

## Appendix G - OSRI Grant Policy Manual

### **Final Report Form - Oil Spill Recovery Institute**

This report may be submitted by mail, fax or e-mail

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**Deadline for this report:** Submittal within 90 days of grant/award expiration. **Also,** note that a summary Financial Statement shall be submitted **within 30 days** of the grant expiration.

**Today's date:** 11/11/2005

**Name of awardee/grantee:** Jeremy Kasper/Thomas Weingartner

**Project title:** Modeling the effects of river discharge, windstress and sea ice on Arctic coastal circulation

**Dates project began and ended:** June 2003-June 2005

#### **PART I - Outline for Final Program or Technical Report**

This report must be submitted by all grantees. However, for those whose project work resulted in a peer reviewed publication (whether in draft or final form), this report may be abbreviated and the publication attached as part of the report.

A. Abstract or summary of project work.

The Regional Ocean Modeling System (ROMS) was configured to model up- and down-welling along a straight coastline in the presence of a simulated fast ice cover. In addition to utilizing ROMS for these process model studies, I have completed the coursework for my degree program and am currently taking my PhD. comprehensive exams.

As a preliminary investigation, ROMS was initialized as a two-layer system with fresher water overlying denser, deep water. A wind was blown along a straight coastline with simulated fast ice extending from shore to the 20 m isobath (Figure 1). The model domain was a channel with coasts on the Southern and Northern boundaries and with open boundaries on the Eastern and Western sides. Model results showed that inshore of the fast ice, wind driven currents were negligible (bottom Figure 2). Data from Weingartner and Okkonen (2001, figure 2 top) show nearshore flows under the Beaufort Sea ice as more substantial than the modeled flows. Model results and the lack of correlation with local windstress of the under ice currents observed by Weingartner et al. suggest that a remotely forced alongshore pressure gradient is driving the nearshore under-ice currents of the Alaskan Beaufort Sea.

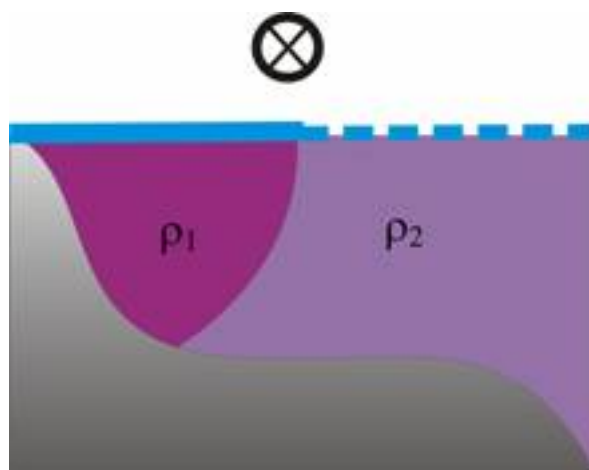


Figure 1 Schematic showing the extent of the solid fast ice (to the 20 m isobath) and the direction of the windstress (alongshore and into page). The density profile ( $\rho_1 < \rho_2$ ) represents the stratification that results after the model has reached a steady state.

