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Three-Dimensional Seismic Imaging of Deep-water Overflow at the Faroe-Shetland Channel

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Exchange of water across the Greenland-Scotland Ridge between the Atlantic Ocean and the Arctic Mediterranean is a key component of global overturning circulation. The Faroe-Shetland Channel is a major conduit for this transport and dominates northward transfer of heat. Here, we investigate the spatial and temporal variation of thermohaline structure within this channel using three-dimensional seismic reflection imagery generously provided by PGS. A total of 200 separate seismic sequences, acquired in April-October of 1995–1997 and covering an area of $\sim$500 km^2, have been processed and analyzed. Observed acoustic reflections are caused by changes in temperature and, to some extent, salinity. In this way, fine-scale thermohaline structure is imaged. Bright reflectivity at depths of 300–800 m corresponds to the prominent pycnocline (temperature contrast $\sim$8°C; salinity contrast $\sim$0.3 psu) that separates North Atlantic Water from Faroe-Shetland Channel Deep Water. At shallower depths, weaker reflections reveal highly discontinuous fine-scale structure. Below depths of 450–800 m, nearly constant temperature and salinity give rise to negligible reflectivity. Seismic images show pronounced variation in the depth and thickness of the pycnocline. This variation is mapped across all 200 seismic images. Seismic reflections within the pycnocline are automatically tracked and the slopes of these reflections are used to estimate geostrophic shear. Observed variations in pycnocline depth and geostrophic shear suggest energetic mesoscale fluctuations, in particular the passage of an anticyclonic eddy in July-August 1997. This mesoscale activity is interpreted with the aid of contemporaneous high-resolution satellite images and wind speed records. Motions at smaller scales are analysed using the displacement spectra of tracked seismic reflections. Internal wave spectral subranges are isolated and compared to the Garrett-Munk model spectrum. Diapyncal diffusivity is estimated using turbulent spectral subranges, and variations in mixing rate are interpreted with reference to the observed mesoscale activity.