

Integrating Charting and Acoustic Habitat Research

NOAA Hydrographers and Fishery Biologists Collaborate on Multi-Mission Projects in Alaska

By Lt. Jay Lomnicky, NOAA
Benthic Mapping Specialist
and

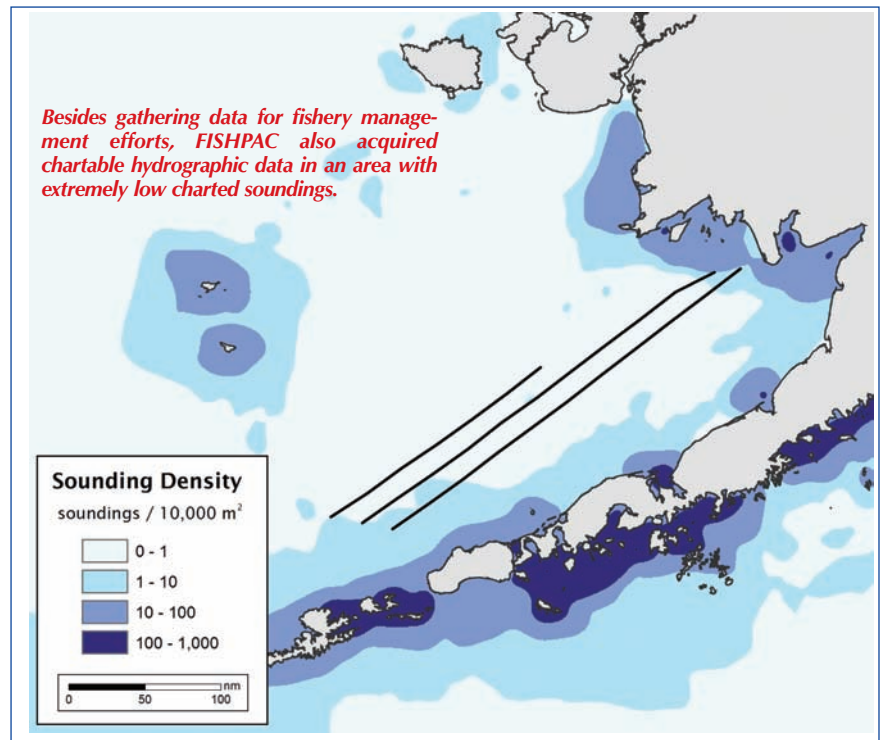
Dr. Robert McConnaughey
Research Fishery Biologist
National Oceanic and Atmospheric
Administration
Seattle, Washington

The National Marine Fisheries Service (NMFS) is the National Oceanic and Atmospheric Administration (NOAA) line office responsible for managing the fishery resources of the United States according to mandates in the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

The MSFCMA and associated legislation emphasize the maintenance of a healthy ecosystem and dictate management of sustainable and economically viable fisheries.

The authorizing legislation also requires that NMFS identify the habitat requirements of all life stages of all managed species living within the U.S. Exclusive Economic Zone (EEZ). Collectively, "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity" are known as Essential Fish Habitat (EFH). The amount of habitat which comes under the purview of management is a staggering 3.4 million square nautical miles. Alaska waters alone represent a striking 950,000 square nautical miles, an area roughly equivalent to one-third of the land area of the entire United States.

The sheer size of this management area presents a strong incentive for collaborative operations that would simul-



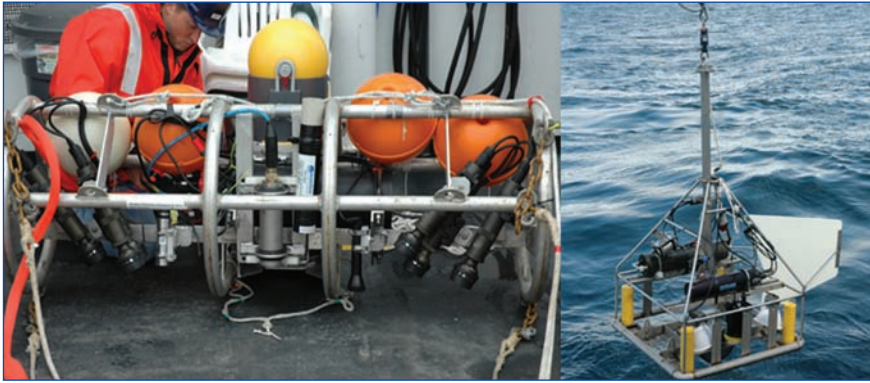
taneously advance multiple NOAA missions in an efficient and cost-effective manner.

