflection from the neutral angle. The AUV did not successfully converge on the target depth during any of the dives, however the AUV was able to automatically and safely terminate every dive after reaching the prescribed bailout depth of 10 m.

20070803 – Deployed the AUV from SIO Pier. **The AUV completed 7 missions successfully and safely.** The parameters controlling depth-holding behavior were adjusted to values determined from examination of mission data from 20070802 to accomplish PID tuning. These parameters were: proportional gain on depth, dive-plane neutral point angle, and dive plane deflection from the neutral angle. Each mission comprised a single leg dive lasting from 3.5 to 10.0 minutes. **On each mission, the AUV successfully dove and swam underwater, and converged on, or very close to, the target depth of 6.0 m, with only about ± 0.1 m to ± 0.2 m of deviation from the realized target depth (Figure 2).** The choices of neutral angle (-15°), fin deflection range (7°), and proportional gain (1) were correct values for producing consistent, repeatable depth-holding for a propeller speed of 550 RPM. Depth-holding was achieved for 550 RPM. Echosounder data were collected successfully (Figure 3).
Figure 2. Precise depth-holding during autonomous dives was achieved on 03 Aug. 2007. The depth below surface and the pitch angle of the AUV are shown here.

20071220 – Deployed the AUV from SIO Pier. Multi-leg missions were attempted, but were not successful. Single-leg missions were successful, precise depth-holding was again achieved during fully autonomous dives, and the echosounder was operated.

20080117 – Deployed the AUV from the R/V D. V. Holliday. Multi-leg missions were attempted, but were not successful. Single-leg missions were successful and precise depth-holding was again achieved, and echosounder data were collected. A long-duration depth-holding dive lasting 15-minutes was successful. Autonomous, terrain-following dives were attempted and were successful with the AUV precisely following the target altitude above the seafloor.

Figure 3. EK60 echogram collected by the AUV on 03 Aug. 2007.
IMPACT/APPLICATIONS

The NOAA Fisheries AUV is now operational for simple, single-leg missions collecting echosounder data.

TRANSITIONS

The AUV still requires code debugging and code modification to achieve multi-leg missions. Hardware modifications could be required to achieve faster dive speeds. Constant regular attention and basic maintenance are required to keep the AUV operational and to keep personnel proficient in its operation. Plans for continued development include: debugging multi-leg mission code; debugging the stereo cameras and strobe; replacing the existing foam with syntactic foam; completing dives at faster speeds; multiple-depth single-leg missions; adaptive sampling algorithms; and deeper dives.

RELATED PROJECTS

NPRB Proposal: “Assessment of Rockfish Species in Untrawlable Habitat Using Advanced Acoustic, Optical and Trawl Technologies,” Chris Rooper, AFSC; Tom Weber, UNH; and D.A. Demer, SWFSC.

PUBLICATIONS

NOAA Fisheries AUV Video (http://swfsc.noaa.gov/textblock.aspx?Division=FRD&id=1105)


PRESENTATIONS

Presentation to congressional Staff

NMFS Science Board Meeting, May, La Jolla, CA; presented “The Collaborative Optically-assisted Acoustical Survey Technique for Surveying Rockfishes in the Southern California Bight,” and highlighted the potential of conducting COAST with the NMFS AUV.

HONORS/AWARDS

Progress in this area has been slowed due to funding delays and legal limitations on the use of the AUV.
TITLE: Broad-scale sampling of marine sound scatterers using small, low-cost, autonomous echosounders and animals as survey platforms.

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GOALS
Small, low-cost, narrow bandwidth, echo-sounder tags (EchoTag) are under development that will allow for inexpensive sampling of marine backscatter. The EchoTag will be secured to a range of platforms including drifting buoys, Argo-style floats, and large marine animals which will allow for a complementary sampling approach including standardized surveys and selective sampling of regions of high productivity where marine animals forage. These data will provide fisheries resource managers more information on the temporal and spatial patterns of low- to mid-trophic level species.

PRIORITIES
Develop a micro echosounder, integrate it into an EchoTag that can be deployed on large marine mammals and autonomous platforms such as floats or gliders.

APPROACH
Characterize a commercial micro echosounder (Simrad ES10) and integrate it into an EchoTag. Also, develop a custom micro echosounder and integrate it into a second version of an EchoTag. Compare the costs and performances of each approach. Develop attachment mechanisms that are appropriate for use on large marine mammals and turtles.

