ACCESS NUMBER: 30073

STUDY TITLE: Gulf of Mexico Circulation Modeling Study

REPORT TITLE: Gulf of Mexico Circulation Modeling Study Annual Progress Report, Year 2

CONTRACT NUMBER: 14-12-0001-30073

SPONSORING OCS REGION: Gulf of Mexico

APPLICABLE PLANNING AREAS: Straits of Florida and Gulfwide

FISCAL YEARS OF PROJECT FUNDING: 1983; 1984

COMPLETION DATE OF REPORT: April 1986

COSTS: FY 1983: $78,663; FY 1984: $80,272

CUMULATIVE PROJECT COST: $158,935

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KEY WORDS: Straits of Florida; Eastern Gulf; Central Gulf; Western Gulf; physical oceanography; currents; modeling; transport; patterns; Loop Current; wind forcing; seasonality; eddy

BACKGROUND: In 1983, the U.S. Department of the Interior funded a four-year circulation modeling program for the Gulf of Mexico. The first study year tested the two layer hydrodynamic primitive equation ocean circulation on a 0.2 degree grid. Important aspects of the first year were correctly specifying coastline and bottom topography for maximum circulation simulation, and how best to include wind forcing. During the second study year, investigators utilized the same basic model with various parameter changes to conduct experiments.

OBJECTIVES: (1) To progressively upgrade in modest increments an existing numerical ocean circulation model of the Gulf of Mexico so that the final model has horizontal resolution of about 10 km and vertical resolution approaching 1 to 10 m in the mixed layer, 10 m at the thermocline, and 100 m in deep water.

DESCRIPTION: During this four-year project, the validity of the upgraded model will be continuously tested, and velocity field time series delivered periodically based on the

most realistic simulation of Gulf circulation available. Experiments during the second year were with the existing NORDA/JAYCOR two layer hydrodynamic primitive equation ocean circulation model of the Gulf of Mexico on a 0.1 degree grid. Simulations generated included wind-forced only, port-forced only, and wind-forced plus port-forced. Model parameters included: upper layer inflow transport, lower layer inflow transport, wind stress, horizontal eddy viscosity, grid spacing, upper layer reference thickness, lower layer reference thickness, minimum depth of bottom topography, Coriolis parameter, gravitational acceleration, reduced gravity, interfacial stress, coefficient of quadratic bottom stress, and time step. Experiments were conducted by adjusting these parameters to achieve best simulations when compared with existing data.

SIGNIFICANT CONCLUSIONS: Simulations using wind forcing only did not provide realistic Gulf wide circulation patterns. This is because wind-induced flows in the eastern Gulf of Mexico, except on the continental shelf, are very small relative to the dominant port-forced Loop Current system. In the western Gulf of Mexico, wind-forced currents were quite significant. Port-forced experiments provided realistic Gulf wide circulation patterns; however, there was little variability from one Loop Current eddy cycle to the next. The port-forced plus wind-forced experiment provided the best simulation of Gulf surface currents during this study.

STUDY RESULTS: Two wind sets were used in the wind-forcing experiment (seasonal ship winds and monthly modeled geostrophic winds). Both gave similar results everywhere except in the southwestern Gulf in winter and spring. The ship observation-based wind fields generally tended to overestimate wind strengths. Interannual wind variability had significant effects on the simulation.

The port-forcing experiment produced the best simulation and had a horizontal eddy viscosity (A) of 50 m^2 sec^{-1} and a coefficent of quadratic bottom friction of 0.0003. Surface currents were sampled every three days for complete eddy shedding cycles. Little variablity was generated in terms of eddy movement as all simulated eddies followed the same south of west path across the Gulf. It was believed that this was the preferred path of actual Loop Current eddies in the Gulf of Mexico. Generally, the port-forced simulations provide good models of a typical Loop Current eddy cycle.

Port-forcing plus wind-forcing experiments were difficult to obtain long-term simulations from because of the effect of wind forcing on the range of horizontal eddy viscosities. Wind forcing produced upwellings between anticyclonic eddies and the coastline; these upwellings stopped the simulation. Monthly averaged winds were added after six years of port-forced spin up. Simulated surface currents were sampled every three days for more than ten years using this experiment.

STUDY PRODUCT: Wallcraft, A. J. 1986. Gulf of Mexico Circulation Modeling Study Annual Progress Report, Year 2. A final report by JAYCOR for the U.S. Department of the Interior, Minerals Management Service Gulf of Mexico OCS Region, Metairie, LA. NTIS No. PB87-107421. MMS Report 86-0027. Contract No. 14-12-0001-30073 94 pp.