NOAA-Fisheries Advanced Sampling Technology Working Group (ASTWG)
FY05 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. ASTWG FY05 priorities 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 was delivered in FY05 and significant progress has been made towards acceptance trials and evaluating the capabilities of this alternative sampling platform. Building on the success of the underwater image analysis workshop in FY04, the report from the workshop was published and improvements in acquisition and analysis of underwater images are ongoing. Efforts at improving our ability to verify acoustic backscatter and utilizing broad acoustic bandwidth methods are benefiting acoustic-based assessments. The tagging workshop was a successful forum for sharing state-of-the-art knowledge, fostering communication among government scientists, and providing opportunities for future collaborations.

Summary reports of the national initiatives and Fisheries Science Center advanced technology initiatives are provided in this report to highlight accomplishments by the ASTWG and the Science Centers through funding by the ASTWG.

Regional Support of FY05 ASTWG:- Alaska Fisheries Science Center
(Representatives: Chris Wilson, 206-526-6435, Chris.Wilson@noaa.gov; David Somerton, 206-526-4116, David.Somerton@noaa.gov)

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

Priorities
The FY05 priorities for the AFSC were to participate in efforts to continue development of improved survey sampling platforms and sampling gear, and continue efforts to evaluate a replacement system (Simrad EK/ER60) for the standard echo sounder (Simrad EK500).

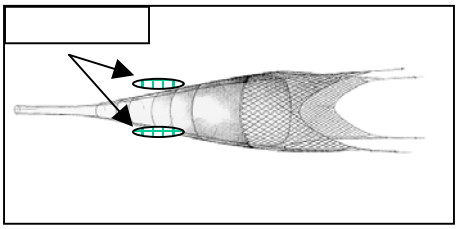
Approach
The AFSC was involved in several regional activities to develop alternative sampling platforms and improve remote sampling devices. A multisampler codend device was built and will be used to improve acoustic-trawl survey estimates. Work was also initiated to evaluate whether the size and species composition of large midwater trawl catches taken during every AFSC acoustic-trawl survey, were biased due to net selectivity of the trawl. Trawl catches form an essential part of most acoustic-trawl surveys because this information is used to scale the acoustic data so it is vital that any large biases that result from net selectivity are identified and addressed. Innovative use of a Dual Frequency Identification Sonar (DIDSON) system is providing critical observations to assess the potential net selectivity of the trawl. These two developments will be used on projects that seek to improve the quality of stock assessment efforts.

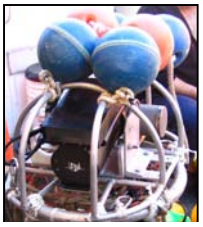
Work Completed
Codend multisampler device.
Construction of a codend multisampler device was completed in August (Figure 1). The multisampler is attached to the back of a large trawl and is capable of collecting discrete samples during a single haul by opening and closing three condends via an acoustic link from the ship. The multisampler was designed by researchers at the Institute of Marine Research in Bergen, Norway, where it has been used extensively on similar trawls. Field trials with the AFSC multisampler were conducted in October 2005. Various sensors, including an

underwater video camera, tilt sensors, and a DIDSON were used to adjust and monitor the multisampler so that it was properly oriented on the trawl. It was possible to successfully communicate with the device to a net depth of at least 660 m. Additional steel struts will be added to strengthen the multisampler side rails. The final phase of field trials are planned to occur during the winter and summer 2006 acoustic-trawl pollock surveys to determine whether the device can accommodate large fish catches without sustaining damage to the frame or nets. One of the first uses of the multisampler will be to confirm that walleye pollock are stratified vertically by sex and depth when they are surveyed during the winter pre-spawning period.

Net selectivity field work. Several field experiments were conducted in FY05 to develop methodologies to evaluate the net selectivity in large midwater trawls. Trawl size selectivity can be a potential source of error in acoustic biomass estimates, because trawl-based size compositions of the target species are used to scale the acoustic backscatter to biomass. Midwater trawls, unlike bottom trawls, present unique challenges in selectivity studies because of their relatively large size. For example, the midwater trawl used routinely in AFSC pollock acoustic-trawl surveys has a surface area of about 4500 m^2 compared to the two standard survey bottom trawls with areas of only 250 m^2 or 375 m^2. The greater surface area makes adequate coverage of the main body of the trawl by recapture nets or video cameras impractical.

To observe and quantify fish escapement behavior from the midwater trawl several complementary methodological approaches were attempted. Small monofilament mesh pocket nets that were attached in various locations on the midwater trawl in combination with the DIDSON were determined to be the best method to evaluate the fish escapement behavior (Figures 2-3). The pocket nets provided samples to determine the species and size of the fish, which escaped through the trawl meshes, and the DIDSON allowed unobtrusive observations of fish behavior (Figure 4). Preliminary results suggested high escapement rates of 5 individuals m^{-2} h^{-1} during one deployment, which represented 1.2 times the number of targets retained in the codend if the observed escapement rates were applied to the entire surface of the net. The DIDSON represents a relatively new and innovative instrument that can provide valuable, unbiased information to understand the consequences of the behavior of fishes and other organisms as they interact with large trawls.





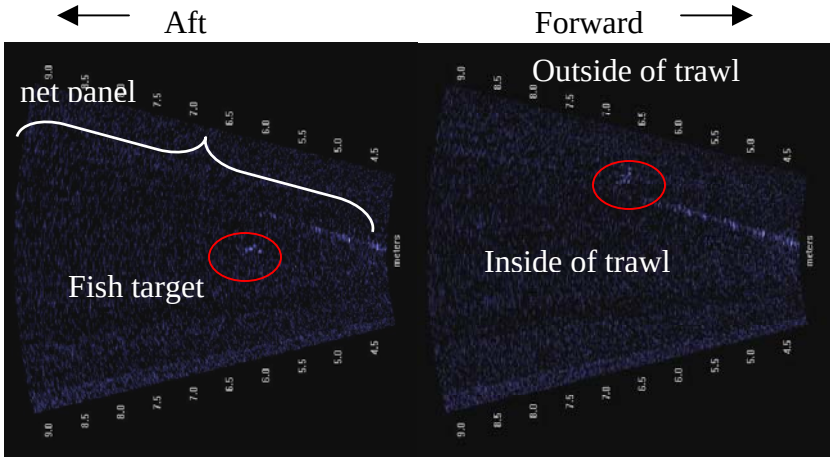


Figure 4. DIDSON images of a fish target escaping the trawl.

Impact/Applications

Integration of the multisampler into routine acoustic-survey and bottom trawl surveys will provide new information on the spatial patterns of the target species. With this device, it will be possible to collect multiple, discrete samples during a single trawl haul. This new sampling capability will enable researchers to accurately determine vertical and areal distribution patterns of those marine organisms, that can only be caught with large trawls, to a much finer resolution than has ever been possible. Consequently, the multisampler will provide the potential to dramatically improve survey-based estimates of distribution and abundance. The net selectivity work illustrates one important new use of the DIDSON system. This instrument will both provide novel methods of remote sensing that will benefit acoustic survey methods and related investigations over a large range of spatio-temporal scales.

Expenditures

The Alaska Fisheries Science Center was allocated $183K in FY05 for ASTWG activities. Funds were used to: build and field test the codend multisampler device, and initiate the midwater trawl net selectivity work ($40K), publication and printing of the papers presented at the 2004 Video Analysis Workshop ($3.0 K), cover a portion of the travel expenses for the ASTWG Tagging workshop ($3.2 K), travel for S. Furnish to AUV training ($1.9 K) and D. Somerton and C. Wilson to two ASTWG meetings ($2.2 K). Funds were also used for unanticipated repairs and modifications to the *Oscar Dyson* to may the vessel functional ($24.5 K). Finally, funding was used to partially support Dr. John Horne's appointment at the UW JISAO ($35.6 K) and support for technical help from PMEL to complete survey work on the Miller Freeman and Oscar Dyson ($72.1 K).

Regional Support of FY05 ASTWG: Northeast Fisheries Science Center
(Representatives: Michael Jech, 508-495-2353, Michael.Jech@noaa.gov; William Michaels, 508-495-2259, William.Michaels@noaa.gov)

GOALS
The goal of ASTWG supported efforts at the NEFSC is to improve the accuracy and precision of living marine resource assessments and initiate efforts toward ecosystem-based management through the use of optical and acoustical technologies.

PRIORITIES
Priorities during FY05 were to develop the technical infrastructure required to improve stock assessments, participate in new ASTWG national initiatives and continue efforts at on-going initiatives.

APPROACH
Acquire the necessary tools and instrumentation to develop an electronics lab and participate in training to improve our knowledge of advanced sampling technologies. Support participation in ASTWG-sponsored initiatives and support collaboration with academic and other governmental partners.

