Abstract View

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On the Low-Frequency Fluctuations in the Eastern Skagerrak and in Gullmaren

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ABSTRACT

An analysis is presented of the fluctuations with periods exceeding approximately one day in the coastal zone of the eastern Skagerrak and in the fjord Gullmaren based primarily on data from a three-month field experiment during the spring of 1979. Mean flow in the coastal zone consisted of a strong, persistent northward flow in a wedge of brackish water near the coast—the Baltic current-superimposed on a weaker general barotropic northward flow. Three distinct low-frequency bands characterized by high degrees of organized motion and different spatial structure are identified in the coastal zone by coherence and phase analysis. For a two day or more band, alongshore flow appears to be driven locally by the wind. Topographic vortex modes in the Skagerrak may explain highly-organized 56 h fluctuations. For the 5–6 day band the fluctuations are related more to the wind stress over the northern North Sea than to the local one. Topographic waves propagating eastward along the Norwegian Trench may communicate this remote forcing to the eastern Skagerrak. Our results and some additional analyses of historical data imply that as they reach the eastern Skagerrak these waves may be scattered into internal Kelvin waves and general topographic waves, the latter of which exhibit seaward as well as northward energy propagation. Also, large observed alongshore momentum flux divergences in this band may act as forcing functions for the mean circulation. Baroclinic instabilities do not seem to be an important source of low-frequency fluctuations in the study region.

For the two week or more band the first Empirical Orthogonal Function (EOF) current mode was again more coherent with the northern North Sea than local wind stress and was highly coherent with the first adjusted sea level EOF mode from four stations around the Skagerrak-Norwegian trench region. These and other results suggest a topographic gyre model for the very low-frequency barotropic circulation in this region.

The fluctuations in Gullmaren with periods less than ~4 days appeared to be driven directly by the wind over the fjord and not by its interaction with the coastal zone. Coherence and phase relationships between EOF current and salinity modes and comparisons with expected phase speeds and vertical structures of “dynamical” modes there

show the existence of internal seiches around periods of 27 and 56 h. At periods exceeding ~ 4 days, fluctuations in Gullmaren are mainly coupled to those in the coastal zone. Large halocline depth and surface salinity variations at periods exceeding two weeks may be related to slow changes in the Baltic current (Kattegat-Baltic Sea estuary system) as well as to conditions in the Skagerrak.

The relaxation of a downwelling event was studied in detail. It is shown that such coast-parallel wind events, although infrequent in the study area, have a profound effect on nearshore current structure and the exchange between Gullmaren and the coastal zone.

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