**Modeling The Formation And Offshore Transport**
**Of Dense Shelf Water From High-Latitude Coastal Polynyas**

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## LONG-TERM GOALS

Our long-term goal is to understand the role that dense water, formed on high-latitude continental shelves, plays in the thermohaline circulation of the Arctic Ocean and the maintenance of the mean hydrographic structure of the deep Arctic basins, e.g. the upper halocline.

## OBJECTIVES

Our immediate objective is improve our basic understanding and ability to predict (1) the formation and offshore transport of dense shelf waters formed beneath high-latitude coastal polynyas and (2) the pathways by which dense shelf waters enter the deep basins.

## APPROACH

Our hypothesis is that dense water, formed beneath coastal polynyas, is transported across the shelf by small-scale (15-25 km) eddies (e.g. Gawarkiewicz and Chapman, 1995; Chapman and Gawarkiewicz, 1997; Chapman, 1999; Gawarkiewicz, 1999). These dense water eddies are capable of moving offshore across the shelf break and into the deep basins where they contribute to the maintenance of the observed thermohaline structure. We are testing this hypothesis with (1) process-oriented numerical modeling designed to examine the effects of alongshelf currents, submarine canyons and wind forcing on eddy fluxes, (2) analyses of historical observations from the Chukchi Shelf, and (3) realistic numerical modeling in conjunction with ongoing field programs to test our ability to model realistic coastal polynyas.

## WORK COMPLETED

(1) A study is nearly complete that examines the effects of a steady background alongshelf current on dense water formation and transport from a steady idealized coastal polynya. Salt rejection during ice formation is modeled by a constant surface buoyancy flux imposed over a limited region. The shelf is straight with uniform topography, except where a submarine canyon intersects the

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shelf. The ocean is initially homogeneous and at rest. An alongshelf current is imposed at one end of the model domain.

2) Progress has been made in analyzing historical observations (from T. Weingartner, U. of Alaska-Fairbanks) and comparing model scales of eddy features with temporal variability observed in the mooring records.

## RESULTS

(1) In the modeling study, the basic ocean response is unchanged by the ambient current; i.e. an unstable density front forms at the polynya edge and breaks up into small-scale eddies which then carry the dense water away from the polynya (Figure 1a). However, the alongshelf current has two important effects. First, it carries water along the shelf and out of the polynya thereby reducing the time the water spends beneath the surface density flux, and thus reducing the typical density anomaly of the dense water formed. Second, the alongshelf current adds an alongshelf velocity component to the eddy translation, thus increasing the alongshelf flux of dense water while decreasing the offshore flux (Figure 1b). The total volume of dense water formed in not appreciably altered, but its spatial distribution is quite different and the extreme density anomalies are reduced.

The influence of a submarine canyon located downstream of the polynya (in the direction of the imposed alongshelf current) is also examined. A canyon oriented perpendicularly or diagonally away from the coast has little effect on dense water transport, i.e. almost no dense water enters the canyon. The tendency of the flow to follow isobaths carries virtually all of the dense water around and past the canyon (Figure 1c). On the other hand, a canyon oriented parallel to the coast (as in the case of Barrow Canyon at the eastern edge of the Chukchi Shelf) can carry an appreciable amount of dense water. However, the dense water is not funnelled down the canyon. Rather, the flow between the canyon and the coast is accelerated by the converging isobaths, so as much dense water may be carried between the coast and the canyon as in the canyon itself (Figure 1d). The details are sensitive to the magnitude of the alongshelf current. Thus, dense water formed beneath a coastal polynya may follow three different paths; it may move (i) directly offshore, (ii) along the shelf down the canyon or (iii) along the shelf between the coast and the canyon. The distribution depends on the strength of the alongshelf current and the canyon geometry.

2) Observations suggest very large variability in the salinity and velocity fields from the central Chukchi Shelf. Salinity variations are 1.0 PSU or larger, with changes occurring on time scales of 1 to 5 days. Associated with these large changes in salinity are velocity fluctuations of 20 cm/s. The numerical model can reproduce these scales, but only with a relatively shallow region adjacent to the coast, and only if bottom friction is much less than typical of mid-latitudes.

