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STUDY TITLE: NEGOM-ADCP Backscatter Enhancement

REPORT TITLE: Spatial and Temporal Variability of Plankton Stocks based on Acoustic Backscatter Intensity and Direct Measurements in the Northeastern Gulf of Mexico

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BACKGROUND: Because of their ability to remotely measure current velocity in the water column over a vertical range from a few meters to hundreds of meters, acoustic Doppler current profilers (ADCPs) have become increasingly important constituents of physical oceanographic research since their development in the mid 1980s. Shortly after ADCPs were put into use aboard University-National Oceanographic Laboratory System (UNOLS) research vessels, it was recognized that useful biological data can be extracted from the backscattered acoustic energy of the ADCP while simultaneously measuring current velocity. The biological use is based on the premise that zooplankton in the water column are the predominant particles that scatter sound pulses transmitted by an ADCP operating at frequencies of several hundred kHz. Thus, the backscatter intensity of the acoustic pulses is thought to represent a biological signal directly related to the size and concentration of zooplankton in the water column.

As part of the DeSoto Canyon Eddy Intrusion Study (EIS), twelve 300 kHz broadband ADCPs were moored along the slopes of the DeSoto Canyon in the Northeastern Gulf of Mexico. The EIS, funded by the U.S. Department of the Interior, Minerals Management Service (OCS contract 1435-01-96-CT-30825) monitored the circulation of the DeSoto Canyon area for two

years to investigate the effect of Loop Current eddies on over the continental margin of the NE Gulf of Mexico. The Workhorse® ADCPs used in the study were manufactured by RD Instruments, Inc., of San Diego, California, and deployed by Science Applications International Corporation (SAIC). The twenty-five month mooring deployment period ran from March 1997 through April 1999 and consisted of six instrument deployment/re-deployment periods of approximately four months each. During this time the twelve moored ADCPs recorded current velocity as well as acoustic backscatter data. The current velocity data set has been summarized by SAIC (Access Number 30825), and the acoustic backscatter intensity (ABI) data set is the subject of this Technical Summary (Access Number 30851).

OBJECTIVES: (1) To use a moored array of ADCPs to define spatial and temporal scales of variations in ABI and zooplankton biomass in the water column; and (2) To determine how variations in ABI and zooplankton biomass may be linked to current flow in the DeSoto Canyon area.

DESCRIPTION: The twelve ADCP instruments were moored in total water depths ranging from 100 m to 1300 m. Most instruments were moored along cross-margin lines, with three ADCPs moored on each of the lines A, B, and C. Line D consisted of moorings D1 and D2. A narrowband ADCP was moored at a third D-line location, but ABI data recorded by this narrowband instrument were not evaluated for the present study. E1 was the easternmost mooring; this was located along the 100-m isobath off the western Florida shelf. Each of the ADCPs was moored in an upward-looking orientation; all hung suspended at either 80 m or 90 m below the waters surface. Echo intensity data were recorded every 30 minutes during the 25-month mooring deployment period, and these data were recorded in equally spaced 4-meter depth binds. To serve as sea truth for the ABI data, zooplankton collections were made on three oceanographic research cruises (N2, N3, N4) conducted in the NE Gulf in support of the NEGOM Chemical Oceanography and Hydrography study during the 25-month ADCP deployment period.

SIGNIFICANT CONCLUSIONS: Results of this combined physical and biological research show that ABI data recorded by ADCPs do represent a biological signal that serves as an approximation for zooplankton standing stocks in the NE Gulf of Mexico. Spectral analysis of acoustic data reveals daily variability in ABI as well as low frequency, weekly to monthly, variability. This low frequency variability in ABI is linked to current flow in the DeSoto Canyon area, and correlations between ABI and current velocity vary with the movement of warm slope eddies and other mesoscale features along margin and so into and out of the region of the moored array. Wind mixing associated with hurricane-strength storm events appears to affect the acoustic backscatter recorded by ADCPs, and increases in ABI during these periods are attributed to the downward mixing of bubbles from surface turbulence. From this research the interactions between physics and biology are evident, and so we recommend that ABI data from ADCPs which may in the future be moored in other areas of the Gulf of Mexico be studied as well.

STUDY RESULTS: Regression analysis showed a positive relationship between ABI and zooplankton biomass, and the power of this relationship was higher for large-size organisms (> 2 mm). Vertical analysis of ABI in the upper 90 m of the water column revealed a general

increase in backscatter (biomass) with depth. This result was not unexpected, as plankton are not evenly distributed vertically, and since herbivorous (phytoplankton-eating) zooplankton are usually more abundant at or near the deep chlorophyll maximum, which is usually deeper than 70 m in the deepwater Gulf of Mexico. We also found that mean ABI for the two-year record was highest at the shelf-break sites and lowest at the oceanic stations. Again these results were not unexpected, for as in other oceans, the Gulf of Mexico has higher plankton stocks in neritic than oceanic waters.

In an effort to better understand the relationship between ABI and chlorophyll concentrations in the NE Gulf of Mexico, backscatter data were used in conjunction with SeaWiFS ocean color data from the study area. We found a significant positive correlation between ABI and remotely sensed surface chlorophyll concentrations. These results were not surprising, as zooplankton populations increase with enhanced food supply. However, chlorophyll concentrations in the DeSoto Canyon region did not follow the well-defined annual cycle of primary production for the Gulf of Mexico (low in spring-summer, high in fall-winter). Instead, remotely-sensed surface chlorophyll was annually highest in mid-summer. Analysis of remotely sensed altimetry data showed that this was apparently due to the consistent occurrence of anticyclonic eddies over the DeSoto Canyon in summertime. Data from NEGOM Chemical Oceanography and Hydrography cruises confirm that entrainment of low salinity, high chlorophyll river water by these eddies located over the study area transported this "green water" cross-margin to at least the 1000 m isobath in summers 1998 and 1999.

Spectral analysis of acoustic time series data allowed us to study the variance in ABI as a function of frequency. Evident in all plotted spectra was a sharp peak in energy density centered at one cycle per day, and these peaks were indicative of the diel vertical migration of zooplankton in the water column. All plotted spectra were red, showing decreases in spectral density as frequency increased. Red variance spectra are common for oceanic long-term variability, and this spectral analysis revealed low frequency, weekly to monthly variability in the ABI record were associated with current flow in the DeSoto Canyon area.

To further investigate the relationship between ABI and current flow, correlation analysis was carried out using combined backscatter and current velocity data. Significant correlations between ABI and offshore flow indicated the transport of neritic zooplankton off shore to deeper waters. Changes in ABI were also correlated with along-shelf flow, although these correlations varied as the direction of flow changed relative to the along-margin movement of mesoscale physical features.

The effect of hurricane-strength mixing events on ABI was investigated using data from the time periods in which Hurricanes Georges and Earl passed close to the DeSoto Canyon study area. It was found that there is a backscatter response to such storm events, but that increase in ABI is not a biological respnse. Rather, the response is a physical consequence of the abrupt changes in acoustic scattering that occur with the downwared mixing of bubbles from surface turbulence and wave action and breaking.

STUDY PRODUCTS: Scott, R. L., D. C. Biggs, and S. F. DiMarco. 2001. Spatial and Temporal Variability of Plankton Stocks based on Acoustic Backscatter Intensity and Direct

Measurements in the Northeastern Gulf of Mexico. A final report for the U.S. Department of the Interior, Minerals Management Service Gulf of Mexico OCS Region, New Orleans, LA. OCS STUDY MMS 2001-057 Contract No. 1435-01-97-CT-30851 134 pp.

Scott, R.L. 2001. Spatial and Temporal Variability of Plankton Stocks based on Acoustic Backscatter Intensity and Direct Measurements in the Northeastern Gulf of Mexico. MS thesis, Department of Oceanography, Texas A&M University, College Station, TX. 146 pp.

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