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STUDY TITLE: Modeling and Data Analysis of Circulation Processes in the Gulf of Mexico

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SPONSORING OCS REGION: Gulf of Mexico

APPLICABLE PLANNING AREA(S): Eastern, Central and Western Gulf of Mexico

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KEY WORDS: Gulf of Mexico, Florida Straits, Yucatan Channel, numerical model, Princeton Ocean Model (POM), data analysis, data assimilation, currents, deep currents, continental slope, topography, topographic Rossby waves, Loop Current, Loop Current eddies, boundary eddies, deep currents, kinetic energy, ray tracing.

BACKGROUND: This study was conducted to utilize a sophisticated numerical circulation model (POM), extract indicators of Gulf ocean dynamic patterns from the model results and compare these patterns to those identified in existing observational data bases. This study contributed to sequential development of a verified circulation model that may eventually support evaluation of physical oceanographic conditions and processes as they relate to oil and gas exploration and production, in particularly in the deeper portions of the northern Gulf of Mexico. At a qualitative level, several numerical models are able to reproduce major circulation patterns in the Gulf. The present effort was to compare not only this incarnation of the POM, but also quantitatively evaluate how well it reproduced details of the known current patterns. The project report presents results of the numerical modeling activities, the quantitative expression of the modeled flow patterns and a rigorous comparison with comparable analysis and presentation of existing field measurements.

OBJECTIVES: The objectives of this study were to describe and understand circulation processes in the Gulf of Mexico through coordinated modeling and data analysis. The main focus was on two topics: topographic Rossby waves (TRWs) and slope eddies with particular emphasis on their occurrence in deepwater regions over the northern continental slope and rise in the Gulf of Mexico.

DESCRIPTION: The study area for this project nominally included the entire Gulf of Mexico from the Yucatan Channel, over the entire Gulf and to the Florida Straits. Process evaluation and comparison was primarily that occurring deepwater portion of the northern Gulf of Mexico (water depth > 1000 m). Most observational programs used for comparison with model results were supported by the MMS over the past twenty years. These included Year 1-5 of the Physical Oceanography Program, the DeSoto Canyon Study and the Deewater Currents in the Northern Gulf of Mexico. The model used to simulate ocean patterns was a version of the Princeton Ocean Model (POM) as modified by L. Y. Oye, one of the study PIs.

SIGNIFICANT CONCLUSIONS: Methods for initializing and optimizing a proven numerical circulation model produced strong similarities between the simulated and measured conditions. While some discrepancies between model and observations, many patterns were consistent and indicate that many of the processes governing feature generation and evolution are incorporated in the model dynamics and energetics.

STUDY RESULTS: Based on the results of a high-resolution model, the analysis concentrated more precisely on regions in the Gulf where TRW's are likely to occur, their possible generation site(s) and mechanism(s), and also propagation paths. It was found that TRW's in the 20 to 100-day periods are excited by small-scale peripheral eddies or meanders around the LC or propagating Loop Current Eddies (LCE's). The TRW's propagated westward and the energy was predominantly confined seaward of the 3,000 m isobath in the central and western Gulf. It was also concluded that the deep Gulf circulation was cyclonic, and that the deep (horizontal) shear in part accounted (together with sloping topography) for the seaward confinement of the TRW rays

This study evaluated whether this model can generate the observed spatial and temporal evolution of the slope eddy field over the north-central Gulf of Mexico. Selected field surveys measurements (LATEX C and GulfCet I) in conjunction with satellite altimetry and sea surface temperatures were used to initialize the model while similar and independent later observations were used to evaluate how successfully the model reproduced observed conditions. The use of basin-wide SSH and SST remotely sensed observations allowed the large scale (e.g. LC and LCE) circulation patterns to be integrated in the model initialization. Between initialization and verification, the model 'predicted' growth the of eddy energy in this initial field. The growth agreed with the observed increase of the kinetic energy of the geostrophic flow between initialization and verification intervals. Stability analysis indicated that the growth was caused by mixed barotropic and baroclinic instabilities. The success of this use of hydrographic surveys in a model assimilation scheme was a first step along the path that will allow the incorporation of in-situ, ocean observing systems into real-time model predictions.

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STUDY PRODUCT(S): Oey, L.-Y., P. Hamilton, H. C.-Lee. 2003. Modeling and Data Analyses of Circulation Processes in the Gulf of Mexico. Final Report. U.S. Dept. of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study MMS 2003-074, 129 pp.

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