## IMPACT/APPLICATIONS

The results suggest the sensitivity of the offshore transport of dense shelf water to variations in shelf topography and the presence and strength of ambient shelf currents. Thus there is no obvious place that we can expect to find dense water leaving the shelf, and this should be taken into account when designing a field program to observe shelf-basin interactions.

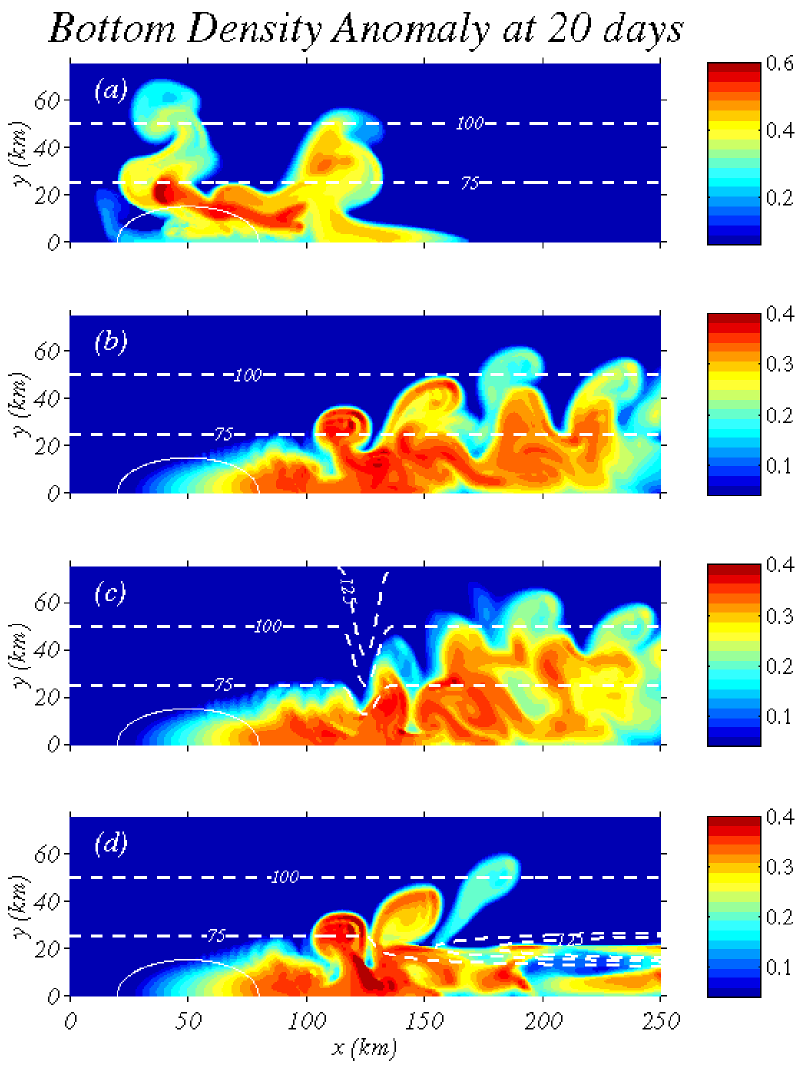


***Figure 1:  Plan views of bottom density anomaly after 20 days of constant surface buoyancy flux imposed within the half-ellipse centered at the coast at x=50 km (white curve): (a) uniform topography with no ambient alongshelf current; (b) uniform topography with a 10 cm/s ambient alongshelf current to the right; (c) same as (b) but with a submarine canyon oriented normal to the coast; (d) same as (b) but with a submarine canyon oriented parallel to the coast. Note that dense water only enters the parallel canyon in (d).***

**TRANSITIONS**

There are no transitions at this point.

## RELATED PROJECTS

We are working closely with Tom Weingartner (U. of Alaska, Fairbanks), Don Cavalieri (NASA/Goddard Space Flight Center) and Thorsten Markus (U. of Maryland) in the examination of historical observations from the Chukchi Shelf and the realistic modeling of this region. We are also working closely with Knut Aagaard (U. of Washington), Tom Weingartner and Seelye Martin (U. of Washington) to develop a realistic model of the St. Lawrence Island polynya in conjunction with the field program that has recently taken place there.

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