WORK COMPLETED
Japanese scientists were hosted at SWFSC to consider the possibilities of co-developing a micro echosounder tag, based on an existing design (Miyamoto et al., 2004). Through this exchange, it was learned that the existing design was based largely on a custom integrated circuit proprietary to Honda Electronics. Therefore, for expediency, a decision was made to explore both commercially available micro echosounders and custom designs.

A series of experiments were conducted to characterize the performance of a commercial micro echosounder (Simrad ES10; Fig. 1). Measurements were made of: power consumption, pulse duration, transmit frequency, transmit power, transducer efficiency, time-varied gain, receiver sensitivity, and
receiver linearity. Experimental comparisons with a Simrad ES60 were also performed (Fig. 2). Three ES10 micro echosounders and custom deep water transducers were purchased.

In parallel, a micro echosounder design has been developed and three prototypes have been produced (Fig. 3). Miniaturization of the custom micro echosounder design is currently underway. Additionally, a contract has been awarded to Pisces Design for the design, construction and testing of custom tag attachments which are suitable for deploying the EchoTags on large marine mammals and sea turtles.

RESULTS
Through these experiments, the performance characteristics of the ES10 has been comprehensively studied. The basic operating characteristics of the ES10 have been investigated as well as the more underlying mathematical processes that are involved. This information makes it possible to understand the limitations of the system, and how best to operate the ES10 to ensure maximum efficiency and stability. Additionally, the receivers of the custom micro echosounders have been tested at length and the transmitter and data processing designs are in progress. A graphical user interface was developed in Matlab for controlling the ES10, monitoring its function, and logging the data in Simrad .raw format. Raw files collected simultaneously with both the ES10 and ES60 echosounders were thus compared using Matlab and standard data processing tools (i.e. Echoview).

Figure 1: Typical setup for ES10/ES60 echosounder comparison
Figure 2: $S_v$ values obtained from the ES10 and ES60 echosounders over one track line from a depth of ~5 to 180 meters. For this track line, the ES10 Gain setting was set to 0 dB.
Figure 3: Prototype micro echosounders for possible use in EchoTags.

IMPACT/APPLICATIONS
Currently electronic tagging studies are being conducted at all Science Centers in efforts to define pelagic animal habitats on species including turtles, sharks, fish, and marine mammals. Small pelagic fish and invertebrates support large national and global fisheries constituting 30% of global catch by weight. In addition, these species form a critical link in marine food webs between primary and secondary production and marine predators. There are currently large gaps in our understanding of the dynamics of marine ecosystems and how they are impacted by environmental change. These gaps are the most glaring as we attempt to move towards ecosystem management. The EchoTag should provide needed data on spatial patterns of sound scatterers leading to better understandings of animal habitats and the impacts of environmental variability over a range scales.

TRANSITIONS
The finished EchoTag technology will ultimately be available for use throughout NMFS.

PUBLICATIONS

PRESENTATIONS
Progress in this area has been delayed due to funding delays.

HONORS/AWARDS
Progress in this area has been delayed due to funding delays.

EXPENDITURES
Grant total = $98k.

REFERENCES
Advanced Sampling Technology Working Group  
2007 Progress Report to  
The Office of Science and Technology

TITLE:  
Optical validation of acoustical targets using a high-speed underwater camera system

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GOALS  
This project includes development and deployment of a high tow-speed, low-blur, towed underwater camera system for immediate, underway ground-truthing of fisheries acoustics survey data. The purpose of the system is to provide concurrent imaging of the constituent organisms in the acoustic scattering layers while underway at full speed during fisheries acoustic surveys. The system will accomplish remote species identification and enumeration, specifically ground-truthing for fisheries acoustics data. System goals include: durability; high tow-speed; capable of being towed at a depth of 15 m a speed of 15 knots; capable of being towed constantly at depths to 40 m at full transit and survey speed (up to 15 kts); capable of being towed at 150-m at low speed <2 kts. Remote control of tow depth. Remote viewing and storage of images. Limited remote control of cameras.

PRIORITIES  
Priorities of this project for 2007 were to design and develop hardware for the towed camera system, and to begin testing.