It is well known that information about seabed sediments can help to explain the distribution and abundance of commercially important groundfish and crabs. However, traditional seabed sampling methods (e.g., grab samplers) are inefficient when considering large areas.

Theoretical considerations suggest seabed ensonification as an alternative method for characterizing seafloor habitats. While the relationship between acoustic returns (backscatter and bathymetry) and geological properties of the seafloor is reasonably well

established, it is generally unknown whether these data describe the specific characteristics that are important to fisheries.

Recent research by the Alaska Fisheries Science Center's (AFSC) Resource Assessment and Conservation Engineering (RACE) division suggests that processed acoustic backscatter may serve as a proxy for direct sediment measurements. For example, a pilot study in Bristol Bay, Alaska, has shown that processed backscatter from an L-3 Klein Associates Inc. (Salem, New Hampshire) 5410 side scan sonar contributes significantly to quantitative habitat models by explaining distributional patterns for a diverse group of



(Above) Groundtruthing efforts included the modified TACOS with digital and analog live video feeds (right) and the modified SEABOSS grab sampler with digital video and still-image cameras.

(Right) Seafloor groundtruthing mosaic created from TACOS video clip using software developed by Dr. Yuri Rzhanov at UNH.

benthic fish and invertebrate species, including flathead sole, Pacific cod and red king crab.¹ Similarly, processed backscatter from a vertical-incidence split-beam echo sounder shows correlations with groundfish abundance.

Based on these pilot-study experiences, fishery scientists recognize the utility of acoustics for benthic habitat mapping and also the need to partner with an organization that has greater experience and capabilities for collecting these and other environmental data over large areas of the EEZ.

The National Ocean Service (NOS), another NOAA line office, has diverse responsibilities, including promoting safe navigation through production of nautical charts and the acquisition of tidal and current data, as well as the conservation of critical marine habitat through creation of protected areas and marine sanctuaries. Within NOS, the Office of Coast Survey (OCS) routinely conducts hydrographic surveys with various sonar systems for the production of nautical charts. Their expertise in acoustic surveying makes OCS the natural partner for benthic habitat mapping. However, it has been estimated that 545 ship years and \$5 billion (acquisition only) are required to completely survey the U.S. EEZ with conventional acoustic systems. Potential collaboration between NMFS and NOS is also constrained



by fundamental differences in organizational priorities for charting and fishery management. That is, hydrographically important areas tend to be near the coast, heavily trafficked and relatively shallow. The priority attached to deeper and less-trafficked waters, where federally managed fisheries are generally most productive, tends to be very low. As such, conventional hydrographic surveying in these areas is unlikely to occur on a time scale beneficial to fishery managers.

The convergence of capabilities and directives of NMFS and OCS, bolstered by passage of the Coastal and Ocean Mapping Integration Act of 2004, presents a unique opportunity to leverage the resources of both organizations while simultaneously addressing their unique congressional mandates. Under one scenario, NMFS advances its EFH objectives related to seabed mapping with the support of OCS assets and expertise with acoustic systems.

OCS, in turn, benefits by receiving reliable hydrographic data from out-year survey locations, as well as possible fiscal contributions to expand the operational capabilities of its hydrographic fleet. In the process, this partnering not only produces multi-use data, but does so while making efficient use of limited resources.

2006 FISHPAC Experience

The FISHPAC project was conceived to characterize groundfish habitat in Alaska waters while at the same time producing high-quality bathymetry according to criteria set forth in the NOS Hydrographic Surveys Specifications and Deliverables—thus ensuring its reliable and expeditious incorporation into nautical charts. Led by NOAA fishery scientists from the AFSC RACE division, FISHPAC represents a landmark change in philosophy for NOAA hydrographic data acquisition. For the first time on this scale, several NOAA line offices and outside organizations worked cooperatively to gather environmental data to apply to discrete NOAA mandates. The groups involved included NMFS, OCS, NOAA's Office of Marine and Aviation Operations, the U.S. Naval Undersea Warfare Center (NUWC) and the University of New Hampshire's (UNH) Center for Coastal and Ocean Mapping (CCOM), as well as several private contractors and suppliers of undersea technology.

