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**STUDY TITLE**: Gulf of Mexico Circulation Modeling Study

**REPORT TITLE**: Gulf of Mexico Circulation Modeling Study Annual Progress Report, Year 1

**CONTRACT NUMBER**: 14-12-0001-30073

SPONSORING OCS REGION: Gulf of Mexico

APPLICABLE PLANNING AREAS: Straits of Florida and Gulfwide

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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**: An accurate understanding of circulation patterns in the Gulf of Mexico are essential when predicting dispersal of pollutants or any other transportable contaminants. Conventional methods of obtaining circulation data are time consuming and costly. Computer simulations obviate some of the time and expense involved in characterizing or predicting oceanic circulation patterns. The U.S. Department of the Interior sponsored a four-year effort to upgrade and test an existing computer model of Gulf of Mexico circulation patterns that will provide management personnel with quick and reliable simulations of particular circulation patterns in the absence of field collected data.

**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 this first year were with the existing NORDA/JAYCOR two layer hydrodynamic primitive equation ocean circulation model of the Gulf of Mexico on a 0.2 degree grid. Particular attention was given to specifying the coastline and bottom topography for maximum realism. 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**: Changes to the original model parameters such as inflow transport of the upper and lower layers improved the simulations. The experiment yielding the best results included the addition of wind forcing after port forcing had fully spun up. The use of seasonal climatological winds introduced considerable variablility and was not a successful experiment. This experiment also revealed that ocean circulation climatologies were inappropriate for use in oil spill risk analyses in the Gulf of Mexico.

**STUDY RESULTS**: Five experiments (Experiments 9, 34, 40, 60, and 68) were included in the Year 1 report. Experiment 9 gave the best simulation of the Gulf of Mexico at the beginning of the project, based on available comparative data. The model was driven from rest to statistical equilibrium solely by a steady inflow through the Yucatan Straits. The model effectively simulated eddy shedding by the Loop Current. As shed eddies propagate westward, the model spontaneously develops a counter-rotating vortex pair, a structure observed in the western Gulf of Mexico. The simulation sheds an eddy once every 390 days, and observed eddy shedding cycles were very similar. The eddies generated in Experiment 9 were large with high maximum currents. In the two layer model, upper layer transport can be reduced to produce smaller eddies. The use of wind forcing based on seasonal climatology was used in Experiment 34. Basic circulation patterns exhibited much more variability in this case. Experiment 40 employed 20 Sverdrup (Sv) upper layer transport and 10 Sv lower layer transport, as opposed to 26 Sv (upper) and 4 Sv (lower) used in Experiment 9. This experiment produced sea surface variability maps that were consistent with maps produced from hydrographic and satellite altimeter data. Experiment 40 was considered the best mean sea surface variabilty model for the Gulf of Mexico. Experiment 60 was identical to Experiment 40, except that horizontal eddy viscosity was reduced. Some new circulation features not seen in Experiment 40 were revealed. Experiment 68 was identical to Experiment 40 except for the addition of wind forcing after the port-forced circulation had fully spun up. This experiment produced the furthest northward penetration of the Loop Current ever attained by simulation. Similar intrusions have been seen in the Gulf of Mexico. The model's inadequate representation of shelf topography makes it likely that the currents simulated in shallow water (<100 m) were

too high. Simulated surface currents from Experiment 68 were considered the best simulation data available at the end of Year 1. They consist of velocity component (u and v) fields on a 0.2 degree rectangular grid covering the Gulf area, sampled every three days for 3,780 model days (10.3 years).

**STUDY PRODUCT**: Wallcraft, A. J. 1984. Gulf of Mexico Circulation Modeling Study Annual Progress Report, Year 1. 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. PB87-128641. MMS Report 85-0025. Contract No. 14-12-0001-30073. 111 pp.