APPROACH  
During the periods of surveys when only the fisheries echosounders are operating, and no validation data are collected, it is often unclear whether acoustic targets represent fish or invertebrates; large individual fish or small aggregations of fish; or fish recently caught or something totally different. In practice many assumptions are required to even distinguish fish from non-fish targets in echosounder data. This camera system is designed to provide information about taxa, species identity and sizes of target-organisms, and therefore would reduce apportionment errors and improve acoustic
stock assessment. The ability to confirm that a target identified in the echogram was a fish school of a particular species while underway would be a significant advancement from the current state of the science. Furthermore, this system is designed to operate at high speed to allow deployment while navigating at full speed and to minimize the imposition on survey vessel time and other operations.

**WORK COMPLETED**

Designs of existing towed bodies were reviewed. Published articles relating tow-body designs and mechanics were reviewed. Preliminary designs and sketches were developed and discussed with contract engineers and machinists. Engineering drawings were developed, reviewed and revised. Engineering design, drawings, and identification of sources of materials and components are complete. Some components have been manufactured and integrated. The system assembly has been slowed due to delayed availability of funds. The project is currently in the fabrication stage. The system is expected to be completed and ready for field testing by May, 2008.

**RESULTS**

Final design and technical drawings are complete, as shown (Figure 1).
Cameras, lenses, a control computer, communications system components, and batteries have been specified and purchased. The modular design for the battery compartment follows that of the DropTS system project. The control module also benefits from portions of the design incorporated in the DropTS system, satisfying modularity and some interchangability. Sources have been identified for the underwater actuators for moving the wings, and for the metal tube to serve as the main body shell. The camera and flash housings and dome ports have been fabricated (Figure 2).

A scale model of the towbody was fabricated (Figure 3). Tow tests of the scale model are to be conducted in a flume in January, 2008.
IMPACT/APPLICATIONS

This system is designed to provide continuous ground-truth imagery while survey ships are underway at full speed. The ability of continuous operation at full survey speed means that verification data will be collected without imposing upon the survey vessel's time. Using the proposed device will produce more validation data and better stock assessment without the need to adjust survey designs. There is already interest by investigators in using this system for ground truthing fisheries acoustics surveys. This system will provide information that will allow more accurate interpretation of survey echosounder data and aid in the effort to apportion scattering by taxa and species.

TRANSITIONS

Progress in this area has been delayed due to funding delays.

RELATED PROJECTS

This project has benefitted from the DropTS project by incorporating some of the system component designs.

PUBLICATIONS

Progress in this area has been delayed due to funding delays.

PRESENTATIONS

Progress in this area has been delayed due to funding delays.

EXPENDITURES

Grant total = $61.74k
TITLE: Workshop on the Simrad ME70 broad bandwidth multi-beam for fisheries applications

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GOALS
The Simrad ME70 broad bandwidth multi-beam echosounder has been installed on two of NOAA’s new noise-reduced survey vessels, Henry B. Bigelow, and Oscar Dyson, and will be installed on more FSVs including Belle S. Shimada. The principal goals of this project were to expedite training of NOAA Fisheries researchers on the design, function and application of the ME70 through workshops and facilitated collaborations. Another objective was to develop a coordinated and complementary multi-beam research plan among researchers representing NOAA and IFREMER to more fully determine the performance capabilities of the instrument and to address fisheries-related research questions of mutual interest.

PRIORITIES
In 1997, Kongsberg Simrad Mesotech developed one of the first multi-beam sonars that provided digital return data over its entire profiling range. In 2005-2006, Simrad introduced a new highly sophisticated broad bandwidth multi-beam instrument, model ME70, dedicated to fisheries research (Simrad 2006). The ME70 was specified by the French scientists at IFREMER, and the system was installed aboard the research vessel, Thalassa. Following a number of modifications, the ME70 has met the design specifications. A hydrographic option for the ME70 is still being refined and is expected to meet the specifications for IHO standards by December, 2007.

The ME70 is designed with a wide frequency bandwidth, large dynamic range, and a high degree of user-controlled flexibility in beam steering and beam opening capabilities. It is possible to make direct comparisons with traditional vertical echo sounding systems. The ME70 will provide immense opportunities for research over a wide variety of topics important to fisheries including target
identification, estimations of fish distributions, abundances and natural behaviors, three-dimensional imaging of schools, fish reactions to the surveying vessel, and detection of demersal fishes.

