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KEY WORDS: Mississippi River; sediment; plume; satellite oceanography; Atchafalaya River; river discharge; shelf circulation; sediment transport; atmospheric forcing; Loop Current; Loop Eddy

BACKGROUND The Mississippi River is the major contributor of freshwater, sediments, pollutants, and nutrients to the northern Gulf of Mexico continental shelf and slope. These river inputs have important impacts on all aspects of continental shelf oceanography in the northern Gulf of Mexico. This study utilized four years of satellite information obtained by the NOAA Advanced Very High Resolution Radiometer (AVHRR) to quantify which areas of the continental shelf and slope of the Gulf of Mexico are subjected to discharges emanating from the Mississippi River through the Balize Delta. Results of this study provide important information concerning suspended sediment distribution on the continental shelf, potential fate of riverborne contaminants and circulation processes in the vicinity of the delta.

OBJECTIVES: (1) To determine which areas of the continental shelf and slope in the Gulf of Mexico are most influenced by riverborne sediments and pollutants of the Mississippi River through the Balize delta, (2) to gain a better understanding of the

environmental forcing factors controlling the distribution of river water and sediments in the northern Gulf of Mexico.

DESCRIPTION: As this is the first comprehensive study of the Mississippi River plume using satellite data, a large geographic area was included when analyzing the satellite imagery data base. The coordinates of this area were 25¡ to 31¡ N latitude and 86¡ to 98¡ W longitude.

Four years of digital data acquired by the Advanced Very High Resolution Radiometer (AVHRR) of the NOAA environmental satellites were available for this study. Reflectance information, derived from the visible channels, provides a quantitative means of defining the Mississippi sediment plume and was used as the primary database for this investigation. Sea surface temperatures, computed from the thermal infrared channels, were helpful in identifying the maximum spatial extent of plume waters and for the detection of Loop Current eddies and filaments. A calibration algorithm relating satellite reflectances to suspended sediment concentrations, or seston, was developed by obtaining "surface truth" samples via helicopter simultaneously with satellite overpasses in April 1992. Over 3000 images between July 1988 and October 1992 were screened for cloud cover from which a subset of the best images was chosen for subsequent analysis. River water and sediment discharge data and wind measurements at Grand Isle were also used to investigate environmental forcing of plume variability.

SIGNIFICANT CONCLUSIONS: Individual satellite images revealed that the Mississippi River sediment plume ranged in size from 450 km2 under low discharge conditions to 7699 km2 under high discharge conditions. For the high discharge image group, the maximum composite plume covered an enormous area of the continental shelf and slope, totaling 13,207 km2 and extending from 88¡ 20' W to 90¡ 50' W and offshore to the 1000 meter isobath. Although the average characteristics of the plume were found to be related to river discharge, wind speed and direction played a major role in determining plume morphology and surface sediment distribution over the continental shelf and slope. Southeasterly winds confined the plume to the continental shelf and nearshore zone whereas strong westerly and northerly winds, usually associated with cold-front passages, resulted in off-shelf transport of plume waters. Slope currents associated with Loop current eddies and filaments often determined the fate of river waters after leaving the shelf region.

The satellite imagery revealed that a substantial amount of water discharged through the eastern passes may flow south and then west to join the discharge from South Pass and Southwest Pass. This additional westward flow occurred under the influence of strong northeasterly winds during the autumn and winter. A distinct anticyclonic circulation pattern (clockwise-rotating) was observed west of the delta in the Louisiana Bight in approximately 50% of the images. The net result is an accumulation of river sediments, pollutants and nutrients within the bight and on the shelf west of Southwest Pass.

STUDY RESULTS: Descriptive maps of the Mississippi River sediment plume were constructed by compositing satellite images according to river discharge. This analysis revealed that the "mean" plume under medium discharge conditions, 10,0001- 20,000 m3 s-1, covered 2200 km2 of the continental shelf. Under high discharge conditions, 20,001 - 35,000 m3 s-1 the mean plume doubled in size. The maximum composite plume covered 13,207 km2 of the continental shelf east and west of the delta and south to the 1000 m isobath. Thus, the average characteristics of the plume were found to be related to river discharge. The relationship between plume area and river discharge was further investigated using linear regression techniques. Using 30 mg.1-1 as the definition of the sediment plume, a good relationship was found (r2 = 0.83). The relationship became weaker when the plume was redefined in the final analysis by using a suspended sediment concentration of 10 mg.1-1. Plume size west of South Pass was better correlated with discharge than that east of South Pass. A close examination of individual images revealed that wind speed and direction played an important role in determining plume geometry and surface sediment transport over the continental shelf and slope. The plume west of South Pass was strongly influenced by changes in wind direction and speed. Under southeasterly wind conditions, the plume flowed southwestward and usually recurved northwards into the Louisiana Bight. Westerly winds rapidly deformed the plume, initiating off-shelf transport of plume waters. The sediment plume east of South Pass exhibited less variability than that of the western plume. Westerly winds did not have as much of an influence in the east as the plume was in the lee of the land. In addition, southeasterly winds which prevail much of the time confine the eastern plume to the coast and also cause resuspension of sediments near the coast. All of these factors could decrease plume area variations east of the delta. Loop Current filaments and eddies were often observed intruding onto the continental shelf east of the delta making circulation processes in this area variable and complex.

STUDY PRODUCTS: Walker, N.D. and L.J. Rouse. 1993. Satellite Assessment of Mississippi River Discharge Plume Variability. A final report by Louisiana Universities Marine Consortium for the U. S. Department of the Interior, Minerals Management Service, Gulf of Mexico Region, OCS Office, New Orleans, LA. Contract No. 14-35-0001-30470, OCS Study MMS 93-0044. 50 pp.

Walker, N.D., L.J. Rouse, O.X. Huh, D.E. Wilensky and V. Ransibrahmanakul. 1992. Assessing the spatial characteristics and temporal variabilities of the Mississippi and Atchafalaya River plumes. Proceedings of the First Thematic Conference on Remote Sensing for Marine and Coastal Environments. New Orleans, Louisiana. SPIE 1930:719-728.

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