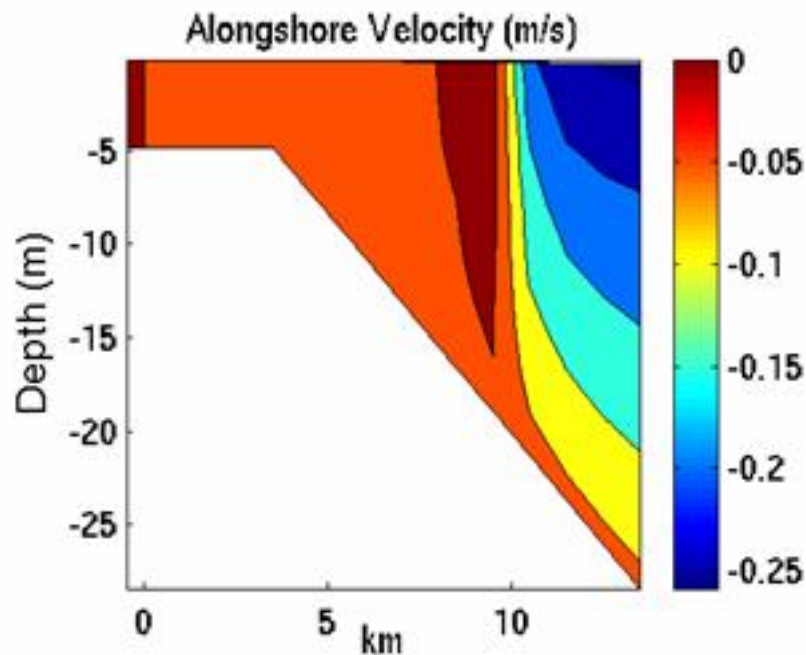
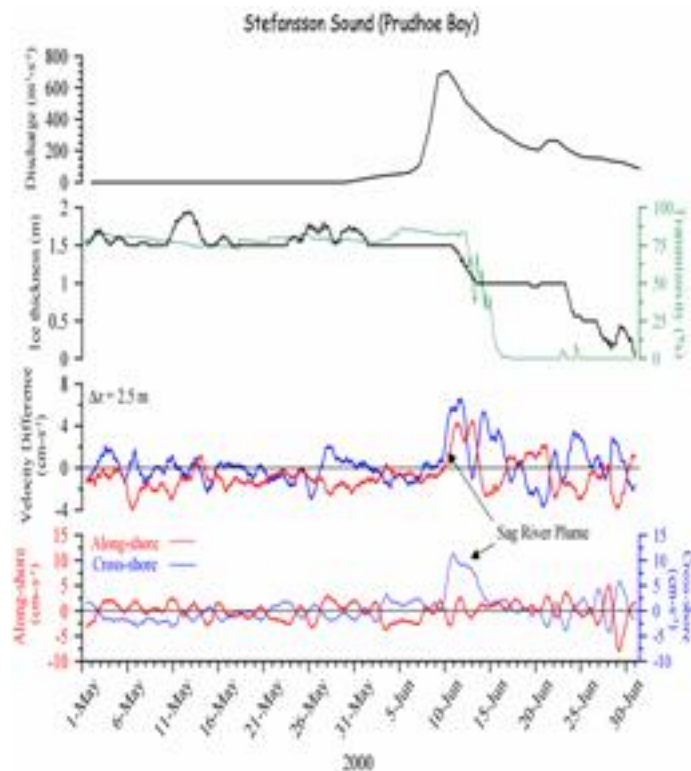


Figure 2 (Top) taken from Weingartner et al. 2001. Underice currents from the Alaskan Beaufort. (Bottom) Model results of the situation illustrated in Figure 1. The sea ice (not shown) extends out to the 20 m isobath (~10 km offshore). At the edge of the fast ice a velocity front is clearly visible. Inshore of the front, the velocities are negligible and offshore of the front, surface velocities are on the order of 0.25 m/s (directed into the page, the same direction as the wind). From the figure it is clear that little to no momentum is transferred across the shelf.

Because of these findings, an analytical solution to a modified version of Csanady's

1978 “arrested topographic wave model” was examined. Csanady’s 1978 model consists of the linearized, vertically integrated momentum equations along a straight coastline with no forcing. The initial condition is a bulge of water near the western boundary constrained to nearshore. Bottom topography linearly increases with distance offshore and bottom friction is included. The analytic solution describes the bulge as gradually spreading with distance downstream (to the east). The bulge of water forces alongshore flow and thus Csanady’s model is a good starting point to interpret flows such as those observed by Weingartner et al. Parameterizing shorefast ice as a surface friction term and including it in Csanady’s momentum equations leads to an analytical solution where the offshore spreading distance is smaller (downstream of the bulge) than the original solution.

For comparison purposes, to validate model output and provide facility with the model, ROMS was configured to mimic Csanady’s problem: open boundaries were specified at the western, northern and eastern boundaries and a straight coastline was placed along the southern boundary. The vertically integrated equations of motion were used and the bathymetry linearly increased with distance offshore. Bottom friction was included. The model domain was 600 km long (West to East) by 150 km with 1 km grid spacing. A bulge of water was placed at the western boundary and allowed to propagate downstream (eastward).

