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STUDY TITLE: Water and Ice Dynamics in Cook Inlet

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APPLICABLE PLANNING AREA: Cook Inlet

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KEY WORDS: Cook Inlet circulation, tides, tide rips, drifters, 3-D modeling

BACKGROUND:

Cook Inlet tide rips are zones of surface convergence and high horizontal velocity. Planning and development in Cook Inlet require knowledge of the tide rip characteristics, their locations and the general circulation. To better understand these issues, drifting buoys were released over a three year period and satellite-tracked, remote-sensing data were analyzed, and a 3-D model was verified using the observed data.

OBJECTIVES:

This study provides trajectory data from drifters released in Cook Inlet. Drogue depths ranged from 5 to 80m and the position and velocity data along with satellite SAR data helped validate numerical models that provided model tide constituents and model code to MMS for additional studies.

DESCRIPTION:

Forty-five drifters were deployed in Cook Inlet. Position data were used to compute velocities using centered differences. Observations and models show tidal fronts typically associated with convergence zones aligned with gradients in bathymetry. Satellite data shows drifting ice In Cook Inlet collects along tide rip fronts providing strong visual signatures of frontal locations.

SIGNIFICANT CONCLUSIONS:

More than 65,000 hours of drifter data from Cook Inlet, the northern Gulf of Alaska, and the Bering Sea have been collected and archived. Of these, there are almost 35,000 hours of position and velocity data in Cook Inlet from The Forelands to Kennedy Entrance and Cape Douglas. The buoy data show a high-energy, high-velocity, and high convergence zone to the east of Kalgin Island aligned in the north-south direction with the bathymetric slope.

Radar backscatter (brightness) from sea ice is typically larger than from open water. In winter, the ice edge (frontal) location exhibits a relatively large spatial gradient in radar backscatter that was used to identify frontal locations from nine SAR images acquired in February 2002, December 2003, January 2004, and February 2004. They show that the greatest number of frontal features occurs in a zone extending southwestward from near the West Foreland to along and beyond the eastern shore of Kalgin Island. This zone roughly corresponds to the location of the West Rip and qualitatively agrees with the buoy observations and model results.

A 3-D tidal model (Finite Volume Community Model – FVCOM) of Cook Inlet with spatial resolution of 160 m near the coastline and 13 km along the open boundary has been used to simulate the 8 major tidal waves in this region (5 semidiurnal and 3 diurnal). Tidal data are from satellite-based archives of tidal constituents for the Gulf of Alaska and Northern Pacific Ocean. Model results of the tidal elevations and phases of the four major waves are in good agreement with observations.

Error between model-predicted and observed Lagrangian velocities is much smaller than the maximum value of tidal current velocity in the inlet but was the same order of magnitude as wind- and buoyancy-driven subtidal currents, suggesting that it is critical to resolve accurately the subtidal currents in Cook Inlet in order to provide realistic water transport. Realistic forecasts require accurate winds. The RAMS wind forecasts did not predict an observed and relatively large 24 hour wind event. Wind speed and direction were not correct during air-frontal passages. For example, in late September, the wind measurement shows a strong southward wind velocity of ~15 m s^{-1} at both NSFA2 and AUGA2 locations, but RAMS predicted that the maximum wind velocity was directed eastward. Similar issues arose in late October and November. In November, the phase of the model-predicted wind seemed to have a shift from the observed wind.

STUDY RESULTS:

Our model Lagrangian particle tracking experiment shows that the buoyancy- and wind-driven circulations play a critical role for particle trajectories and water transports in Cook Inlet. To simulate accurately the trajectories of drifters deployed in this region requires accurate meteorological forcing fields. We recommend that an improved meso-scale meteorological model system with data assimilation be developed to provide reliable and accurate winds in Cook Inlet for the hindcast application and for ocean model simulations and forecasts.

STUDY PRODUCTS:

Johnson, M. A. .2008. *Water and Ice Dynamics in Cook Inlet.* MMS 2008-061. University of Alaska Fairbanks Coastal Marine Institute and USDOI, MMS, Alaska OCS Region, Fairbanks, AK. Final Report MMS Contract 0198CA30909 TO 0102TO85308

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Mesa, CA for MMS Alaska OCS Region.

