

Effects of Biota on High-Frequency Acoustic Propagation: Completion of SAX99 Analysis

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LONG-TERM GOALS

Our long-term goal is to identify, quantify and understand important interactions among organisms, particles (including sediments), solutes and moving fluids. The reason for this goal is to enable solutions of interesting forward and inverse problems involving benthic biota.

OBJECTIVES

Our objective is to build a simulation model of fish feeding that incorporates known constraints on feeding rates and feeding geometries and acoustically estimated fish abundances to determine the extent to which fish feeding can account for rates of change in backscatter intensity from the seabed that were observed in the SAX99 field study.

APPROACH

The first modeling work is very simple. Fish produce pock marks by sucking in mouthfulls of sediments and filtering the sediments out through the gills or spitting them back out. We are using bottom photographs from SAX99 to estimate the diameters of fresh pits. We calculate three-dimensional effects on microtopography by assuming that the fish produces a point-down cone whose vertex angle is twice the angle of repose (*c.* 68°). We assume that the volume of sediment removed from this cone is deposited in a 2-D gaussian fashion around the center of the cone. We incorporate various assumptions about the placement of successive "bites." We seek to determine whether feeding rates close to published ones can explain the rate of change in backscatter seen in SAX99 at 40 and 300 kHz. Moreover, we ask whether the spatial patterns of bottom change reflect school sizes and locations seen in BAMS and XBAMS scans. We definitely do observe patches of fish schools during the day but not at night in the SAX99 records.

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WORK COMPLETED

We have used ScionImage software to extract pit geometries and have rudimentary programs implemented in Matlab.

RESULTS

Our first impression is that fish feeding will be able to explain much of the microtopographic change and change in high-frequency backscatter during the SAX99 study.

IMPACT/APPLICATION

With the hindsight of SAX99, we believe that fish pock marking may be a more acoustically dominant activity than has been inferred from prior results. For example, we had suggested that, at the STRESS/CODE site in winter, diurnal migration of urchins into and out of the sediments dominated rate of change in backscatter (Jumars *et al.* 1996). The direct correlation of rate of change in decorrelation of backscatter with near-seabed irradiance, however, makes fish pock marking (feeding by visual predators) a much more likely explanation. We would be extremely pleased to have stumbled upon a dominant biogenic effect on acoustic propagation and one that might immediately connect biologically useful (predation intensity) and acoustically useful (rate of change of backscatter) measurements. Furthermore, this fish activity may be an important component of bioturbation that is not reflected in infaunal composition.

RELATED PROJECTS

This project is part of a more general long-term effort on our parts to develop means of detecting benthic organisms and their activities over unprecedented scales (notably over large areas and short times compared to any sampling methodology used previously) and to determine their impacts on acoustic propagation. It was fueled by two empirical studies suggesting biological effects on backscatter (Jumars *et al.* 1996; Briggs and Richardson 1997) and a theoretical one showing that temporal decorrelation in backscatter at some sites is consistent with a simple model of bioturbation (Jones and Jackson 1997). We followed up with experimental manipulations to test that hypothesis (Self *et al.*, 2001). SAX99 extended these efforts to sediments with greater sound-speed contrasts (with sound speed in overlying seawater; Richardson *et al.* 2001 and in preparation). This work on biological and biogenic effects has been done in collaboration with Richardson and Briggs of NRL Stennis. Their measurements for Orcas were embedded in Self *et al.* (2001), and we have mutually agreed that our manipulations in SAX will be embedded in a broader manuscript on SAX99 manipulations that they will lead.

Chris Jones of APL (N00014-00-1-0034) and Pete Jumars of the University of Maine (N00014-00-1-0035) are developing a cluster of instruments that allow experimental testing in convenient field sites of the putative effects of organisms whose field abundances can be manipulated. The concept is of a Portable Acoustic Laboratory (PAL) that can be deployed wherever there is a source of power and a data cable for download. In this way mechanisms can be investigated without waiting for an expensive field experiment to be fielded. The system currently has 300- and 120-kHz transducers to ensonify the sediments. One future target of this system may be to test the predictions of our simulation models, for example by providing a chemical cue that stimulates fish feeding locally.

Under separate funding, Pete Jumars at the University of Maine is also working with the related phenomenon of emergence by seabed fauna that may influence both surface microtopography and volume heterogeneity. This complementary grant is entitled "Shallow Scattering Layer (SSL): Emergence Behaviors of Coastal Macrofauna" (N00014-00-1-0662).

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