Although NOAA has made a significant investment in multi-beam technology for fisheries applications, and the potential value of the ME70 is clear to NOAA researchers, there is a need for expanding our knowledge of the instrument’s performance capabilities, and developing a practical working knowledge of the instrument. Furthermore, the ME70 generates very large volumes of data and requires new methods of data storage and processing. A tele-training was organized to provide a large number of NOAA Fisheries scientists with an understanding of the ME70’s features, user interface and potential applications. A workshop with the IFREMER scientists was also chosen as a way for NOAA to gain expertise with the ME70 and acquire the necessary ancillary hardware and software to make optimal use of it. Personal contacts made through the field workshop will facilitate research collaborations.

**APPROACH**

The approach to gaining ME70 expertise within NOAA Fisheries was three-fold:

1) Tele-training of NOAA Fisheries scientists from around the country;
2) Field-training of three NOAA Fisheries scientists that will be involved in the use of the ME70 systems installed on Henry B. Bigelow, Oscar Dyson, and Belle S. Shimada; and
3) Collaborate with IFREMER scientists on the development of a research plan to more fully determine the performance capabilities of the ME70, continue to make performance refinements, and to address fisheries-related research questions of mutual interest.

**WORK COMPLETED**

NOAA Fisheries scientists (Chris Wilson (AFSC), David Demer (SWFSC), Larry Hufnagel (NWFSC), Scott Furnish (AFSC), Rick Towler (AFSC), and Mike Jech (NEFSC)) attended a tele-training 24-25 September, 2007, led by Lars Nonboe Anderson, the ME70 Product Manager.

Subsequently, a field workshop was held off the west coast of France from 18-25 October, 2007, aboard the French survey vessel Thalassa, which boasts the first ME70 installation. The French scientists that hosted the workshop (Laurent Berger, Carla Scalabrin and Verena Trenkel) are intimately familiar with the design, development, testing and refinement of the ME70. David Demer and Christopher Wilson represented NOAA Fisheries, learned how to configure and use the ME70; learned how IFREMER synchronizes the ME70 with the Simrad EK60 and other acoustic instrumentation using custom software (Hermes); and developed relations which should facilitate international collaborations for sharing of software and research and development (Fig. 1). NOAA scientist Mike Jech could not participate in the Thalassa cruise due to survey obligations.

While aboard Thalassa, Berger, Scalabrin, Trenkel, Demer, Wilson and IFREMER scientist Valerie Mazouric (remotely) collaborated on a research plan for characterizing, refining and applying the ME70.
Figure 1. Laurent Berger from INFREMER describing the installation of Simrad’s first ME70 broad bandwidth multi-beam echosounder aboard research vessel Thalassa.
Colleagues at INFREMER shared their strategies for configuring the ME70, documented in a report prepared by Valerie Mazouric and Laurent Berger. They also relayed a number of lessons learned:

**Bottom detection:** The ME70 operating in Fisheries Research mode uses echo amplitude to detect the seafloor. This algorithm is effective for near-vertical beams, but is inaccurate for beams away from normal incidence. Thus, for steered beams, the ME70 bottom detection algorithm with the default backstep (same as implemented in the EK60) detects the bottom inside the bottom echo. This generally results in an over-estimate of the range to the seafloor.

**Beam cross-talk:** Cross talk between beams can be reduced by decreasing side-lobe levels (increasing beam widths), and increasing the frequency separation of adjacent beams. Theoretically, side-lobes can be reduced to -70 dB (two-way), whereas in practice, levels of only -55 dB have been achieved. More analysis is needed to understand this disparity. Meanwhile, even with side-lobe levels of -55 dB, care must be taken to quantify fish detected beyond the shortest range to the seafloor level (e.g. outside the ‘spherical volume’).

**Parasite echoes:** The ME70 beamforming has an artifact at a fixed range of 75 cm from the seafloor. This ‘parasitic echo’ is due to cyclical folding in the FFT corresponding to a fixed 128 points at the 62.5kHz sampling rate. Thus, the dead zone is the same size or larger on the ME70 versus the EK60. Valerie Mazouric plans improved beamforming techniques to remove this artifact.

**Grating lobes:** Steering beams at steep angles can result in grating lobes. This phenomenon is accentuated in the V-configuration compared to the inverse-V-configuration. Grating lobes can be predicted HERMES. Simrad plans to restrict configurations that result in grating lobes.

