FINAL PROJECT REPORT

1989

Controls upon the Fine-Scale Distribution of Epizooplankton

ONR Contract N00014-87-J1116
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1. Summary of Objectives and Research Approach

This report describes the activities conducted during the period October 1, 1986 through Sept 30, 1990 under contract number N00014-87-J1116 awarded by the Office of Naval Research to the Rosensteil School of Marine and Atmospheric Science.

Our general objective has been to understand: (1) the biological and physical mechanisms controlling the fine-scale (1-10m) distribution of epizooplankton, (2) the ecological significance of these distributions, and (3) the affect of these distributions upon the fate of particles (phytoplankton) within the upper water column.

More specifically our research has been directed at answering the following questions:

1) Do physical gradients influence zooplankton distributions directly or indirectly?

2) Is the vertical distribution of zooplankton controlled by density gradients or loci of current shear situated within steep density gradients?

3) How strong a physical gradient must exist and how long must it persist to influence the zooplankton distribution?

4) How and under what circumstances does the fine-scale distribution of epizooplankton particle-grazers affect the fate of particles within the upper water column?

Our basic approach has been to conduct field experiments in which epizooplankton distributions are detailed both photographically and acoustically while simultaneously delineating both the near- and far-field physical environment using in situ and remote instrumentation. Complementary measurements of zooplankton grazing and the concentrations of potential food particles were often made at selected depths. The underlying rationale of this approach has been the conviction that to link physical and biological information into a dynamical understanding will require synoptic data obtained on fully comparable time and space scales. This conclusion derives from the general observation that while scale of biological and physical variation are often coupled they are so in a complex and non-linear manner.

2. Summary of Research Activities

In pursuing the above objectives we have sampled a diversity of systems that contrast in both temporal stability and physical dynamics. The first such system sampled during this contract period was the Southern California Bight. Early in the cruise (for comparison with previous Gulf Stream sampling) we repeated vertical distribution studies over a diel cycle. A new approach was taken in analyzing acoustic data from this and the prior cruise. Acoustically determined size-biovolume distributions were used to construct biomass spectra. This method permits statistically rigorous comparison of samples from different times, depths, water masses, or physical regimes. A critical analytical breakthrough has been the use of difference spectra. The biomass spectra characteristic of the Gulf Stream appear to be distinctly different from those reported for the North Pacific Gyre and the California Current. We then conducted one "fixed grid" and two series of "moving grid" experiments designed to characterize horizontal patchiness. Grids aproximately 1 km on a side were sampled with 1km/1000sample transects approximately 333m apart at a depth of 15m (the middle of the mixed layer). Because we suspected significant advection, we translated the transect positions with reference to a Lagrangian window-shade drogue during the "moving grid" experiments. These data are currently being analyzed.

The second system sampled was the Alaskan Coastal Current system off the SE Coast of Alaska. The current is driven by a salinity gradient arising from melting ice. It is episodic but recurrent and specific features exist for periods of days to weeks. Data obtained in this effort has been extensively described at AGU meetings and is the basis for three manuscripts either in preparation or already submitted for publication.

The third system studied was the Gulf Stream front and its associated meanders. We participated in two cruises as the lead zooplankton component in BioSYNOP. During these cruises we collaborated in measuring the mesoscale distribution of zooplankton, measured the fine-scale distribution of zooplankton and estimated grazing pressure with on deck and in-situ incubation experiments.

Although sample analysis from BioSYNOP is far from complete, we can already draw some preliminary conclusions. Biomass maps prepared from the mesoscale MOCNESS survey that traversed the entire meander confirmed the dramatic difference between Slope and Sargasso Sea (both Spring and Fall) and suggested as well frontal enhancement particularly at the leading (convergent flank). Zooplankton sampling efforts were intensified along the leading (western) and tailing (eastern) flanks just seaward of the north wall of the Stream. Copepod abundance and zooplankton biomass appeared to be considerably more abundant at the leading flank. The fine-scale vertical distribution of copepods was also distinctly different. Along the western flank intense peaks were clearly associated with layer water mass structure and there was a dominant shallow peak seen in all size classes. Grazing experiments revealed the elevation of nocturnal rates but did not clearly indicate a difference in grazing rate per unit biomass at western and eastern flanks.

