Characterizing Variability in the Distribution of High-Frequency Acoustic Backscattering in a Shallow Water Coastal Region

Gareth L. Lawson
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
phone: (508) 289-3649 fax: (508) 457-2134 email: glawson@whoi.edu

Timothy K. Stanton
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
phone: (508) 289-2757 fax: (508) 457-2194 email: tstanton@whoi.edu

Peter H. Wiebe
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
Phone: (508) 289-2313 fax: (508) 457-2169 email: pwiebe@whoi.edu

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http://www.whoi.edu

LONG-TERM GOALS

The central goal of this project is for the Primary Investigator, Gareth Lawson, to design, execute, and defend his doctoral thesis research. In terms of its scientific purpose, this research seeks to contribute to our understanding of spatial and temporal variability in the distribution of high-frequency acoustic backscattering stemming from zooplankton (e.g., Figure 1).

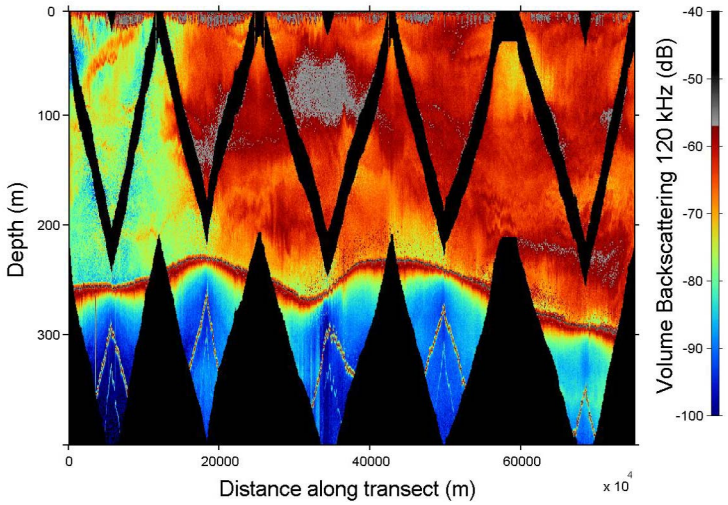

Figure 1: Volume backscattering (dB) measured at 120 kHz in Georges Basin, December 1999, showing distinct spatial patchiness both along-transect and with depth.

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OBJECTIVES

The objectives of the project are three-fold: 1. To quantify the spatial and temporal variability in the distribution of acoustically-inferred zooplankton biomass in shallow water coastal regions. 2. To assess the predictability and persistence of such patchiness, and understand its association with physical and biological oceanographic processes. 3. To continue the process of field-testing and refining newly-developed models of zooplankton acoustic scattering.

APPROACH

The overall approach is to apply the models of zooplankton scattering recently developed at Woods Hole Oceanographic Institution (WHOI) to multi-frequency volume backscattering data collected in continental shelf regions under earlier research projects, in order to infer zooplankton abundance and biomass by size group. The areas under study presently include the Gulf of Maine and the Western Antarctic Peninsula, and the data used for analysis were collected with the WHOI BIo-Optical Multi-frequency Acoustical and Physical Environment Recorder (BIOMAPER-II). An important aspect of the research involves the development of the exact methodology to be used for making the necessary inferences. Inferred estimates of zooplankton abundance will be compared between times and regions to assess patterns in variability, and examined in light of other physical and biological processes studied concurrently during the cruises.

This award was given to allow the Primary Investigator, Gareth Lawson, to pursue his doctoral thesis research. The Co-Primary Investigators, Timothy Stanton and Peter Wiebe, act as thesis advisors.

WORK COMPLETED

Most of the work completed in the first year of the award has involved Gareth Lawson fulfilling required course-work, refining the exact questions to be addressed by the doctoral research, and successfully defending the thesis proposal. In terms of actual research, certain preliminary investigations were made into the distribution of acoustic backscattering in an antarctic continental shelf region west of the Antarctic Peninsula. This area has the advantage of a relatively simple zooplankton community, making it an ideal location to begin the process of inferring biological quantities like zooplankton abundance and distribution from multi-frequency acoustic data. The results of these initial investigations have been written up in a manuscript submitted to Deep-Sea Research II. Preliminary analyses also were made of multi-frequency data collected in the Gulf of Maine, including descriptions of the vertical distribution of zooplankton backscattering and calculations of descriptive statistics (e.g., mean backscattering in different basins).

RESULTS

The distribution of zooplankton backscattering in the antarctic continental shelf study region showed strong seasonal and spatial variability, much of which appears to be understandable in light of meso-scale circulation. These initial analyses also suggest that high-frequency backscattering stems from a complex mixture of zooplankton taxa, rather than being due to one kind or size class of animal. Preliminary investigations into data collected in the Gulf of Maine have revealed interesting inter-annual variability, which will be further explored in analyses to be conducted during the coming year.

IMPACT/APPLICATIONS

The project will result in a detailed understanding of variability in the distribution of zooplankton backscattering, ultimately allowing such variability to be modeled and predicted. This constitutes an essential step in constraining the uncertainty introduced into Navy representations of the acoustic field by these important scatterers, and in understanding the implications of zooplankton patchiness to the distribution of predators, including marine mammals and exploited fish species. Most of the research will make use of existing scattering models. Through comparisons of acoustic data with video and net samples, these models will be further evaluated and extended when necessary. The outcome will be field-tested acoustic scattering models of complex, naturally occurring scatterers.

RELATED PROJECTS

The development of the BIOMAPER-II and its use in a series of cruises in the Gulf of Maine were funded in part by the ONR (Grant Numbers N00014-95-11102, N00014-98-1-0362, and N00014-97-1-0646), and in part by NOAA (Grant 31654-5717). Additional data under analysis were collected with the BIOMAPER-II in the Antarctic, as part of the Southern Ocean GLOBEC program (NSF Office of Polar Programs Grant OPP-9910307). Some of the methodologies developed in the present project are also being applied to data collected during the U.S. Georges Bank GLOBEC program, as part of synthesis analyses funded by NOAA (Cooperative Institute for Climate and Ocean Research Grant NA17RJ1223). The zooplankton scattering models employed in the project were originally developed under a number of ONR-funded projects (primarily Grant N00014-95-1-0287).

PUBLICATIONS

Lawson, G.L., P.H. Wiebe, C.J. Ashjian, S.M. Gallager, C.S. Davis, and J.D. Warren. In revision. Acoustically-inferred zooplankton distribution in relation to hydrography west of the Antarctic Peninsula. Deep Sea Research II. [submitted, refereed]