STUDY TITLE: Wave Climate and Boundary Layer Dynamics with Implications for Offshore Sand Mining and Barrier Island Replenishment, South-Central Louisiana

REPORT TITLE: Wave Climate and Bottom Boundary Layer Dynamics with Implications for Offshore Sand Mining and Barrier Island Replenishment in South-Central Louisiana

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BACKGROUND: In an earlier MMS-funded project conducted by the PI of the current report, three numerical modeling objectives were undertaken: (1) to develop a numerical model of wave energy transformation and decay across the inner shelf encompassing Ship Shoal and the nearshore adjacent to the Isles Dernieres; (2) to develop a nearshore sediment transport model along the Isles Dernieres; and, (3) to quantify changes in (1) and (2) due to removal of various sediment quantities based on likely scenarios provided by MMS.

OBJECTIVES: The current project included three additional field measurement objectives: (1) to procure and fabricate an additional bottom boundary layer instrumentation system; (2) to obtain direct field measurements of temporally- and spatially-varying directional wave spectra at two locations; and, (3) to obtain direct field
measurements of bottom boundary layer hydrodynamic processes and suspended sediment transport. All experiments were conducted at Ship Shoal.

DESCRIPTION: Instrumentation was deployed on the Louisiana inner shelf during two winter periods, between November 24, 1998 and February 2, 1999, and February 9 and March 25, 2000. The three instrumentation packages consisted of two types of frame-mounted systems, both of which included a self-contained data recorder module. System 1 was a unique multi-sensor package nicknamed WADMAS, which consisted of a Paroscientific pressure sensor, a sonar altimeter, and a vertical array of three co-located Marsh-McBirney electromagnetic current meters and Seapoint optical backscatter sensors (OBS’s). This instrumentation enabled WADMAS to measure water level, directional wave parameters, and seabed elevation, as well as current velocity and suspended sediment concentration at heights of 20, 60, and 100 cm above the seabed. Systems 2 and 3 each consisted of a pressure sensor and a SonTek\textsuperscript{TM} downward-looking Acoustic Doppler Velocimeter (ADV) that measured seabed elevation, relative particulate concentration and three-dimensional currents at an elevation of approximately 20 cm above the bed. During the first deployment, Systems 1 and 2 were deployed in approximately 8.5 m of water on the seaward side of Ship Shoal, while System 3 was deployed in about 7 m of water on the landward side. During the second deployment, Systems 1 and 3 were deployed in the same locations as previously, while System 2 was placed at a 3.5 m water depth in the middle of the Shoal. During each deployment and retrieval, divers collected sediment from the bed, and water samples from the water column, and observed and measured any visible bed forms. Data were then processed and analyzed using conventional methods found in the literature.

STUDY RESULTS: Hydrodynamic, bottom boundary layer, and sedimentary processes on the Louisiana inner shelf during the winter are characterized by episodic variability, largely as a result of the quasi-periodic cycle of recurring extratropical storm passages in the region. Extratropical storms are generally characterized by increases in: wave height, near-bed orbital, and mean current speed, shear velocity, suspended sediment concentration, and sediment transport. Decreases in wave period and apparent bottom roughness are also apparent. Despite these regularities, considerable variability between storms, as well as during storms themselves, is reflected in hydrodynamic, bottom boundary layer, and sedimentary processes. During strong storms, some indices were several orders of magnitude greater than during fair weather, while during weak storms they were lower.

The following extratropical storm classification, consisting of two storm types, is proposed on the basis of their influence on the Louisiana inner shelf. Type 1 storms are characterized by weak southerly pre-frontal and strong northeasterly post-frontal winds that cause strong post-frontal responses including high, short-period, southerly waves, strong, southwesterly currents, and moderately high southwesterly sediment transport. Type 2 storms include periods of both strong southerly pre-frontal winds, which generate high, long-period northerly swell waves, and strong northerly post-frontal winds, which cause energetic southerly storm waves. Rotational, net southeasterly
currents and high shear velocity occurs during both the pre- and post-frontal phases, while sediment transport occurs predominantly during the post-frontal phase, when it is southeasterly. Local extratropical storms are apparently not the only cause of high-energy responses on the Louisiana inner shelf. Distant storms apparently cause high, long-period waves, accompanied by moderate rotational currents that can create high sediment transport. Results suggest that resuspension and transport of bottom sediment may sometimes occur during winter fair weather conditions, although it has previously been considered unlikely.

**SIGNIFICANT CONCLUSIONS:** Differences between the seaward and landward sides of Ship Shoal are apparent. Waves tend to be higher and longer in period on the seaward side, while mean currents are generally higher landward, where they are directed onshore, unlike the offshore site, where seaward currents predominated. It is apparent, therefore, that Ship Shoal exerts a significant influence on regional hydrodynamics, reducing wave energy and modulating current velocity. The short-term evolution of Ship Shoal appears to be the result of a balance between fair weather influences, which cause erosion and landward migration, and winter storm influences (particularly Type 2 storms), which cause accretion and seaward migration.


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