WORK COMPLETED
An Electronics Engineer (ZP-03) was hired and we have completed the first phase of developing an electronics lab with the basic tools and instrumentation necessary for maintaining and developing advanced sampling technologies. The NEFSC supported participation for three scientists at the ASTWG tagging workshop in August. Jech and Michaels completed multibeam training conducted through the University of New Hampshire, and the electronics engineer completed training in fiber optic systems.

RESULTS
An evaluation of the new Simrad EK60 and comparison to the standard echo sounder used by NMFS was published in the scientific literature. Efforts are on-going for measuring the *in situ* target strength of pelagic and semi-pelagic fish species in the northwest Atlantic. Development of a new underwater towed vehicle with state-of-the-art acoustic and optic technologies is nearing completion.

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 and enhances collaboration with academic partners and other governmental agencies.

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

PUBLICATIONS

Jech, J.M, K.G. Foote, and D. Chu. 2005. "Comparing two 38-kHz scientific echo sounders." ICES J. Mar. Sci. 62: 1168-1179.

PRESENTATIONS

Chu, D., L. C. Hufnagle, Jr., and J. M. Jech. 2005. "Quantitative acoustic measurements with multibeam sonars". ICES FAST WG, Rome, Italy, April 2005.

Jech. J.M. 2005. "Using objective classification methods to evaluate uncertainty in fisheries acoustics surveys". ICES FAST WG, Rome, Italy, April 2005.

Jech. J.M. 2005. "Report of a workshop to evaluate the Simrad EK60 and comparisons to the Simrad EK500". ICES FAST WG, Rome, Italy, April 2005.

Jech, J.M., J. Condiotty, and I. Higginbottom. 2005. "Applications of multibeam to fisheries – quantifying water-column target behaviour and distribution". FEMME2005, Dublin, Ireland, April 2005.

AWARDS

J. M. Jech. NOAA Administrator's Award. 2005 for integrating theoretical acoustic models with survey data to improve population estimates.

Expenditures [$139.5K]

The Northeast Fisheries Science Center (NEFSC) was allocated **$135K** in FY05 for the FTE position and **$4.5K** for ASTWG activities. The NEFSC hired an electronics engineer (ZP-03) who began on Feb. 8, 2005. Because the FTE started on Feb. 8, 2005, approximately **$75K** was allocated to salary, benefits and overhead, which left approximately **$65K** in salary lapse. The **$4.5K** was allocated to participation to the national ASTWG meetings and for three scientists (full support for one scientist and partial support for two scientists) to the ASTWG Tagging Workshop.

The salary lapse was spent to develop technical infrastructure and support ongoing national and regional initiatives. In support of the acoustical assessment national initiative and to continue with the EK60 evaluation initiated in FY04 **$26K** was allocated for a portable CTD for laboratory and *in situ* measurements, fabrication of an aluminum towbody for *in situ* target strength measurements, fabrication of a live well to maintain live fish at sea, a lightweight anchor roller for *in situ* target strength measurements, a Simrad 120 kHz transducer for laboratory experiments, and transducer cables and connectors for *in situ* and laboratory measurements. In support of the optical assessment national initiative **$2K** was allocated to purchase a software package for processing stereo video images. In support of the multibeam initiative, **$2K** was allocated for Jech's participation at the FEMME multibeam conference. The remaining salary lapse (**$35K**) was allocated to building and developing the technical infrastructure necessary to an advanced technology program. Expenditures included acoustic and fiber optic training, electronic components, tools and instrumentation, and computers, peripherals and software.

Regional Support of FY05 ASTWG: Northwest Fisheries Science Center
(Representatives: Guy Fleischer, 206-860-3289, Guy.Fleischer@noaa.gov; Earl Prentice, 206-842-5434, Earl.Prentice@noaa.gov)

Goal
The goal of the Northwest Fisheries Science Center (NWFSC) is to work in concert with the ASTWG to improve the accuracy and precision of living marine resource assessments. This goal will be accomplished by identifying information 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
Priorities during FY05 included securing a qualified candidate for the advanced technology FTE, the participation in ASTWG national initiatives, advancing the understanding and improvement of methods for assessing fish behavior during interactions with bottom trawls, implementing a proof of concept study of electronic catch monitoring, and the further advancement of techniques for assessing important groundfishes in untrawlable areas of the West Coast.

In response to the request from the Advanced Sampling Technology Working Group (ASTWG), the NWFSC developed a list of stock assessment, ecosystem monitoring and habitat characterization needs that might be met through application of advanced sampling technology. The list assembled (see Appendix) covers the major needs that could be addressed through AST. The prioritized list of candidate technologies and supporting rationale is our initial assessment of those deemed most promising for addressing current gaps in our ability to monitor and assess living marine resources and their ecosystem on the West Coast.

Approaches
In addition to hosting the Advanced Sampling Technology Working Group Tagging Workshop, held in Seattle WA 23-25 August 2005, the NWFSC was involved in several regional activities to develop advanced technologies for improved stock assessment efforts. These efforts included the use of a sonar imaging device (DIDSON) for initial application to assess gear designed to reduce bycatch, the acquisition and initial field testing of a video plankton recorder (VPR) to investigate zooplankton communities by means of an imaging system that simultaneously collects images of plankton and information on the physical properties of the water column, the deployment of various fishery and habitat sensor gear, including the WHOI Seabed AUV, as part of an advanced technology cruise, deployment of electronic monitoring (EM) systems for the West Coast shore-based hake fleet, and the application of fishery acoustics to specific gaps in our ability to reliably assess the status and trends of key groundfish species.

Work Completed
NWFSC lead a multi-disciplinary team comprising colleagues from the Woods Hole Oceanographic Institute's (WHOI) Deep Submergence Group and Oregon State

University Active Tectonics & Seafloor Mapping Lab, as well as students from Oregon State University, Washington State University and University of Washington (UW) on a cruise aboard the UW research vessel Thomas G. Thompson. During this cruise, scientists used in situ acoustic and optical instruments to better understand how these technologies can inform and improve assessments of fisheries and their ecosystems. Scientists also mapped the underwater terrain using the vessels' advanced mapping system and by deployment of an advanced scientific autonomous underwater vehicle (AUV), with an array of sophisticated sensors that enabled scientists to navigate and photograph benthic habitats and faunal communities for later examination and quantitative analysis.

The DIDSON imaging device was field tested and put into initial deployments. The goal of the first phase of this project was to obtain baseline information on the behavior of demersal fishes when they are overtaken by a bottom trawl. In situ information of this nature is critical to the successful development of future species-selective trawls and bycatch reduction devices for West Coast groundfish fisheries. Our project combined the use of conventional low-light video with the DIDSON imaging sonar (Dual-frequency IDentification SONar) to document and to categorize fish behavior in front of and in the mouth of a bottom trawl.

NWFSC scientists, in cooperation with industry representative and fishermen, conducted a pilot widow rockfish (*Sabastes entomelas*) survey plan designed to investigate potential alternative methods of widow rockfish assessment along the West Coast.

Established a contract with major manufacturer for principle initial applications of broadband acoustics uses for fisheries assessment to (1) investigate use of broadband for near bottom echo detection in otherwise 'dead zone' and (2) use of broadband frequency response for discrimination of different backscatters.

Electronic monitoring (EM) systems were installed on all 28 shore-based hake fishing vessels as proof of concept as a tool to confirm practices of maximized retention. This advanced technology, integrating video images, GPS coordinates, and winch and hydraulic sensors, documents fishing practices at the tow level.

NWFSC proudly announces the addition of Stan Tomich, Advanced Technology position candidate, to the staff of the NWFSC. Stan started with NWFSC in November of 2005.

