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Dense water cascades: physical mechanisms and implications for fishery on the Rockall Bank

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Rockall Bank is a large bank situated in the northeast Atlantic well beyond the continental shelf, approximately 300 km west of the Hebridean island of St Kilda. It is very shallow in places (typically 65 to 200 m), and rises above the sea surface at Rockall rock itself. The seabed of the Bank changes gradually, and away from the bank the seabed slopes down to more than 1500 m making a particularly steep slope at the southeastern edge of the bank. The Rockall Bank is an area of great biological significance featuring species-rich fish and coral-associated benthic communities in the depth range of 100-1000 m. More than 80 species of fish have been recorded within the area of the Bank and its slopes, including haddock, cod, and monkfish. Large concentrations of blue whiting occur over the Bank in early spring and use the area as a spawning ground. The fishery around Rockall dates back about 2 centuries. Since the exclusive economic zones were introduced in the Rockall Bank area, international fishery has developed on the slopes of the bank in deeper waters. It looks logical that variable physical environments on and around the Bank can significantly influence the functioning of the ecosystem and fishery in the area. This study is concerned with the process of dense water cascading from the Rockall Bank, which could particularly influence the benthic element of the ecosystem.

Cascading is the motion of dense water which is formed by cooling, evaporation or freezing in the surface layer, along a sloping sea bottom to a greater depth. This process is of topical interest to studies of shelf-deep water exchanges and nutrient fluxes. This paper analyses observed cases of cascades in various parts of the world ocean, with particular focus on the Rockall Bank cascades. In-situ data of thermohaline properties of waters are considered together with satellite imagery, both in the IR (AVHRR) and microwave bands of the spectrum. Winter convection in the area can reach a depth

of 400-600m, which is deeper than much of Rockall Bank. As a result, the water over the bank cools to a lower temperature than in the surrounding deep areas. This leads to the formation over Rockall Bank of a “cold water patch” (Shapiro et al, 2003). Cold water, which is formed from around November-April, leaves the Bank as a dense water cascade (Ivanov et al, 2004). The hypothesis here is that the cascading waters in March -April could influence the spawning cycle of blue whiting.

The rate of cascaded flux is estimated using the theory by Shapiro and Hill (1997); and the temperature contrast between the bank and the deep sea using the formula from (Shapiro et al, 2003). Temperature contrasts at the surface were best seen using microwave data. Unlike the AVHRR, microwave optimally interpolated data are unaffected by cloud cover; however, with the shorter time scale (daily) compared to the AVHRR data (weekly and monthly), this surface temperature difference is more variable. In both data sets the temperature is clearly linked to the topography, particularly at the southeastern boundary of the bank. The colder patch is 1-2žC cooler than the surface water adjacent to it, over the Rockall Trough, and tends to be seen within the area which corresponds to the 500m depth contour. This estimate is close to the in-situ measurements (dT=0.75žC) and theoretical value (dT=0.88žC). Potential cascading sites are correspondent to the location of most intensive fishing effort as identified by J.Hall-Spencer (ICES WGDEC report 2005). This study was partially funded by EU-INTAS grant 03-51-4620.