The exchange of water between the Faroe Shelf and the surrounding waters and its effect on the primary production

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Abstract
The interannual variation of the spring bloom and its effect on the marine ecosystem on the Faroe Shelf has been observed for a couple of decades. However, the mechanism controlling the spring bloom has so far not been known and attempts to explain the mechanism have mostly ruled out possibilities. The Faroe Shelf is to a variable degree isolated from the surrounding waters by a tidal front. It has previously been suggested that variations in the density difference across the front and how water masses are transferred across it affect the spring primary production, which is thought to be a driver of the shelf ecosystem. Using air–sea heat flux data and sea temperature observations on the shelf and off the shelf, we estimate the cross-frontal volume exchange in January–April and find that it increases with the tidal current speed and decreases with the cross-frontal temperature difference. Using the observed exchange rates, we show that the phytoplankton growth rate may be reduced by more than 0.05 day^{-1} when the exchange is intense and off-shelf production is still low. Based on frontal dynamics theory, we suggest that the cross-frontal exchange rate in the above mentioned period is determined by the rate of vertical turbulent diffusion through the front. A simple theoretical model is found to support this hypothesis qualitatively as well as quantitatively. This supports that variations in horizontal exchange are an important controlling factor of the initial spring bloom and that the horizontal exchange during the winter can be determined by vertical turbulent diffusion. Our results will be relevant for the primary production in other similar systems of small geographical extent and also for other problems involving cross-shelf exchange, such as oil spill dispersal.

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