**Bad elements:** INFREMER has expressed significant concern regarding TRX32 board reliability.

**ME70 software versions:** Different versions of the ME70 software have been installed on Dyson V 1.0.6 (26.02.2007) versus Thalassa. V 1.0.X (XX.XX.2007). Simrad explained that this was due to changes necessary for the bathymetric option and that eventually all ME70 systems will use the same version.

**ME70 lock-ups:** The ME70 on Dyson shut down abnormally on 3 consecutive nights during the tests (i.e., on virtually all nights). There is some concern about software bugs in the operating system and beamformer.

**ME70/EK60 synchronization:** INFREMER uses custom Hermes software to synchronize the ME70 and EK60 functions and to merge the acquired data into common files in .hac format.

**ME70 configurations:** INFREMER uses custom Hermes software to configure the ME70, to predict its performance, and to visualize the resulting beam patterns.
Implementation of dual-sphere calibration: INFREMER recognized the need to implement a method for dual-sphere calibrations.

Option to change calibration parameters in replay mode: Simrad has restricted this possibility, as in the EK60.

Fixed range parasite echoes observed for some beam configurations (not necessarily repeatable): Simrad claims that this is due to a software bug that has been fixed.

Loss of pings in the new beamformer (a few pings every XXX minutes depending on work load of the system): Simrad claims that this was due to a software bug that has been fixed.

Shift in gain values after a new version was installed in August 2007 (1.5dB): Simrad claims that this was due to a software bug and has been fixed.

Instability of the calibration program after a new version was installed in August 2007 (crash of the system when “suspending” some hits): Simrad claims that this was due to a software bug and has been fixed.

Additionally, INFREMER shared their experiences with the bathymetric option for the ME70. The ME70 system with Bathymetric Option can either operate in the standard fishery research mode or as a bathymetric system based on the EM70 with the performance of the EM1002S, except for the covering sector. The data formats are the same as for the EM 710.

The system has one transmit mode with 0.2 ms CW pulse duration with a total frequency band of approximately 7 kHz. Three stabilized beams at frequencies of 83, 90 and 97 kHz are projected downwards ± 50 deg. and ±15 deg. to each side. Thus, the total swath is about 130 deg., or 4 times water depth coverage, and generates approximately 200 soundings (approximately 3° across-track and 2° along-track) per ping. The operational depth range is approximately 3-300m, with a maximum range of approximately 600m. The sidelobe levels are less than -25 dB. Bathymetric measurements meet IHO S-44 Order 1, possibly Special Order. The backscattering strength is accurate to ±2 dB and precise to ±1 dB.

The ME70 exports pitch and roll stabilized beamformed data to the EM Hydrographic Multibeam Processing Unit (HMPU). The HMPU corrects the data for calibration parameters (sensor installation, time delays, sensor offsets), transmitted source level, transmission losses, receiver amplification, angular effect, beam footprint; refraction considering the sound speed profile; instantaneous pitch, roll, and heave; and tide. A standard EM Operator Station can be used for data quality control and logging (INFREMER uses their own software for this function). The EMOS displays the following in real-time:

- Time-series of stave signals (per ping);
- Panoramic display of echo levels at beamformer output (per ping);
- Waterfall displays of swath bathymetry and sidescan image;
- SSP and SSV;
- Time-series of attitude parameters;
- Selected beam output data (amplitude/phase processing; successive soundings); and
Geo-referenced bathymetric and reflectivity maps.

The Raw Data Logger Option is also applicable. As with the Fisheries Research mode, raw data logged in Bathymetric mode is limited to short periods.

Finally, representatives from INFREMER and NOAA Fisheries discussed a possible collaborative research plan which includes:

ME70 refinement
- Element data stability
  - Estimation of element data variability and improved prediction of side lobe levels (INFREMER)
  - Estimation of transducer performances through time and diagnosis of the possible degradations (INFREMER/NOAA)
- Cyclical folding parasite echo before bottom detection
  - Beamforming analysis (INFREMER)
  - Implementation by Simrad (INFREMER/NOAA)
- LFM mode
  - Performance analysis of this mode for range detection and resolution (NOAA/INFREMER)
- Ability to configure the system in advanced mode
  - Manual frequency and steering settings for fish directivity patterns analysis
  - Implementation of ability to freely set the bandwidth in advanced mode in HERMES (INFREMER)
- Calibration
  - Measure broad bandwidth TTS of spheres (NOAA)
  - Analyze near-field depending on beam configuration
- Share experience on calibration procedure with 25mm WC sphere and 75/84mm WC spheres, evaluation of positive and negative aspects for each
  - Share information on stability of gains
  - Develop standard calibration data summary
  - Update a shared table for gain values
- Developments required of Simrad
  - Ability to calibrate complete configurations and retrieve the gains automatically for a sub-configuration in order to limit the blind zone
  - Display of the layers for the single target analysis on the echogram during calibration
  - Possibility to sort the values measured (TS_comp TS_angles) in the calibration program to make easier the filtering of wrong echoes (sort by time, TS, angle, etc.)
  - For the solution of calibration with two spheres, possibility to merge automatically the results of the two calibration in the beam configuration
- System reliability
  - Share information on:
    - TRX32 board reliability
    - Software bugs in OS and beamformer
  - Current problems of the system:
    - Directivity function of reference beams as estimated during calibration is strongly decreasing at the edge
Fixed range parasite echoes observed for some beam configurations (not necessarily repeatable)
Loss of pings in the new beamformer (a few pings every XXX minutes depending on work load of the system)
Shift in gain values after a new version was installed in August 2007 (1.5dB)
Instability of the calibration program after a new version was installed in August 2007 (crash of the system when “suspending” some hits)
Why is there a trigger pulse evident in passive mode?

Update a shared table for malfunctions

Post-processing modules
- Noise filtering
  Implementation in HERMES of regular passive mode data acquisition in EK60s and ME70s for later noise filtering (INFREMER)
- Bottom detection
  Improved bottom detection in steered beams using amplitude and phase (INFREMER)
  Ping to ping analysis for spatial filtering of bottom shape; amplitude and phase detection (INFREMER; Sebastian Bourguignon)
- Navigation/directivity/environment compensation
  Estimation of EK60/ME70 beam coverage percentage for filtering data (INFREMER)
  Prediction of location and level of side lobe echoes based on accurate prediction of beam directivities (INFREMER)
  Sound speed and absorption compensation (NOAA)
- School and layer extraction
  Computation of descriptors (INFREMER/NOAA?)
- Single target extraction
  Extraction of single targets (NOAA)
- Fish directivity pattern
  Sv layer versus steering angle for all frequencies (INFREMER/NOAA)
  Sv school versus steering angle for all frequencies (INFREMER/NOAA)
  TS single target versus steering angle for all frequencies (NOAA)

Software considerations
- HERMES
  Beam configuration
  Automated simultaneous EK60/ME70 data acquisition (HAC and .raw formats)
  Control of acquisition (ping rate and synchronization)
  Contract for HERMES and MOVIES3D to be discussed
    Possible sharing of modules with a written agreement between institutes
    Module property and maintenance to be discussed
    Timetable for module development at NOAA to be discussed

IMPACT/APPLICATIONS
The ME70 multi-beam has the potential for addressing many aspects of stock assessment and ecosystems work which are critical components of the NOAA mission. For this reason the ME70 was also the instrument chosen for installation on the new, noise-reduced class of NOAA fisheries research vessels; thus work should begin for planning how to make the best use of these valuable tools. The multi-beam workshop not only provided training for NOAA researchers but also facilitated an exchange of innovative research plans among NOAA and IFREMER researchers. In particular, plans
are made to assess the performance capabilities of the ME70 in terms of measurement and sampling uncertainties in comparison with more traditional acoustic instruments (i.e., EK60) used in assessments of living marine resources.

The ME70 technology holds promise to help address four ASTWG themes including: remote species identification and enumeration, near-boundary assessments, and broad-scale movements of living marine resources. Although the workshop activities focused primarily on water-column related issues, discussions also addressed seafloor characterization using multi-beam technology and thus address the fourth ASTWG research theme.

Finally, The NOAA 2005-2010 Strategic Plan states that we should, “Engage in technological and scientific exchange with our domestic and international partners to protect, restore, and manage marine resources within and beyond the Nation’s borders.” This workshop is a prime example of a means towards accomplishing this goal.

TRANSITIONS
The workshop collected the expertise and experiences of international experts. Thus, it will help guide and expedite the implementation of the ME70 multi-beam echo sounder with NOAA Fisheries. Collaborations created though this workshop have been and will continue to be productive.

RELATED PROJECTS
Multiple teleconference workshops have been held with Simrad and NOAA users and future users of the ME70.