Results

Untrawlable Habitat Survey – Surveys of Daisy Bank off Newport, OR, Coquille Bank off Port Orford, OR and Santa Lucia off Morrow Bay, CA were completed using various sampling

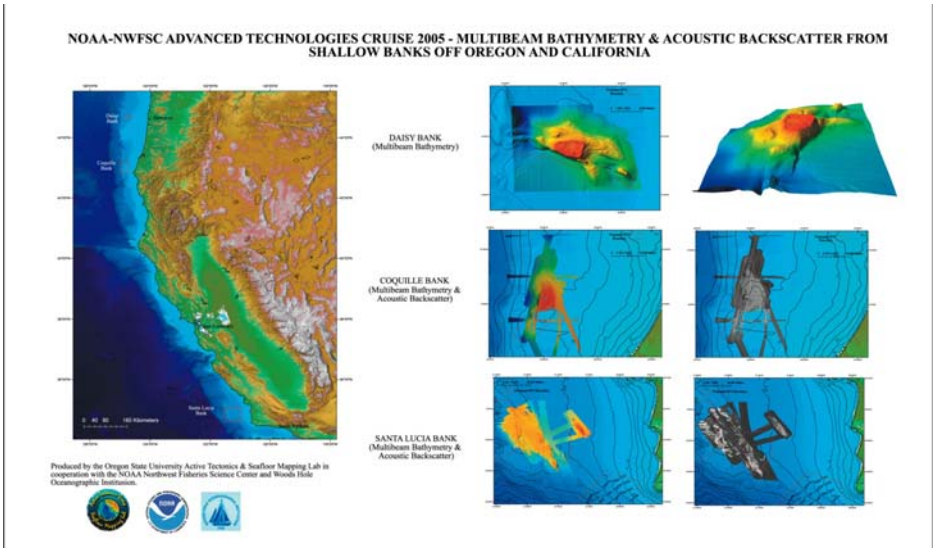


Figure 1. Locations and initial multibeam maps used as part of advanced technology assessments of study areas.

technologies (Figure 1). These are areas of special concern in regard to consideration for gear restrictions to protect habitat. Characterization of each area was based on detailed digital photo mapping of fish, invertebrates, and benthic habitats by the WHOI Seabed AUV, acoustic multibeam mapping of both the seafloor and the water column, acoustic sub-bottom profiling, and physical oceanography characterization by ADCP current profiles, CTD profiles, and video plankton recorder. The AUV-acquired data, mosaics of detailed digital photo mapping of fish, invertebrates, and benthic habitats, will provide information on distribution and habitat association for demersal fishes and structure forming invertebrates (sponges and gorgonian corals). For fish-habitat relationships, we aim to be able to discern differences in assemblage structure both among broad-scale habitat types (rocky vs. soft sediment) and within rocky habitat (cobble vs. boulder) (Figure 2). Together, the mosaic of geologic, physical oceanographic, and biological floral and fauna features will be used to characterize each areas' ecosystems.

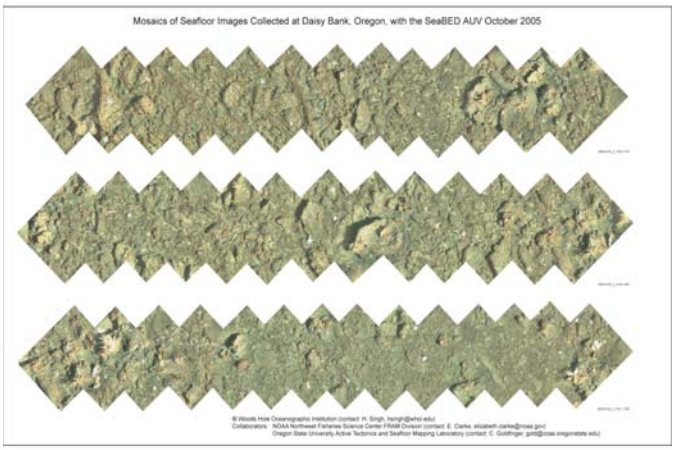


Figure 2. Example of mosaic images used to quantify benthic biological and physical features of study areas.

Widow rockfish Survey – Initial surveys, conducted in early 2005, found that we could locate, observe, and measure widow rockfish schools with standard single frequency fishery acoustics techniques and use underwater video for verification. The sites we sampled off central Oregon, a subset of those identified by fishermen in the ad hoc working group, were found to contain widow rockfish aggregations that we were able to locate using local fisherman knowledge of the grounds (Figure 3). The acoustic data collected with the industry-supplied scientific echosounder installed on the chartered commercial vessel we used in this study was of good quality. We were able to examine patterns of variability in widow rockfish at the sites we visited, and based upon these observations were able to produce recommendations for future pilot work and development of an index of widow rockfish abundance using these techniques.

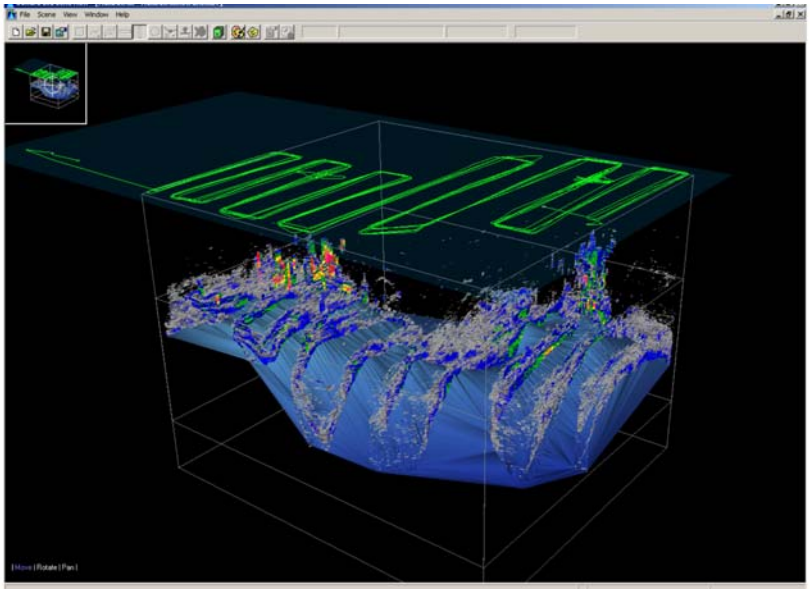


Figure 3. Three dimensional echograms of widow rockfish schools.

DIDSON Image Analysis – This project represents the first successful application of DIDSON sonar in bottom-tending mobile fishing gear. A novel set of mounting frames (Figure 4) provided a stable platform for sonically imaging all areas in front of and in the mouth of the trawl (e.g., footrope, headrope, wings, and form of the footropes mud cloud). This first season's work resulted in the acquisition of an extensive set of paired observations with video and DIDSON imaging of the same areas/fish targets, providing the first documentation of the efficacy of using DIDSON sonar in mobile fishing gear. Pacific halibut (Figure 5), lingcod, Pacific hake, skates, and other flatfish were imaged routinely. These preliminary observations will be the basis for the second phase of study to assess the methods to reduce bycatch.

Figure 4. DIDSON and video camera mounting on bottom trawl.

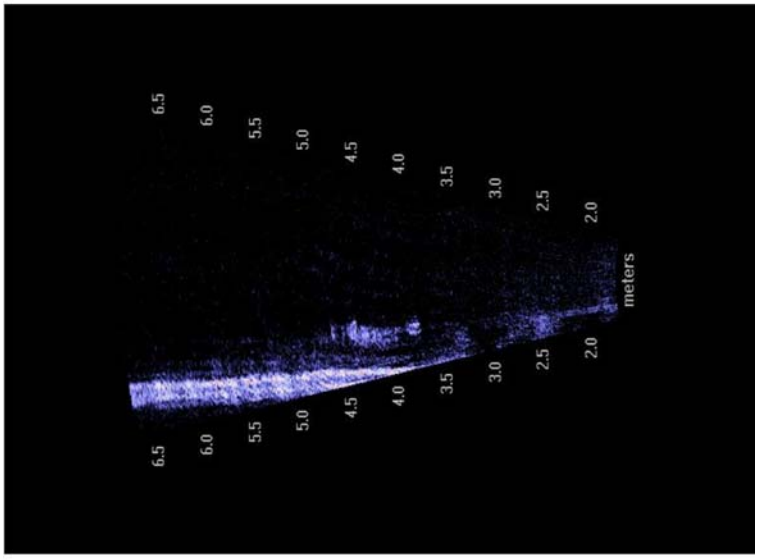


Figure 5. DIDSON image of Pacific halibut in mouth of bottom trawl.

Observer EM System – The integration of video images, GPS coordinates, and winch and hydraulic sensors, is being tested as an autonomous tool to document fishing practices at the tow level. The recorded images are used to quantify information on bycatch and discard data that are utilized by groundfish managers (Figure 6). These data are conventionally collected by human observers deployed aboard fishing vessels.

Figure 6. Examples of images collected of fishing operations by advanced electronic monitoring (EM) system.

Impact/Applications

Advances of the coordination of the application of a suite of advanced technologies by the interdisciplinary team of scientists were successful. Our goal was to explore the challenges in coordinating the acquisition, storage, integration, and analysis of these data.

Better understanding of acoustics techniques for assessment of pelagic rockfishes fish, in concert with video images, will advance our ability to assess the status of the full assemblage of West Coast groundfish stocks.

To date, we have comparative optical and video images on the avoidance behavior of fish to a selective flatfish trawl.

Electronic monitoring of fishing practices of the West Coast hake shore-side fleet holds promise for wider application for monitoring purposes in the future.

