Wind-Driven Cross-Shelf Transport on a Shelf with Curvature

Steven Morey

Center for Ocean – Atmospheric Prediction Studies
The Florida State University
Geostrophic currents on a shelf are dominantly along-isobath (PV conservation)

Large cross-shelf gradients in physical and biochemical variables elevate the importance of the secondary cross-shelf flows.
Example:
Cross-shelf transport off of California yields cold filaments... ... and offshore export of chlorophyll-rich waters.
Gag grouper (*Mycteroperca Microlepis*) spawn along the outer shelf edge in winter through early spring.

Larvae are transported onshore to nursery habitat (sea grass) in the coastal region by some undetermined mechanism.
Idealized Coastal Upwelling

- Offshore Ekman Transport
- Upwelled Onshore Transport

Wind
Cross-isobath surface Ekman transport is proportional to, and to the right of, $\tau y$
Little cross-shelf surface Ekman transport, and hence upwelling/downwelling, when winds are mainly blowing across-shelf.
This does not look like an idealized straight shelf.

Decrease in Shelf Width (following the Shelf Wave propagation direction)
Alongshore depth-averaged velocity (from along-shore shallow-water momentum equation with a flat shelf)

\[ \bar{u}^y = \frac{\tau^y}{\rho_0 r} \]

Alongshore transport

\[ U^y = W \bar{u}^y \]
Change in along-shelf transport must be balanced by cross-shelf transport where the shelf width changes.

$$\bar{u}^y = \frac{\tau^y}{\rho_0 r}$$

$$U^y = W \bar{u}^y$$

Cross-shelf Transport due to Changing Shelf Width
Solution to a linear, steady homogeneous potential vorticity equation over an idealized shelf - upwelling wind case

Cross-shelf velocity component

From Pringle, JPO, 2002
Thus, under an upcoast wind regime, one might expect enhanced onshore transport at the shelf constriction.
Upwelling on the Northern West Florida Shelf

2008 N7-Tower velocity (cm/s - 40HLP filtered) 3m / 15m

N7 Tower observations
Upwelling Index for the northern West Florida Shelf

A spatially-varying upwelling index is computed as the pseudostress projected onto the along-isobath direction

- Positive in the topographic wave propagation direction - downwelling

QuikSCAT winds can be used due to the large width of the shelf

1. The topographic gradient is computed over a ~30km length scale (comparable to Rd)

2. QuikSCAT Level 2B winds are converted to pseudostress $|u|u$

3. Pseudostresses are bin-averaged and projected onto the local along-isobath direction

(Computed between 10m and 300m isobaths)
SeaWinds/QuikSCAT Along- Shore Pseudostress

05 Jan 2000 23:58 UTC
SeaWinds/QuikSCAT Along-Shore Pseudostress

09 Jan 2000 11:36 UTC
North-northeasterly winds produce a dominant upwelling pattern over the shelf with onshore surface Ekman transport in the western Apalachee Bay region.
July Climatology

Only month with upwelling-favorable winds over the northern and western Apalachee Bay region.
Summary

- QuikSCAT winds are useful for studies of the West Florida shelf due to its width.
- The curvature of the northern West Florida Shelf produces significant along-shore variability in inferred cross-shelf transport.
- The narrowing of the shelf suggests regions of enhanced cross-shelf transport due to simplified dynamics.
- A localized region of upwelling is suggested by the analysis, and is evident in the observations.
- This work would be further supported by extending the NGI observational array westward toward the narrower portion of the shelf to provide a better characterization of the cross-shelf transport pathways.