The primary objective of the FISHPAC project was to evaluate the utility of acoustic backscatter for characterizing EFH in the eastern Bering Sea (EBS) and then to compare the relative performance and cost of several different sonar systems for that purpose. Catch data from annual AFSC bottom-trawl surveys in the EBS are being statistically compared with fully normalized backscatter from several sonar systems, including two hull-mounted multibeam echo sounders (Reson [Slingerup, Denmark] models 8111 and 8160), two towed side scan sonars (Klein models 5410 and 7180) and an independent single-beam echo sounder mounted on the Klein 7180 tow body. This empirical approach assesses significance of acoustic data as a measure of habitat quality "through the eyes of a fish," precluding potential biases associated with more subjective methods of association. By comparing backscatter data from several sonars, researchers will be able to determine the most useful and cost-effective system for broad-scale deployments. The equally important project objective is to provide the OCS Pacific Hydrographic Branch (PHB) with hydrographic data that readily enter the hydrographic survey data-processing stream with minimal impact on PHB workflow.



Multidisciplined FISHPAC crew members including NOAA ship Fairweather, RACE, UNH CCOM, NUWC and private contractors, standing over a section of their surveyed area.

Three different instruments are utilized to interpret the sonar records, each providing unique and complementary information about the benthic habitats being surveyed. An upgraded version of the Towed Automatically Compensating Observation System (TACOS) provided real-time high-resolution digital video for mosaicking.² The Seabed Observation and Sampling System (SEABOSS) complements TACOS by providing a close-up image of the undisturbed bottom as well as a physical sample of sediments and associated infaunal organisms.³ An ODIM Brooke Ocean (Dartmouth, Canada) Free-Fall Cone Penetrometer (FFCPT) mounted on a moving-vessel profiler (MVP) not only provides information used to infer sediment type according to geophysical principles, but also has an integrated sound-speed profiler for measuring the speed of sound throughout the water column.

Bristol Bay was chosen as the study area because this region supports important commercial fisheries for species including red king crab, Pacific salmon and Pacific halibut, and the Bristol Bay side scan sonar pilot study demonstrated a high degree of spatial variability in the acoustic seafloor return. The relatively flat, featureless seafloor is also an important criterion, since it allows for relatively safe deployment of towed survey equipment. Charted sounding data are sparse in

Bristol Bay, and acoustic data are almost nonexistent over much of its central waters. Notwithstanding, the hydrographic priority of these waters is very low. Considered together, high-accuracy acoustic data from the area would contribute significantly to both the fisheries and the hydrographic missions.

A successful FISHPAC cruise in 2006 proved that interoffice cooperation on multi-mission surveys is feasible, mutually beneficial and highly productive. Without the aid of technically experienced sonar operators and hydrographers, large-scale acquisition and processing of high-quality acoustic data would be impractical for fishery scientists, or at best, unnecessarily expensive.

Conversely, without an exigent need for the bathymetry, many navigable areas such as Bristol Bay would remain unsurveyed well into the future.

Some specialized equipment acquired by NMFS for FISHPAC (e.g., the MVP, C&C Technologies' [Lafayette, Louisiana] C-NAV) is finding good use in the ship's regular hydrographic mission.

In addition to valuable information and technological enhancements benefiting both groups, this inaugural venture provided important experience and insight for improving future projects of this nature, including a follow-up EBS cruise this year.

Lessons Learned

Besides supplying sonar data useful for fisheries management and navigation safety, a number of valuable lessons were learned from the 2006

FISHPAC project effort. Taken together, they provide guidance for planning and executing similar multi-mission collaborative efforts.

A research team will usually bring aboard large quantities of specialized project gear during cruise mobilization. Advance planning for loading and storing these items is important, especially in cases involving otherwise dedicated (hydrographic) vessels.

Complex integrations between project equipment and standard vessel systems should be worked out well beforehand.

Because multi-mission efforts will usually involve unfamiliar activities, time must also be allocated to develop safe and effective operations procedures. In both cases, detailed documentation is a useful starting point for subsequent cruise planning and compensates for ship's crew rotations.