Transitions

The DIDSON images provided information on the performance of a selective flatfish trawl, the speed and direction of movement of fishes, herding behavior, wing interactions, and footrope and headrope effects. Video cameras were used simultaneously, and the resulting paired images were used to confirm which species were observed on the sonar. The strengths of the new sonar are increased viewing range and the ability to see beyond moderate turbidity and obstacles. Weaknesses are insufficient resolution to reliably identify species, and the inability to distinguish fish above the bottom when both are in relative motion. A combination of both video and DIDSON may be the most robust approach before using DIDSON alone. These preliminary observations will be the basis for the second phase of study to assess the methods to reduce bycatch.

Expansion of fish survey efforts into untrawable areas is an important step to improving the assessments of the West Coast groundfish stocks.

Publications

Lauth, R.R., J. Ianelli, W.W. Wakefield. 2004. Estimating the size selectivity and catching efficiency of a survey bottom trawl for thornyheads, Sebastolobus spp. using a towed video camera sled. Fisheries Research 70:27-37 11/04

Lauth, R.R., W.W. Wakefield, K. Smith. 2004. Estimating the density of thornyheads, Sebastolobus spp., using a towed video camera sled. Fisheries Research 70:39-48 11/04

Presentations

Clemons, J.E.R., W. W. Wakefield, C.E. Whitmire, B.N. Tissot, S.G. Merle. Using video and sonar technologies with GIS tools to investigate fish habitat communities off the Oregon coast. Annual Meeting of the American Fisheries Society, September 11-15, 2005, Anchorage, AK

Whitmire, C.E., M.E. Clarke, W.W. Wakefield, M.A. Hixon. Mapping the distribution of structure-forming invertebrates off the U.S. West Coast. Meeting of the North Pacific Marine Science Organization (PICES) 18-22 October 2004 Honolulu, HI

Whitmire, C.E., R.W. Embley, W.W. Wakefield, S.G. Merle, B.N. Tissot, N. Puniwai. Quantitative Benthic Habitat Characterization at Heceta Bank, Oregon. 148th Meeting of the Acoustical Society of America 15-19 November 2004 San Diego, CA
Fleischer, G.W., K. Cooke, P. Ressler, R. Kieser, K. Foote. Examination of in-situ Target Strength of Pacific Hake (Merluccius productus). 135th Annual Meeting of the American Fisheries Society, September 11-15, 2005, Anchorage, AK

Henderson, M., P. Ressler, and J. Horne. Bimodality and target strength: examples and thoughts. 135th Annual Meeting of the American Fisheries Society, September 11-15, 2005, Anchorage, AK

Whitmire, C.E., M.E. Clarke, and W.W. Wakefield. Mapping the distribution of cold-water corals and sponges off the U.S. West Coast. Geohab, Sixth International Symposium, May 4-7 2005, Sidney, British Columbia, Canada.

Whitmire, C.E., R.W. Embley, W.W. Wakefield, S.G. Merle, and B.N. Tissot. A quantitative approach for using multibeam sonar data to map benthic habitats. Geohab, Sixth International Symposium, May 4-7 2005, Sidney, British Columbia, Canada.

Romsos, C., C. Goldfinger, M. Yoklavich, W. Wakefield, J. Chaytor, L. Hufnagle, and M. Amend. Cooperative research and exploration: Multibeam sonar surveys and habitat mapping of the seafloor within the Cowcod Conservation Areas (CCA), Southern California Borderland. Geohab, Sixth International Symposium, May 4-7 2005, Sidney, British Columbia, Canada.

Strom, N.A., C. Goldfinger, B.N. Tissot, W.W. Wakefield. Structure-forming invertebrates: Habitat associations on Oregon's continental margin. Geohab, Sixth International Symposium, May 4-7 2005, Sidney, British Columbia, Canada.

Thomas, R.E., G.W. Fleischer, and P.H. Ressler. Optimal volume backscattering thresholds for echo integration: methods and a case study from the 2003 Pacific hake survey 148th Meeting of the Acoustical Society of America, November 2004, San Diego, California 11/15/2004

Tissot, B.N., W.W. Wakefield, N. P-F. Puniwai, M.M. Yoklavich, J.E.R. Clemons, J. Pirtle, J. Bright. and R.W. Embley. Ecological associations between structure-forming invertebrates and rockfishes on Heceta Bank, Oregon with special reference to corals. Annual Meeting of the American Fisheries Society and Lowell Wakefield Symposium on North Pacific Rockfishes September 11-15, 2005, Anchorage, AK

Wakefield, W.W. J.E.R. Clemons, B.N. Tissot, C.E. Whitmire, T.D. Hart, and R.W. Embley. Habitat associations and diel activity in rockfishes on a deep-water bank off Oregon. Annual Meeting of the American Fisheries Society and Lowell Wakefield Symposium on North Pacific Rockfishes September 11-15, 2005, Anchorage, AK

Expenditures
Working agreement for developmental 70 kHz broadband system - $25,000.

Appendix - Northwest Fisheries Science Center’s Requirements for Advanced Sampling Technologies.
SEE PDF

Regional Support of FY05 ASTWG: Pacific Islands Fisheries Science Center
(Representative: Michael Seki, 808-983-5393, Michael.Seki@noaa.gov)

Goals

The goal of the ASTWG supported program at the Pacific Islands Fisheries Science Center (PIFSC) is 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. These capabilities are further strengthened through partnerships with academia and other research institutions, and through national coordination within NOAA Fisheries.

Priorities

A priority for the Science Center is to develop fisheries independent methods for the improvement of fisheries stock assessments and advancement of ongoing efforts to define and characterize ecosystem parameters.

Approach

Two pilot projects using fishery-hydroacoustic surveys with a Simrad EK60 split beam dual frequency scientific echosounder were launched in 2004 and were progressing in 2005. Both projects, (1) an assessment of settled, juvenile pink snapper (*Pristipomoides filamentosus*) populations to nursing habitats in the main Hawaiian Islands and (2) assessment of resident bigeye tuna (*Thunnus obesus*) populations targeted by commercial handline fishers at isolated seamounts in the Hawaiian Islands, have direct linkages to the NMFS stock assessment improvement program (SAIP).

Work Completed

In FY-05, the PIFSC was allocated a total of $139.5K for ASTWG activities, including labor (one FTE) and travel to national workshops. Consistent with the Center's ASTWG goals, priorities, and spending plan, the PIFSC continued to contract the services of Dr. Reka Domokos through the University of Hawaii-NOAA Joint Institute of Marine and Atmospheric Research (JIMAR) with partial monies ($80K) allocated for the ASTWG-FTE. The Center fisheries acoustics capacity build-out in FY-05 included the procurement of a second frequency (120 kHz GPT) to complement the 38 kHz GPT initially obtained with the portable split-beam Simrad EK-60 echosounder system being use off small boats in shore-based studies.

Assessment of Bigeye Population at Seamounts at the Hawaiian Islands

To assess and monitor resident bigeye tuna populations at Hawaiian seamounts that are heavily targeted by commercial handline fishers, a pilot cruise was conducted in April, 2005, to Finch and Cross seamounts — located ~400 *km* and 290 *km* south of the island of Oahu, respectively. To estimate biomass of the sonic scattering layer (SSL) and to evaluate the feasibility of estimating bigeye biomass using acoustic survey techniques, bioacoustics data were collected on board of the NOAA ship *Oscar Elton Sette* equipped with two hull-mounted SIMRAD transducers with 7 degree beam angles, pinging at 38

kHz and 120 kHz frequencies. The bioacoustics data were ground-truthed with midwater Cobb trawl samples. In addition to bioacoustics, continuous ADCP current data and CTD profiles were collected to study the effects of the physical environment at seamounts on the distribution of bigeye and its forage, the micronekton.

Both seamounts, especially Cross, lie to the lee of the Hawaiian islands chain, with enhanced eddy activity and variable currents. The emphasis of this cruise was the study of the environment at the shallower Cross seamount (with a summit at 330 *m* as opposed to the summit depth of 995 *m* at Finch seamount), located within the Hawaiian EEZ, where known bigeye populations are being exploited.

Preliminary results show that the typical layer depths for the shallow and the deep SSL are ~ 20 - 200 m and 500 - 800 m below surface. Both the shallow and deep scattering layers consist of several thinner layers with various mean volume backscattering strengths (Sv) at each frequency, indicating diverse communities. However, most scatterers within both the shallow and deep SSL scatter stronger at the 38 kHz than at the 120 kHz frequency (*e.g.*, Fig. 1).

