

Wind-Driven Shelf/Basin Exchange on a Broad Arctic Shelf: The Joint Roles of Ice Cover Extent and Shelfbreak Bathymetry

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Large continental shelves comprise over 30% of the surface area of the Arctic Ocean and play a key role in establishing property distributions within the arctic basin. One of the primary mechanisms that drives shelf/basin exchange is wind-driven upwelling. For example, the Beaufort Shelf experiences summer upwelling events that can bring relatively warm, saline and nutrient rich waters from the upper halocline (80-100 m depth) onto the shelf. Such exchange can potentially enhance ice melting, provide nutrients for biological production and act as a preconditioning for brine drainage during the subsequent winter.

For a great part of the year the Arctic Ocean is covered by ice, and this significantly affects hydrographic conditions and the dynamics of wind forcing. Summer melt-back, which proceeds from the coast seaward, currently allows only brief exposure of the ocean surface to wind forcing. The effectiveness of upwelling during this time depends critically on the position of the ice edge relative to the shelfbreak. To demonstrate, we use a primitive-equation numerical model to show that substantial shelf/basin exchange due to wind-driven upwelling occurs only when the ice edge retreats beyond the shelfbreak. Otherwise, upwelling-favorable winds generate virtually no shelf/basin exchange. This suggests that upwelling will be enhanced in “good ice” years (large melt-back) and severely curtailed in “bad ice” years (little melt-back). These modeling results are corroborated by analysis of ice conditions and examples of water properties on the Beaufort Shelf. This behavior is likely to be an important source of interannual variability for physical, geochemical and biological systems, may have important implications for environmental change under scenarios of altered climate.