Some procedural changes may be necessary when conflicting data needs exist. For example, gain and range-scale settings chosen to optimize backscatter may increase noise in the bathymetry data. Such compromises are inevitable in a multi-mission setting; they must be carefully considered in advance and any deviations from standard protocols clearly communicated to all operators.

NOAA is carefully reviewing the 2006 data to gain insight about the best standard operating procedure for simultaneous acquisition of backscatter and bathymetry.

Accurate tide-zone modeling may be difficult for offshore waters. In this case, the nearest continually operating tide gauge was located in Unalaska, Alaska, nearly 350 nautical miles from the northern limits of the survey area. The absence of water-level corrections reduced the quality of the collected bathymetry data.

For future offshore missions, NOAA is investigating the feasibility of installing a supplemental tide gauge and will implement a commercial satellite-corrected global positioning system to support mapping the ellipsoid to the chart.

Similarly, the bathymetry data were affected by the subsurface pool of frigid water (less than 2° C) in the EBS resulting from sea ice melt.⁴ Continuous or more frequent sound-speed profiles using the FFCPT or a traditional sound-speed measuring device with the MVP

would help eliminate the characteristic “smiles” and “frowns” due to erroneous sound-speed correctors.

Overall, the effects of these deviations on data quality were small, while the benefits of integrated mapping were substantial, suggesting future collaborative efforts will be beneficial to both the hydrographic and fisheries branches of NOAA.

Acknowledgments

Thanks to current and former RACE members Cynthia Yeung, Mark Amend and Keith Smith; Dr. Lloyd Huff with UNH CCOM; the officers and crew of NOAA ship *Fairweather*; and specialists from the NUWC, Keyport.

Reference to any specific commercial products, process or service by trade name, trademark, manufacturer or otherwise does not constitute or imply its endorsement, recommendation or favoring by the U.S. government.

The views and opinions of authors do not necessarily state or reflect those of the U.S. government and shall not be used for advertising or product endorsement purposes. ■

References

1. Yeung, C., and R.A. McConnaughey, “Using Acoustic Backscatter from a Side Scan Sonar to Explain Fish and Invertebrate Distributions—A Case Study in Bristol Bay, Alaska,” *ICES Journal of Marine Science*, vol. 65, pp. 242-254, 2008.
2. Barker, B. A., I. Helmond, N. Bax, A. Williams, S. Davenport and V. Wadley, “A Vessel-Towed Camera Platform for Surveying Seafloor Habitats of the Continental Shelf,” *Continental Shelf Research*, vol. 19, pp. 1,161-1,170, 1999.
3. Blackwood, D., K. Parolski and P. Valentine, “Seabed Observation and Sampling System,” *U.S. Geological Survey Fact Sheet*, FS-142-00, 2000.
4. Wyllie-Echeverria, T., and K. Ohtani, “Seasonal Sea Ice Variability and the Bering Sea Ecosystem,” *Dynamics of the Bering Sea*, University of Alaska Sea Grant Press, pp. 435-445, 1999.

Visit our Web site at www.sea-technology.com, and click on the title of this article in the Table of Contents to be linked to the respective company's Web site.

Lt. Jay Lomnicky is a National Oceanic and Atmospheric Administration (NOAA) commissioned officer who is currently assigned to the Resource Assessment and Conservation Engineering (RACE) division of the Alaska Fisheries Science Center. His responsibilities include providing hydrographic support to RACE, technical support to the Towed Automatically Compensating Observation System and acting as a liaison between NOAA line offices involved in FISHPAC.



Dr. Robert McConnaughey is a research fishery biologist at the National Oceanic and Atmospheric Administration Alaska Fisheries Science Center and chief scientist for the FISHPAC project. He holds a Ph.D. in fisheries science from the University of Washington. His current research includes development of quantitative continental shelf scale models to characterize fish habitats in the eastern Bering Sea. This work includes objective evaluation of new technologies and environmental metrics for that purpose.



©Copyright 2008 by Compass Publications Inc. *Sea Technology* (ISSN 0093-3651) is published monthly by Compass Publications Inc., Suite 1001, 1501 Wilson Blvd., Arlington, VA 22209; (703) 524-3136; FAX (703) 841-0852. All rights reserved. Neither this publication nor any part of it may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the prior permission of Compass Publications Inc.