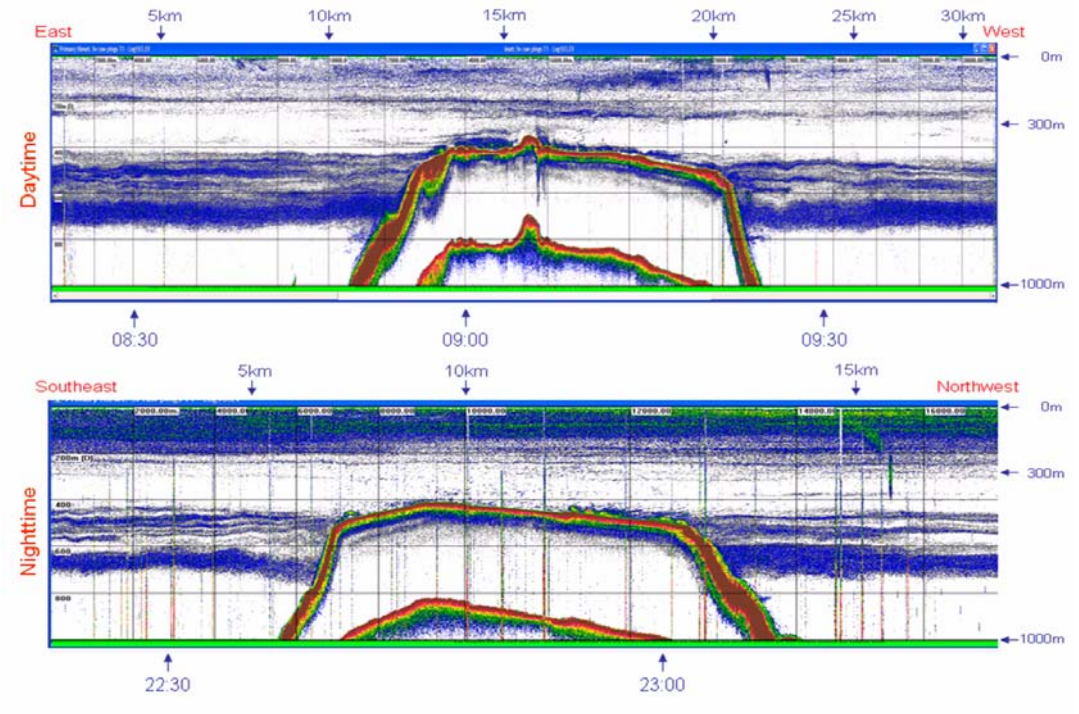


Figure 1: Daytime Acoustic Scattering Layers (S_v) at Cross Seamount at 38kHz (upper panel, from 0 to 1000 m depth), and at 120kHz (lower panel, from 0 to -300 m depth).

Micronekton is found to preferentially aggregate over the shallow Plateau (~ -400 *m*) of Cross seamount in the shallow SSL both day- and nighttimes, as indicated by higher Sv values there then away from the plateau or at the control site (*e.g.*, Fig.1). The deep SSL also shows higher Sv values within ~2 -3 km distance from the flanks of Cross seamount both day-and nighttimes as opposed to areas further away, spreading vertically at the flanks. Daytime the SSL extends over the plateau floor while large aggregations of organisms with high acoustic returns occupy the plateau floor during nights. Both

micronekton and the large aggregations — with acoustic signatures consistent with large schools of nekton — seem to be heavily influenced by the shifting currents at Cross seamount, as observed from the ADCP data.

Acoustic signatures consistent with that of bigeye (and/or yellowfin) tuna were observed on several occasions during daytimes over the plateau (*e.g.*, Fig. 1, at about 09:10 and 09:22). These aggregations typically extend from a shallower (~ -50) to a deeper (~ -250 *m*) scattering layer and show vertical shapes in accord with observed bigeye and yellowfin signatures that are presumably feeding on the two scattering layers. Further, mean TS values are consistent with 37 *cm* FL bigeye and 39 *cm* FL yellowfin, sizes that are typical for these species at Cross seamount. A follow-up cruise, concentrating on bigeye distribution and biomass estimation using bioacoustics, is planned for the spring, 2007.

Assessment of Juvenile Pink Snapper Population at a Hawaiian Nursing Ground

Preliminary work has been completed on a project assessing the effectiveness of stocking the only known premium Hawaii pink snapper nursery ground with aqua-cultured juveniles. The nursery ground is off the east coast of Oahu, with depths approximately between 30 to 120 *m*, covering an area ~10 - 20 km^2. Due to the relatively small size and shallow depths of the study area, a small, 21 foot NOAA vessel, *Kumu*, was chosen for this study. *Kumu* was outfitted to make it suitable for acoustics surveys with a 3 frequency echosounder system. Further, a portable dual frequency (38kHz and 120kHz) SIMRAD EK-60 echosounder system was procured to be used on board the *Kumu* along with an additional 200kHz transducer and GPT available for use in this study. During the first stage of this project, TS measurements of laboratory cultured juveniles with known sizes were obtained in the field (*e.g.* Fig. 2). In addition, bioacoustics data were collected during a planned release of twelve cultured juveniles in the nursing grounds to obtain TS values of freely swimming individuals. This information will be used to acoustically recognize pink snapper in the nursery ground, to estimate their biomass using acoustics, and, ultimately, to determine whether the release of cultured pink snapper helps in recruitment to maintain (or increase) the number of adult pink snapper in the field.

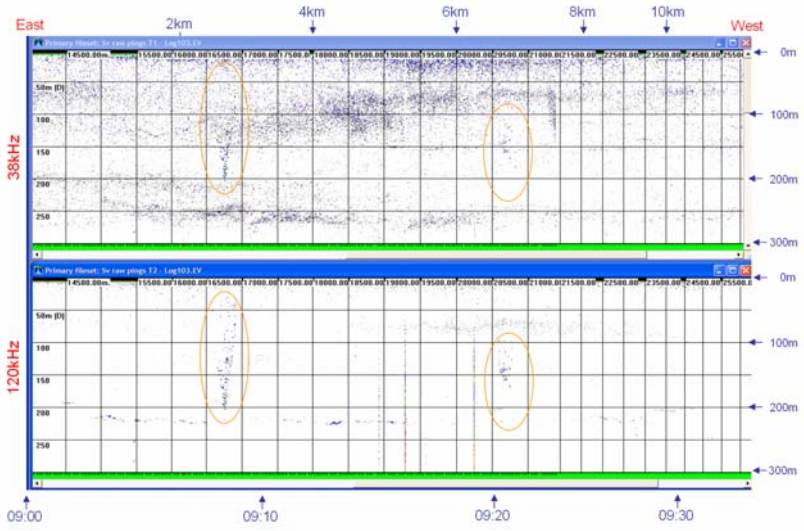


Figure 2: Juvenile pink snapper (FL: 22.9 *cm*) Sv values at 38kHz (top), 120kHz (middle), and 200kHz (bottom) frequencies. The straight line at ~ -12 *m* is the backscattering from a 38.1 *mm* WC Tungsten Carbide calibration sphere attached to a monofilament line with a weight resting on the bottom. The snapper is seen to move away from the sphere, pulling on the line and moving the weight on the bottom.

Related Projects

A study to characterize tuna habitat and the fishing grounds in American Samoa, supported by bioacoustics data (obtained by the hull mounted 38kHz and 120kHz EK60 system on the *Oscar Elton Sette*) describing the behavior and relative biomass of the SSL, have been completed and the results are being written up for publication. Based on these results, a cruise is planned for February, 2006, to further study the American Samoa area utilizing bioacoustics data.

Presentations

Dr. Domokos gave presentations on the "Oceanographic influences on catch rates in the American Samoa longline fishery" at the 56th Tuna Conference in Lake Arrowhead, May 2005 and at the JIMAR Pelagic Fisheries Research Program Principle Investigators Meeting.

Development of autonomous underwater bait stations with stereo imaging for size, distance, and abundance estimates (Project Leader: Kevin Wong; PIFSC; 808-592-7033; Kevin.Wong@noaa.gov)

Goals

To develop stereo image data acquisition/storage/retrieval systems that are compact, modular, field deployable, and suitable for use in a variety of marine ecosystems. The hardware will be coupled with stereo image-analysis software so that in addition to identification and abundance data, information such as distance-to-target and size-of-target can be ascertained from the record.

Priorities

To field a non-extractive method of assessing bottom fish stocks by developing a compact, self-contained, and modular system capable of autonomously releasing bait and acquiring stereo image data using ambient light in deep water environments (250m typical, 500m max rating).

Approach

A working relationship with DEEP Development Corporation (Sumas, WA) has been established as a cost effective way to add limited control functions to an existing underwater Digital Video Recorder so that the unit will be a suitable component for the system. A modular external video sync apparatus has also been designed. Where possible commercial off the shelf components (COTS) have been utilized, such as marine video cameras, surface signature appertanances, acoustic release mechanisms, and Geometric Software's Vision Metrology System (VMS).