Johnson, M. A., S. R. Okkonen, and A. Y. Proshutinsky. 2004. "Water and Ice Dynamics in Cook Inlet." *Annual Report No.10*, University of Alaska Coastal Marine Institute. OCS Study MMS 2004-002. University of Alaska, Coastal Marine Institute and USDOI, MMS, Alaska OCS Region, Fairbanks, AK.

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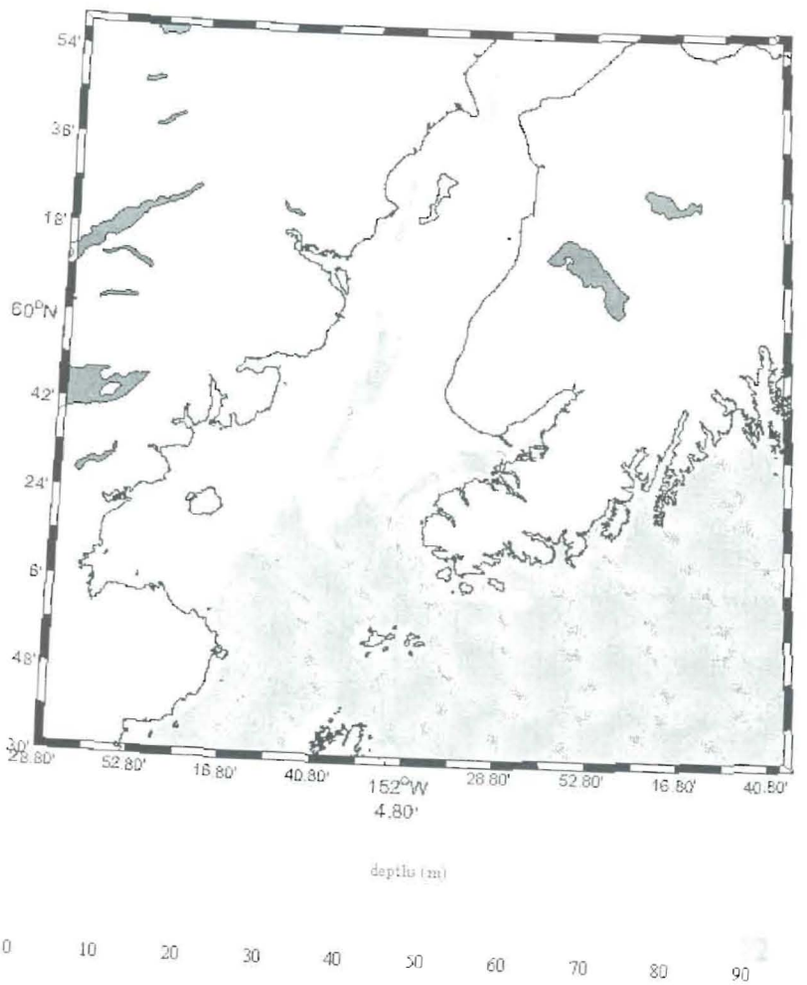
Johnson, M. A., A. Proshutinsky, and S. Okkonen. 2005. Water and Ice Dynamics of Cook Inlet. In *Proceedings of the Tenth MMS Information Transfer Meeting and Barrow Information Update Meeting*, pp. 15-16. Anchorage, AK: Prepared by MBC Applied Environmental Sciences, Costa Mesa, CA for MMS Alaska OCS Region.

Johnson, M. A., A. Proshutinsky, and S. Okkonen. 2006. "Water and Ice Dynamics in Cook Inlet, Alaska." In *Annual Report No.13*, pp. 16-25. Fairbanks, AK: University of Alaska, Coastal Marine Institute and USDOI, MMS, Alaska OCS Region.

Documented numerical model code with forcing functions and tidal constituents over Cook Inlet.

Buoy trajectories in Cook Inlet and the northern Gulf of Alaska with time and velocity information as shapefiles.

Final Report detailing acquisition of satellite tracked buoy data and satellite imagery used for model validation of tidal parameters in Cook Inlet including recommendations for future Cook Inlet programs.

Model tidal constituents and model code provided to MMS (to Drs. Richard Prentki, COTR, and Dr. Walter Johnson). Drifter positions, velocities, and related data to MMS (Dr. Prentki and Dr. Warren Horowitz)

STUDY AREA MAP: