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STUDY TITLE: Southwest Florida Shelf Ecosystems Study, Year II

REPORT TITLE: Southwest Florida Shelf Ecosystems Study, Hydrography and Primary Productivity, Final Report, Volume I and Volume II: Data Appendix

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BACKGROUND: Since 1980, the U.S. Department of the Interior of supported a multidisciplinary study of the southwest Florida shelf ecosystem. This study began by delineating substrate types and benthic communities on the southwest Florida shelf. In the Year II contract modification, emphasis was shifted to examining the relationship between hydrography and primary productivity on the southwest Florida shelf

OBJECTIVES: (1) To demonstrate the existence of an active upwelling mechanism operating on the southwest Florida shelf; (2) to determine modes of interaction or mixing between resident shelf waters, slope waters, and Loop Current waters; (3) to assess primary productivity rates and areas of maxima and minima; and (4) to determine nutrient distributions in the shelf break region during intrusions.

DESCRIPTION: Two cruises were conducted to collect data on hydrography and primary productivity from the southwest Florida shelf. During the first cruise, from 1 to 7 April 1982, eight hydrographic sections consisting of alternating conductivity-

temperature-depth (CTD) water samples, optical and expendable bathythermograph (XBT) stations were run across the shelf and along the 1,000-m isobath. Water samples were collected at discrete depths with Niskin bottles mounted on a rosette sampler coupled to the CTD. Surface temperature, salinity, and relative surface chlorophyll fluorescence were recorded along the transects using the CTD and a fluorometer. Phosphate, silicate, and nitrate were analyzed with an autoanalyzer. Water samples for chlorophyll, primary productivity, and cell count measurements were filtered through 25-mm diameter (0.45-mm pore) glass fiber filters. An acid ratio method was used to determine chlorophyll a and phaeopigment a concentrations. Primary productivity was determined using standard C^{14} methods. Phytoplankton cell count samples of 100 to 400 ml were settled then examined under an inverted microscope with interference contrast, phase contrast, and bright field illumination for counting and identification of phytoplankters. For optical measurements, a spherical quantum sensor determined underwater irradiance (400 to 700 nm) between the surface and depths of 30 to 35 m; a color index meter measured nadir radiances (447 to 521 nm) just below the surface; a 12-channel irradiance meter measured downward irradiance (371, 403, 455, 477, 492, 517, 533, 602, 634, 674, and 687 nm); a quantum irradiance meter measured the number of photons incident on a horizontal unit area in a unit time (350 to 700 nm); a light scattering meter integrated the light scattering function from 3 to 150° at 655 nm; a particle light transmission sensor measured total light attenuation; a one-channel fluorescence meter profiled chlorophyll a water column distribution; and secchi discs estimated attenuation coefficients on the blue, green, and red parts of the spectrum and the depth of the euphotic zone. During the spring cruise, an ocean color scanner with a 90° total field of view and a 3.5 milliradian instantaneous field of view was employed to provide overflight imagery data. Flown on a U-2 aircraft at an altitude of 20 km, the swath width was 39.6 km with the pixel size at nadir about 69 m^2. Sea surface temperatures were also derived from satellite infrared imagery. During the summer cruise, conducted from 12 to 19 September, similar hydrographic data were collected from 95 stations along four repeated transects. Specifically, 36 CTD casts, 57 XBT profiles, and 15 bottle casts were made; 314 samples were collected for nutrient and oxygen analyses, 366 for chlorophyll, 90 for salinity calibrations, 84 for productivity, and 39 for cell counts. Optical measurements, ocean color scanner overflights, and satellite infrared imagery were not included during this cruise.