Once a stable and consistent set of boundary conditions were obtained, a systematic series of experiments was conducted to examine the solution under different conditions:

1. The offshore extent and height of the bulge was varied
2. The resolution of the model was varied
3. The areal regularity of sea ice (parameterized as surface friction) was varied.
4. The magnitude of the surface friction was varied.
5. Windstress was varied between 0 and several constant values.
6. The offshore extent of the fast ice was varied.

Initial analysis of the results shows good agreement with the analytic model i.e. in the presence of fast ice, the bulge is constrained nearer the shore. At the edge of the fast ice there is an abrupt change in the curvature of the flow streamlines. The offshore extent of the fast ice affects the magnitude and distribution of the under ice currents. I anticipate having these results suitable for publication by early Spring, 2006. These simple experiments will also provide a basis for understanding the next set of more complex experiments outlined in the original proposal: the inclusion of riverine influence along an arctic coastline.

## References

Csanady, G.T., (1978) The arrested topographic wave, *Journal of Physical Oceanography*, **8**, 47-62.

Weingartner, T.J., Okkonen, S.R. (2001) *Beaufort Sea Nearshore Under-Ice Currents: Science, Analysis and Logistics*. University of Alaska, Coastal Marine Institute.

B. Review objectives as described in original proposal and state whether these objectives were achieved.

1. Model the behavior and evolution of a river plume established by a rapidly varying discharge signal similar to that of an arctic river. This will be investigated using discharge characteristics appropriate to both small (Alaska North Slope) and large (Mackenzie) rivers.
2. Investigate how surface friction due to land fast sea ice affects the motion of the fresh water plume. This will be addressed by applying frictional drag at the ice-water interface which is a function of ice roughness and plume velocity.
3. Investigate how up- and down-welling surface wind stresses applied at the seaward edge of the landfast ice boundary affects plume circulation. I will do this by applying a surface wind stress to the first model. I will also run this model with and without the effects of ice-water friction as well.
4. Investigate how plume behavior responds to imposed deformed and undeformed landfast ice edges (with and without an applied wind stress). The former characterizes ice conditions in the Beaufort Sea
5. Investigate how the surface buoyancy flux associated with melting ice affects the dispersal of the river plume. I will simulate the changing ice conditions by applying a surface buoyancy flux that mimics ice melt to the ocean surface. As freezing and thawing of the sea ice can occur throughout the period of high river discharge, I will investigate the effects of both a positive and a negative buoyancy flux.
6. Describe the cumulative effects of the factors on the shelf circulation.

C. Describe problems or roadblocks encountered in project implementation.

Slowdowns encountered while implementing the project goals include issues with the chosen model: The Regional Ocean Modeling System (ROMS). ROMS and its predecessor SCRUM was originally written to perform process model type studies such as outlined in the original proposal. Based on the experience of past users, ROMS performed adequately in this regard. However, recently ROMS has

undergone major changes in a drive to use ROMS to model more realistic simulations. These changes made it difficult to implement process type studies and as a result the ROMS “learning curve” was a bit steeper than anticipated. These changes slowed the modeling progress significantly.

D. Highlight accomplishments, whether or not they were part of the original proposal.

None to date.

E. Conclusions.

Despite problems encountered with ROMS, modeling is progressing and it is anticipated that all the goals outlined in the original proposal will be complete by spring 2007 accompanied by publication of the results. Thank you for your support.

F. Appendix including copies of all written reports or publications completed or in progress, resulting from the project work. This also includes abstracts of papers presented at conferences. Please note the acknowledgment of OSRI support stated in Section 10.3.4 of the Grant Policy Manual.

No publications to date.

## Part II - Final Financial Statement

This may be submitted on a separate sheet; it must include the following information.

**Cumulative Balance:** \$3091.68

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<b>Budget Category</b>	<b>Budget Expenses</b>	<b>Remaining</b>
<b>Direct Costs</b>		
Personnel	15,419.43	-419.43

Travel	0.00	0.00
Contractual	0.00	0.00
Commodities (Tuition)	1,818	3,182.00
Equipment	0.00	0.00
<b>Subtotal Direct Costs</b>	17,237.43	2,762.57
<b>Indirect</b>	4,670.89	329.11
<b>Project Total</b>	21,908.32	3091.68

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