Two operational scenarios are envisioned for the Bottom fish camera (BotCam) bait stations: 1) BotCam units will be deployed in the late afternoon in water depths from 100-350 m from fisheries/oceanographic research vessels or chartered fishing vessels. The following morning, the bait stations will automatically activate at a predetermined time. Activation will include turning on low light video camera(s) and exposing bait to attract fish. Surface floats and an RF beacon will assist in re-locating the unit. The unit will be recovered by line haul or by using an acoustically triggered mechanism which will release the BotCam anchor weights, and allow the unit to float to the surface.

2) BotCam units may also be deployed and recovered multiple times per day during research cruises. This application requires the user to quickly reprogram the system between deployments. Furthermore, all steps required to ready the unit for another deployment (including any re-programming of the controller) will typically take place on the exposed deck of a ship or small boat in an environment of high humidity, tropical temperatures (~30 ^{o}C), salt spray, wave wash, and/or rain.

Work Completed

A field prototype BotCam bait station has been fabricated and tested in near-shore waters around Oahu, Hawaii. During the months of September - October 2005, initial field trials on board the NOAA vessel OSCAR E. SETTE were conducted during Reef Assessment

and Monitoring Program (RAMP) cruises OES-0511, 0512, and 0513 in the vicinity of Guam and CNMI.

Results

BotCam bait station systems are a non-extractive method which can provide researchers and resource managers with information about bottom fish species, relative abundance, and size data as well as habitat type. During the 2005 field trials of the BotCam prototype on the NOAA ship OSCAR E. SETTE forty-seven (47) deployments were attempted. The BotCam failed to activate on 7 deployments, failed to reach bottom or was dropped at a site too deep to collect video on 5 deployments, collected compromised (poor video quality but identifiable fish and features) data on 22 deployments, and provided 13 successful deployments.

A large number of activities are conducted during Reef Assessment and Monitoring Program (RAMP) cruises including the launching and recovery of small boats during the day, acoustic surveys, and mooring deployment operations. The logistics associated with conducting all of the concurrent scientific operations constrained the BotCam activities. In addition, handling 200-300m of line for each BotCam deployment presented challenges. The use of expendable cement anchors was also challenging as there had to be a sufficient number of anchors on board for all of the anticipated BotCam deployments during a cruise leg.

The following issues with the BotCam's Viperfish Digital Video Recorder and Controller unit were identified and are being addressed with the next design iteration, which is anticipated to be completed in FY06Q2.

- Determine the root cause and eliminate the scrolling horizontal lines that are appearing on some of the recorded video.
- Incorporate a timer function in the Viperfish software for delayed boot, activation/recording, bait release signal, and system shutdown. (i.e. eliminate the need for the auxiliary pressure vessel and timer.) Programming this timer must be feasible in harsh environments such as the deck of a small boat. Hazards include high humidity, high temperatures, salt water from waves and splashing, rain and wet hands. Ideally, a waterproof interface would be provided.
- Streamline the data download process. The user should be able to quickly connect a laptop computer to the Viperfish Deep communications port and when the Deep unit is powered up communications should be established such that files could be transferred and/or deleted. The user should be able to download large files (that may take on the order of 100 minutes to transfer) with no intervention other than starting the download process. The download cable and interface must be fully waterproof up to the laptop and enough cable (~20ft) should be provided to allow the laptop to be placed in a safe location for the download process.
- The Viperfish should draw from external power (if attached) during the download process. Given that the download process can take multiple hours, battery charging and data downloading should occur simultaneously.

Impact/Applications
With additional BotCam systems, deep water bottom fish bait station surveys can be conducted at a significantly reduced cost compared to the current method of using manned submersibles.

Transitions
Out year funding will allow a number of planned tasks to take place, including: 1) Transitioning from an engineering prototype to a field instrument that can be successfully and repeatedly deployed without the need of a dedicated technician; 2) The development of a video analysis protocol; and 3) The establishment of a 5-year Indefinite Delivery Indefinite Quantity (IDIQ) contract to simplify NMFS-wide procurement of the primary components.

Related Projects
Improvements in stereo imaging, the availability of economical low-light underwater video cameras, or alternative approaches to image acquisition (such as the use of strobes and high rate firewire digital still cameras) can be incorporated into the BotCam, due to the modular nature and independently functioning subsystems of its design.

Publications
Merritt, Daniel W., 2005, BotCam: Design, Testing and Development of a Fully Automated Stereo-Video Bottom Camera Bait Station for Ecosystem Monitoring of Bottom Fish Species, A paper submitted to the Graduate Division of the University of Hawaii in partial fulfillment of the requirements for the degree of Master of Science in Ocean and Resources Engineering.

Merritt, Daniel W., Kevin B. Wong, Christopher D. Kelley, Michael Parke, Joe Laughlin, 2005, Development of Autonomous Underwater Bait stations with Stereo Imaging for Size, Distance, and Abundance Estimates of Living Marine Resources, [Abstract], Submitted for presentation at the Ocean Sciences Meeting (AGU, ASLO, TOS), February 20-24, 2006, Honolulu, Hawaii.

Expenditures
FY05: $60K from ASTWG which included equipment; subsystem and component procurements; supplies; and engineering and field support services for development and testing of a BotCam prototype. Note that prototype development and testing costs were in excess of $60K. ASTWG funds leveraged additional resources from the NOAA Coral Reef Conservation Program and the Western Pacific Fisheries Management Council.

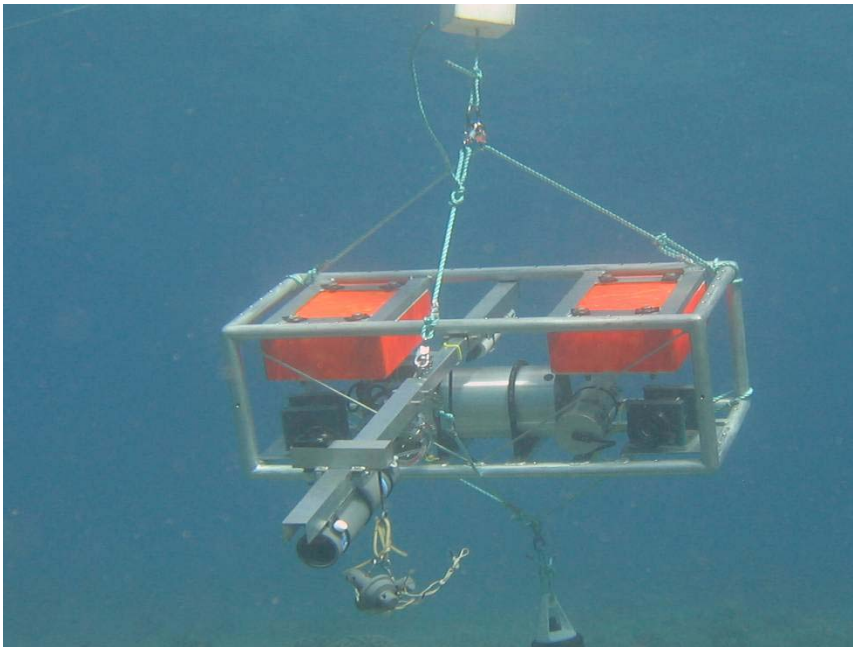


Figure 1: The digital video recorder, underwater video cameras, controller, and buoyancy control foam are contained within the BOTCAM frame. The bait canister is located within the cameras' field of view and the acoustic release is visible below the frame. The BOTCAM is rigged with a downward tilt so that part of the benthic habitat is visualized. The extended bait arm and a swivel in the anchor line help to orient the unit so that the cameras point down-current, in the direction of the bait plume.

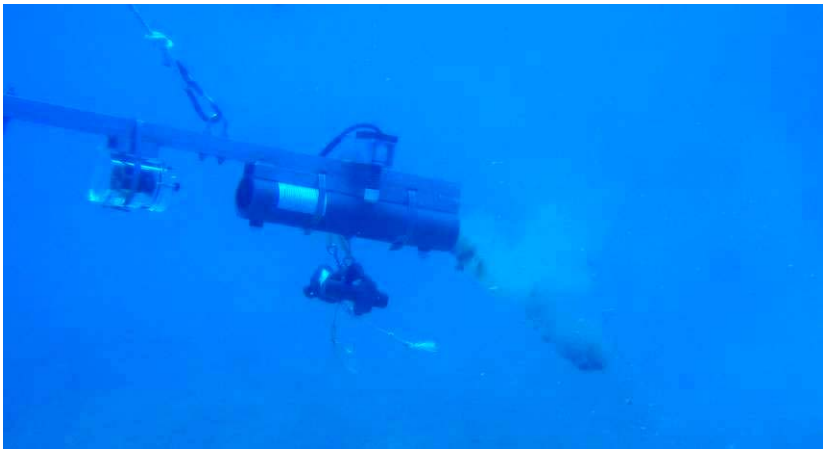


Figure 2: Bait is flushed out of the container after the end caps are automatically removed. An electrical current applied to a burn wire element causes a section of a wire to erode and to trigger the release of bait.

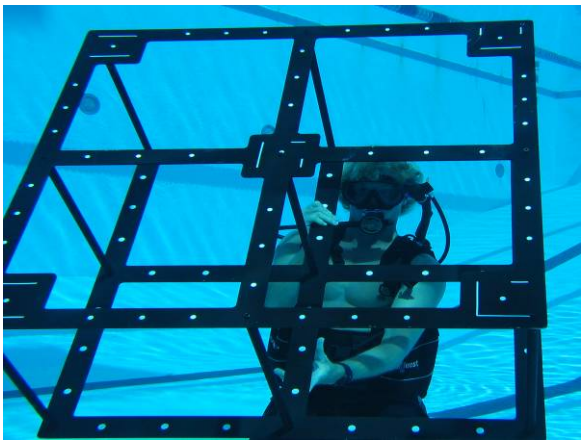


Figure 3: Marine Ecosystems Specialist Joe Laughlin holds a calibration cube used with the Visual Metrology System software to calibrate a pair of cameras for photogrammatic image analysis.

Regional Support of FY05 ASTWG: Southeast Fisheries Science Center
(Representatives: Christopher Gledhill, 228-762-4591, christopher.t.gledhill@noaa.gov; Pete Sheridan, 850-819-8026, pete.sheridan@noaa.gov; Charles Thompson, 228-688-2097, charles.h.thompson@noaa.gov)

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

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

Approach
FY05 activities addressed improving reef fish assessments. Fishery-independent surveys for reef fish are typically conducted using visual methods. For example, surveys of the Florida Keys reef tract are conducted using SCUBA diver census, while surveys of shelf-edge banks along the continental shelf are conducted using baited stationary video cameras. Both of these surveys can be improved by the development of stereo camera methods to obtain accurate measures of fish length. A stationary stereo camera system is being developed specifically for mid-depth (<500 m) fixed location operation. The electronics package is suitably flexible to be incorporated into a portable design (i.e., diver or towed body), and the mechanical packaging and operating software is tailored for the high shock load expected during deployment and recovery.

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

The underwater housing prototype has been fabricated and is waiting pressure testing. The original prototype experienced a weld failure at the maximum pressure and was redesigned to add a larger safety margin. Once testing is complete, 4 more housings will be fabricated. The stereo camera and video camera used in the system are “off the shelf” and have already been delivered. The recording package is based on the PC104+ standard and is therefore composed primarily of “off the shelf” electronic boards, and it uses the Windows XP operating system. All of the electronic boards and disk drives, with the exception of the power control board, have been delivered. The power control board has been designed and is currently being prototyped. The software for the power control board is required to hold the system in a hibernation mode during deployment and

retrieval to minimize the chance of disk drive damage due to shock. This is the only fully custom software in the system. This software is being developed in conjunction with the hardware prototyping. The other required software functions are to control capture and storage of the video and stereo images. The video capture/store function uses a modified demonstration program supplied by the manufacturer of the video capture board. The program modification is to allow command line operation rather than operation via the GUI. This modification is 90% complete. The stereo image capture and store software is a modification to the operating program supplied with the stereo camera. This software also required modification to allow command line operation and has been completed and tested. The stereo processing software has been installed on a dedicated computer. A complete underwater calibration was performed. However further tests with known targets gave unreliable results. This problem is still under investigation.

Due to facility damage from Hurricane Katrina (August 2005), the proposed development schedule was not met. At this time open water tests are not expected before March 2006.

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

Presentations
No presentations were made during FY05.

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

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

Expenditures
Total FY05 funds were $188.5K. Of this, $135K was used to support the advanced technology position, $43.5K was spent on electronics and hardware to build 4 stereo camera systems for a stationary array, $2.0K was spent for processing software, $3.5K was spent for a dedicated processing computer, and $4.5K was spent for travel to ASTWG meetings and the ASTWG-sponsored electronic tagging workshop.

Workshop on advancing the state of electronic tagging technology and use
(Project Leaders: Pete Sheridan, 850-819-8026, pete.sheridan@noaa.gov; John Ferguson, 206-860-3270, john.w.ferguson@noaa.gov; Sandy Downing, 206-860-5604, sandy.downing@noaa.gov)

Goal

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

Priorities

Tagging and marking technologies are key methods used in addressing fishery management issues such as protecting or rebuilding stocks, allocating catches, or evaluating distribution, abundance and viability of fishery organisms or protected species. To advance the use of electronic tags, it is necessary to: 1) explore the transfer of innovative electronic tagging technology within the fisheries community, 2) identify present and future needs of fishery scientists and managers as related to this important research technology, 3) enhance and foster communication and collaboration within NOAA and among government, academia, and industry, 4) develop items to propose funding initiatives, and 5) discuss and develop a framework for a nation / international conference on electronic tagging technology.

Figure 7. Yellowfin tuna equipped with electronic "pop-off" satellite archival tag.

Approach

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

Work Completed

The NMFS workshop on advancing the state of electronic tagging technology and use was held during 23-25 August 2005 at the Northwest Fisheries Science Center. There were 80 recorded registrants. A total of 35 different speakers attended, spanning all six Science Centers, most organism groups (decapods, fishes, marine mammals, sea turtles), all electronic tag types (acoustic, archival, satellite, radio), and various applications of the data (linking tag and environmental data, improving stock assessments). The focus of the workshop was not on the research *per se* but on the technologies: a) how the tagging technologies and the resulting data are currently being used for stock assessment and ecosystem applications (including projections on how these data will or could be used in the future); b) whether there are opportunities to improve tag attachment, tag retention, or vendor services – i.e., identifying common problems with the current technology and

potential ways of resolving them; c) specific data management needs for this technology – i.e., how data are captured, used and managed; and d) advancements or improvements to the technologies that are needed to make them more suitable for meeting NMFS research and management needs.

Results
The co-chairs received abstracts prior to the workshop in order to set the agenda. During the workshop, it became clear that extended abstracts, including color graphics and photographs from the talks, would make the proposed Technical Memorandum a much more valuable venue for information transfer and generation of research support. The co-chairs are presently assembling the extended abstracts from all speakers for FY06 release of the Technical Memorandum. The participants also provided several lists of recommendations including: 1) a biennial NMFS-wide workshop for electronic tag technology users in order to keep up with latest developments; 2) the need to convene an international symposium on tagging technology and use in fisheries management since the last such symposium occurred in 1988; 3) recommendations to electronic tag users; 4) recommendations to electronic tag vendors; 5) recommendations to the Advanced Sampling Technology Working Group for projects required during FY06 and beyond; and 6) a recommendation that a working group prepare an electronic tag funding initiative for submission to PPBES.

Impact / applications
A survey prior to the workshop indicated well over 125 NMFS personnel or contractors involved in the deployment of electronic tags and management of tag data for fishery management purposes. The workshop serves as a contact list, an information conduit to enhance the use of similar tags in different parts of the country, a means to compare and contrast to capabilities and utility of each tag type, and a venue to begin or extend cooperative efforts between field biologists and stock assessment biologists to better utilize tagging data.

Transitions
The Technical Memorandum, scheduled for release in FY06, will serve as the foundation for both the suggested international tagging symposium and the proposed electronic tagging technology funding initiative.

Related projects
Electronic tags were shown to be an effective method for delineation of essential fish habitat and for inclusion in efforts to bring ecosystem approaches to fisheries management closer to fruition.

Expenditures
FY05: $24.5K, including travel for 25 participants and costs for meeting room facilities.
FY06: $5.0K (estimated), including production and distribution costs for a color Technical Memorandum to serve as a contact file for NMFS personnel involved in tagging and to disseminate results to a broad constituency.

NMFS AUV for Economical Ecosystem-Based Fish Stock Assessments
(Project Leader: David Demer; SWFSC; 858-546-5603; david.demer@noaa.gov)

Goals

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

Priorities

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

Approach

Procure and use a commercial Autonomous Underwater Vehicle (AUV), customized with Fisheries instrumentation and conforming to the following general specifications: small, hand-deployable, modular payload, commercial off-the-shelf (COTS) design; 0.35 m diameter; 2.03 m long, 130 kg displacement; speed: 2 - 10 knots; duration: 20+ hours at

2.2 knots; maximum depth: 150 m; fisheries instrumentation: 38 kHz split-beam echo sounder, 300 kHz ADCP, CTD; and stereo imaging with illumination.

Work Completed

The NMFS Autonomous Underwater Vehicle (AUV) model Fetch 3.5 has been custom built by Sias-Patterson to the above specifications. AUV training and pre-delivery testing was conducted at Sias-Patterson, Yorktown, VA, from 4 - 6 October 2004. In attendance were David Demer, and Steve Sessions, and Derek Needham from SWFSC; and David Detlor and Al Shimada from the Office of Science and Technology. Additional training for one AUV-specialist from each Center was conducted from 8 - 12 November 2004 at SWFSC. In attendance were: Sessions, Needham, Mike Jech (NEFSC), Charles Thompson (SEFSC), Kevin Wong (PISC), Demer, Patrick Ressler (NWFSC), and Scott Furnish (AFSC). Two days of classroom training on the NMFS Fetch 3.5 AUV was followed by field training on the Fetch I model (the Fetch 3.5 was not yet operational). Acceptance testing was conducted at the SWFSC during July and August. The AUV was returned to Sias-Patterson for refinements, replacement of the aft-hull section and pressure certification. Final delivery is expected in November 2005.

Results

Training deployments of the Fetch I AUV were made off of the Scripps Institution of Oceanography's pier, and off the fishing vessel Outer Limits.

Mark Patterson, representing the Virginia Institute of Marine Science (VIMS), collaborated with the Advanced Survey Technologies (AST) and U.S. Antarctic Marine Living Resources Programs (AMLR) at SWFSC. In January and February 2005, they used SPI's Fetch I AUV to map krill biomass and characterize canyon habitat in the near-shore areas of the Antarctic Peninsula, where land breeding predators directly compete with the international fishery.

In July and August, 2005, Larry Arnold and Mark Patterson from SP, LLC worked with Steve Sessions, David Demer, Randy Cutter, Derek Needham, Mike Paterson, and Josiah Renfree from SWFSC to test and refine the AUV. The AUV is now functional, but will require further refinements before it can be used for unattended survey operations.

Impact Applications

Concurrent assessments of multiple marine trophic levels, their essential habitats, and ecosystem variability due to natural and anthropogenic causes are increasingly necessary for fisheries management. Most of these studies would benefit from more observations than can be accommodated by the fleet of NOAA research vessels, Therefore, to economically and physically conduct such multidisciplinary studies on the most appropriate time- and space-scales, NOAA Fisheries is developing and acquiring a suite of alternative survey platforms including instrumented small-craft, buoy arrays, and autonomous underwater vehicles (AUVs) to augment the NOAA fleet. Some of the AUV projects discussed for 2006 include improved target strength estimation of west coast rockfish, Bering Sea pollock, and Atlantic herring; and characterization of fish avoidance reaction to traditional versus the new quiet survey vessel.

Transitions

Following AUV characterization experiments during Fall 2005 and Winter 2006, west- and east-coast demonstration projects will be conducted in Spring and Summer 2006. The system for sharing this asset is to be developed, tested and refined using proposals from Centers collaborating on the demonstration projects.

Related Projects

The ASTWG is in the process of adding the following sensors to the AUV: a passive acoustic array; obstacle avoidance sonar, and sidescan sonar. Also being developed is a novel apparatus for deployment and recovery of the AUV from a large survey vessel.

Publications

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

Expenditures

FY05: Large-ship deployment and recovery cradle designed and production contracted $37k. Delivery and testing planned for December 2005.

Money that was allocated to the integration of a sidescan sonar ($38.5k), passive acoustic array ($10k), and obstacle avoidance sonar ($50k), totaling $98.5k, could not be awarded to SP, LLC as planned. Rather, it was used to pre-fund an AUV labor contract for 2006.

Two months of boat time, maintenance and repairs, labor and overtime for the AUV system characterization and field trials totaled $65k. The $30k, which was allocated to this process, was augmented with the $35k allocated to demo projects.

Characterizing the Pressure Dependence of Broad Bandwidth Sound Scatter of Fish for Improved Estimations of Biomass (Project Leader: David Demer, SWFSC, 858-546-5603; david.demer@noaa.gov)

Goals

Multiple-frequency echo sounders are used to survey fish distribution and abundance. Fish density is estimated from the total energy echoed from a fish aggregation, divided by the energy echoed from an individual fish. The aim is to improve the acoustical survey method.

Priorities

Improved techniques are need for: 1) separating the energy echoed from coexisting species, or species identification (SID); and 2) characterizing the acoustic reflectivities of the various species, or target strength estimation (TSE) versus pressure or depth.

Approach

A new method for broad bandwidth characterization of fish may improve both SID and TSE. The technique will be applied inside the new hyperbaric chamber, to measure the pressure dependence of broad bandwidth sound scatter from fish. A catalog of broad bandwidth scattering spectra and total target strengths of targeted and coexisting species can then be measured to improve their acoustical classification and quantification.

Work Completed

A 1000-l hyperbaric tank was designed and manufactured with removable insulation panels. The pump, chiller, sump, and plumbing were procured. Fittings for the broad bandwidth transducer arrays, and the conductivity, temperature and pressure sensors have been designed and fabricated.

Results

Investigations thus far have produced the first broad bandwidth absolute measurements of total target strength for standard metal spheres and good measurement accuracy and precision. It was also shown that multiple frequency echo sounders can be used to remotely distinguish monospecific aggregations of anchovy and sardine. Moreover, the

technique has been used for to characterize acoustic scatter from sea-bass, Antarctica and northern krill, squid, myctophids, rockfish, and salmon.

Impact Applications

By exploiting such differences in scattering spectra, researchers from SWFSC are developing non-lethal survey techniques for protected species such as rockfish (http://www.publicaffairs.noaa.gov/nr/pdf/dec2003.pdf). Moreover, a new physics-based scattering model for Antarctic krill was validated using the measurement technique; application of the model resulted in a two-fold increase in the estimated krill biomass. The measurement technique was also used to demonstrate the importance of accounting for animal shape, in addition to their lengths, when predicting sound scatter from animals.

Transitions

Details of the method and multiple applications have been published in peer reviewed journals, and presented in domestic and international forums. Measurements in the hyperbaric tank are to be made in collaboration with other Centers.

Related Projects

The new technique was used to characterize fish numbers, growth rates, and behaviors in a tank; it may soon be an important tool in aquaculture research and industry. Moreover, the method was developed to measure absolute absorption cross-sections over a broad bandwidth, as highlighted in popular articles from *Science News* (http://www.sciencenews.org/20031115/fob3.asp), which was translated into French, Italian, and Spanish by Courier International, and *Discovery*.

Publications

D.A. Demer, S. Conti, J. De Rosny and P. Roux, "Absolute measurements of total target strength from reverberation in a cavity," *J. Acoust. Soc. Am.*, 113(3):1387-1394 (2003)

S.G. Conti and D.A. Demer, "Wide-bandwidth acoustical characterization of anchovy and sardine from reverberation measurements in an echoic tank," *ICES J. Mar. Sci*. 60:617-624 (2003).

D.A. Demer and S.G. Conti, "Validation of the stochastic distorted-wave Born approximation model with broad bandwidth total target strength measurements of Antarctic krill," *ICES J. Mar. Sci*., 60:625-635 (2003)

S.G. Conti, P. Roux, D.A. Demer, and J. De Rosny, "Measurement of the scattering and absorption cross sections of the human body," *Applied Physics Letters*, 84(5) (2004).

S.G. Conti, D.A. Demer, and A.S. Brierley, "Broadbandwidth sound scattering and absorption from krill (*Meganyctiphanes norvegica*), Mysids (*Praunus flexuousus* and *Neomysis integer*) and shrimp (*Crangon crangon*)," *ICES J. Mar. Sci*. 62(5): 956-96, (2005).

P. Roux, S. Conti, D. Demer, and B.D. Maurer, "Acoustic Method for Fish Counting and Fish Sizing in Tanks". California Sea Grant College Program. Research Completion Reports. Paper. Aqua05_01 (2005). http://repositories.cdlib.org/csgc/rcr/Aqua05_01

S.G. Conti, P. Roux, C. Fauvel, B.D. Maurer, and D.A. Demer, in-press "Acoustical monitoring of fish density, behavior, and growth rate in a tank," *Aquaculture*.

S.G. Conti, J. De Rosny, P. Roux, and D.A. Demer, in-press, "Characterization of scatterer motion in a reverberant medium," *Journal of the Acoustical Society of America*.

S.G. Conti, B.D. Maurer, M.A. Drawbridge, and D.A. Demer, submitted, "Measurements of total scattering spectra of bocaccio rockfish (*Sebastes paucispinis*)," *Fisheries Bulletin*.

Expenditures

FY05: $60k towards Electrical Engineer labor contract (Josiah Renfree).