PUBLICATIONS
Progress in this area has been delayed due to delays in funding and the functional installations of ME70 systems aboard NOAA Fisheries survey vessels.

EXPENDITURES
Grant total = $12k; $4k each to AFSC, SEFSC and SWFSC. AFSC and SWFSC used the funds for travel to the cruise aboard Thalassa.
TITLE: Workshop on modeling fish and zooplankton acoustic scattering  

GOALS
The goal of this workshop is to improve our understanding of the acoustic backscattering by fish and zooplankton in order to reduce uncertainty in acoustic-based abundance estimates.

PRIORITIES
The objectives of the workshop were to:
1) Predict acoustic backscatter as a function of length, frequency, and insonification angle using common data sets of fish and zooplankton.
2) Compare acoustic backscatter predictions among models.
3) Identify advantages and constraints of each backscatter model
4) Compare backscatter predictions to backscatter data (where applicable)
5) Publish model descriptions, comparisons, and recommendations for model use.

APPROACH
Workshop participants were provided anatomical and morphological data of a physoclist (Atlantic cod, *Gadus morhua*), a physostome (Atlantic herring, *Clupea harengus*), and an Antarctic krill (*Euphausia superba*). The workshop participants consisted of “modelers” and “users”. This provided a balance of theory and application. Workshop participants produced:
- Predicted backscatter by fish as a function of
  - fish length (0.10 to 1 m)
  - frequency (12 kHz to 200 kHz)
  - insonifying angle(360° from “head-on” to “tail-on” to “head-on”).
- Model descriptions
- Model algorithms and example calculations

WORK COMPLETED
The workshop was held 22-24 January, 2008 at the University of Washington’s Friday Harbor Laboratories in Friday Harbor, WA. Seventeen participants represented “modelers” and “users”:
1) Michael Jech, NEFSC, Kirchhoff Ray-Mode model (co-convener)
3) Clarence Clay, Professor Emeritus U. Wisconsin-Madison, acoustic modeling
4) Van Holiday, U. Mass-Dartmouth, acoustic modeling
5) Koichi Sawada, Fisheries Research Agency, Prolate-Spheroid Model
6) Ben Jones, U.S. Navy, Distorted Wave Born Approximation – Ray mode
7) Andone Lavery, Woods Hole Oceanographic Institution, High-resolution Distorted Wave Born Approximation
8) Tim Stanton, Woods Hole Oceanographic Institution, acoustic modeling
9) Dezhang Chu, NWFSC, Hybrid models
10) Ben Reeder, Office of Naval Research, Fourier-Matching Method/Conformal Mapping
11) Trevor Francis, U. Birmingham, Boundary-Element Method
12) Ken Foote, Woods Hole Oceanographic Institution, 3D Kirchhoff Approximation
13) Gavin Macaulay, Fisheries New Zealand, Finite-Difference Time Domain
14) Natalia Gorska, U. Gdansk, Deformed Cylinder-DWBA
15) Rebecca Thomas, NWFSC, acoustic modeling
16) Robert Gamble, NEFSC, programmer, logistic support
17) Dick Kreisberg, U. Washington, programmer, logistic support

RESULTS
The models were generally consistent in representing the broad-scale backscattering characteristics and features of Atlantic herring (Fig. 1).

Although there is broad-scale agreement among models, the consensus among the workshop participants was that the agreement should be within 1 dB for the major backscattering features. Therefore the participants have agreed to proceed with further computations to compare the models to standard targets with exact or very well known solutions such as a sphere, prolate spheroid, and cylinder. This work will continue throughout the next calendar year.

IMPACT/APPLICATIONS
All NMFS Science Centers currently use or are developing acoustic surveys for assessments of commercially-fished finfish and invertebrate stocks. Clearly, reducing acoustic measurement uncertainties is of national importance.

TRANSITIONS
Although there is broad-scale agreement among models, the consensus among the workshop participants was that the agreement should be within 1 dB for the major backscattering features. Therefore the participants have agreed to proceed with further computations to compare the models to standard targets with exact or very well known solutions such as a sphere, prolate spheroid, and cylinder. This work will continue throughout the next calendar year.
RELATED PROJECTS
The workshop was also supported by the National Ocean Partnership Program (NOPP) under a grant to John K. Horne.

PUBLICATIONS
None at present.

PRESENTATIONS
None at present.