A series of field tests of a modular high-frequency "Searchlight SONAR" have been made in the Northern Gulf of Mexico and the Gulf of Alaska. Hardware has since been made considerably more rugged and the modular acoustic units have become semi-intelligent packages (SIPs). A hardware and software protocol has been established and we are now constructing the second generation system in which the user will be able to select one to six frequencies (from a larger set) and to generate realtime size-frequency distributions of the plankton populations at a selected depth. We will continue to use in-situ silhouette photography to provide qualitative confirmation of target identity but are already pursuing substitution of video for photographic image acquisition.

3. Publications during this contract period

Carder, K. L., R. G. Steward, G. R. Harvey, and P. B. Ortner 1989.Absorption by marine fulvic and humic acid: its effect of remote sensing of ocean chlorophyll. Limnol. Oceanogr. 34(1): 68-81.

Houde, E.D., P.B. Ortner, L. Lubbers and S.R. Cummings. 1989. Determination of heterogeneity in anchovy egg distributions by in-situ silhouette photography. Rapp. P.-v. Reun. Cons.int. Explor. Mer. 191, 112-118.

Incze, L.S., P.B. Ortner and J.D. Schumacher. 1989. Microzooplankton vertical mixing and advection in a larval fish patch. Journal Plankton Research 12(2): 365-379.

Ortner, P.B., L.C. Hill, and S.R. Cummings.1989.Zooplankton community structure and copepod species distribution in the Northern Gulf of Mexico. Cont.Shelf Res. 9, 387-402.

Dagg, M. J., P. B. Ortner, and F. Al-Yamani 1988. Winter-time distribution and abundance of copepod nauplii in the northern Gulf of Mexico. Fish. Bull. 86(2): 219-230.

Ortner, P.B. 1988. Applications of simple photographic techniques to zooplankton sampling and sample processing in the Arabian Sea. In: Marine Science of the Arabian Sea. M. F. Thompson and N.M. Tirmizi (eds). pp. 67-77.

Ortner, P.B. 1987 Integration of the SeaMartek fluorometer to a towed plankton camera. BIOWATT News 9:2-3.

Ortner, P.B., G.L. Hitchcock, R.L. Cuhel and T.A. Nelsen. Photoautotrophic Production and Particulate Distribution near the Mississippi River Delta. In review, Cont. Shelf Res.

Napp, J.M., E.R. Brooks, F.M.H. Reid, P. Matrai, and M.M. Mullin 1988. The vertical distribution of marine particles and grazers: I. The vertical distribution of food quality and quantity. Mar. Ecol. Prog. Ser. 50: 45-58.

Napp, J.M., E.R. Brooks, P. Matrai, and M.M. Mullin 1988. The vertical distribution of marine particles and grazers: II. Relation of grazer distribution to food quality and quantity.Mar. Ecol. Prog. Ser. 50: 59-72.

Napp, J.M. and D.L. Long 1989. A new isotopic method for the in situ measurement of diel grazing rates of marine zooplankton. Limnol. Oceanogr. 34: 618-629.

Napp, J.M., P.B. Ortner, R.E. Pieper, and D.V. Holliday. Biomass (volume) spectra of epipelagic zooplankton using the MultipleFrequency Acoustic Profiling System (MAPS). In review, Deep-Sea Research.

Nieman, D.R., P.B. Ortner, and L. Incze. Physical determination of biological distributions along a transect between the Sutwik and Semidi Islands. In review, Cont. Shelf Res.

4. Abstracts of presented papers

Ortner, P.B., M.R. Reeve and D.V. Holliday. 1986. Diel variability in Gulf Stream epizooplankton. EOS 67:1029.

Nieman, D.R. 1986. Spatial distributions of Gulf Stream zooplankton relative to acoustic Doppler current profiles. EOS 67: 1029.

Napp, J.M., P.B. Ortner, R.E. Pieper, D.V. Holliday, 1988. "Biomass (Volume) Spectra of Epipelagic Zooplankton in the Gulf Stream Using the Multiple-Frequency Acoustic Profiling System (MAPS): Utility and Results," EOS

The BioSYNOP Zooplankton Group. "Zooplankton Dynamics in Gulf Stream Meanders." The Oceanographic Society Meeting, Monteray CA, July 1989.