SIGNIFICANT CONCLUSIONS: Three independent evaluation methods (field sampling, optical measurements, and remote sensing) confirmed the presence of an upwelling event on the southwest Florida shelf. Upwelling consists of a warm water extension, or filament, of the Loop Current with a pocket of cooler upwelled water occurring between the filament and the Loop Current. Surface extent of an upwelling may be more than 200 km and subsurface extent at least 100 km. Generally, the frontal edge and cold core propagated southeastward for a distance of 95 km; concurrently, the Loop Current moved offshore. Primary productivity affected by Loop Current intrusions was six times higher than unaffected waters. These observations were due to higher nutrient concentrations associated with deeper Loop Current waters upwelled during shelfward movement of the current edge. Productivity values were higher during the summer cruise as opposed to the spring cruise data values. Remote ocean color

scanner imagery agreed with shipboard measurements of surface chlorophyll gradients and verified the oligotrophic nature of the upper 10 m. Loop Current frontal eddies occurring off the southwest Florida shelf were similar to Gulf Stream frontal eddies observed off the southeastern U.S. shelf in terms of length scales and speeds.

STUDY RESULTS: The best depiction of the frontal eddy was made during the spring cruise using satellite infrared imagery. Spatial errors were on the order of ± 15 km with thermal discrepancies of only ± 1°C when compared with shipboard hydrographic measurements. Spring hydrographic data (temperature-salinity profiles) demonstrated that the filament had been uplifted 80 m from deeper Loop Current waters. High nitrogen and low oxygen concentrations indicated that upwelling occurred beneath the uplifted water. Primary productivity was enhanced by movement of offshore nutrients into shelf waters. Spring cruise surface chlorophyll a values ranged from 0.1 to 0.3 mg m^{-3}; high values were patchily distributed. Subsurface chlorophyll a measurements ranged from 0.2 to 1.2 mg m^{-3}. Average primary productivity during the spring cruise was 0.5 g C m^{-2} day^{-1} with the nitracline remaining about 40 to 50 m below the surface. Summer productivity values were higher but exhibited greater variability with depth, attributable to changes in irradiance and chlorophyll a concentrations. Very high productivity values (10 g C m^{-2} day^{-1}), recorded during summer, were associated with a near-surface lens of low salinity water, 10 to 30 m in thickness. The diatom *Rhizosolenia alata* comprised more than 80% of the total diatom population within this low salinity lens. At four stations, seaward of the 200-m isobath where nutrient and density isopleths had been uplifted by the Loop Current eddy, primary production ranged from 0.5 to 0.7 g C m^{-2} day^{-1}; another station, located within the Loop Current, had primary production values of only 0.1 g C m^{-2} day^{-1}.

Results of optical measurements taken during the spring cruise corroborated with hydrographic and productivity data collected along the occupied transects. Vertical water mass properties were divided into three categories based on optical measurements; a homogeneous surface layer of low chlorophyll a and suspended matter concentrations, a transition zone of limited vertical extent where chlorophyll a and suspended matter gradients increased, and an underlying layer extending downward from the lower extremity of the euphotic zone where chlorophyll a and suspended matter concentrations gradually decreased.

During both cruises, the coccolithophorid *Coccolithus huxleyi* was the numerically dominant phytoplankter. All counts at shallow stations were low and had little variation with depth, while around upwelling regions counts were higher with greater variability with depth.

When the Loop Current filament intrudes on the shelf, an interleaving of isohalines demarks mixing between two water masses. A tongue of filament water gradually mixes with a tongue of continental edge water. Length scale of such intrusions ranged from 30 to 40 km. Effective lateral diffusion coefficient estimates were on the order of 0.15 to 4 x 10^{7} cm^{2} s^{-1} for these intrusions.

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STUDY PRODUCT: Woodward-Clyde Consultants and Skidaway Institute of Oceanography. 1983. Southwest Florida Shelf Ecosystems Study - Year 2. Hydrography and Primary Productivity. A final report for the U.S. Department of the Interior, Minerals Management Service Gulf of Mexico OCS Office, Metairie, LA. Vol. I (Final Report) - NTIS No. PB84-113323, Vol. II (Data Appendix) - NTIS No. PB84-113331. Contract No. 14-12-0001-29144.

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