

Spatial shifts in spawning habitats of Arcto-Norwegian cod induced by climate change.

Svein Sundby and Odd Nakken
Institute of Marine Research
P.O. Box 1870 Nordnes
N-5817 Bergen
Norway

The Arcto-Norwegian cod migrates from the feeding areas in the Barents Sea southwards along the Norwegian coast to spawn in March and April. The spawning areas are located along a 1400 km long coastline with the main spawning area Lofoten at the geographical centre and the Møre spawning district at the southern fringe and the Finnmark spawning district at the northern fringe. The recruitment to the cod stock shows large interannual variations strongly influenced by interannual variations in the sea temperature. In contrast, the timing of the spawning is insensitive to the interannual temperature variations. It has, however, been observed a weak long-term change of about one week in the spawning period from the 1930s to 1980s. Although the timing of spawning shows little variations from year to year, the relative contribution in egg production of the various spawning districts shows large interannual variations but these variations do not correlate with the interannual temperature variations. However, we have revisited old time series from the Norwegian Directorate of Fisheries (NDF) and found that on an interdecadal time scale it has been a long-term change in the importance of the various spawning districts. During the warming of the mid 20th century spawning in the two northernmost spawning districts, Troms and Finnmark, increased in magnitude while the spawning intensity in the southernmost district, Møre, decreased (Figure 1). During the cooling in the 1960s and 1970s the situation shifted back to that of the cool period before the 1930s with no spawning in the eastern part of Finnmark. The time series from NDF ended in the mid 1970s, so unfortunately we have not been able to investigate possible shifts during the recent warming of 1990s and the first years of the present century. However, reports from the fishing fleet during spring of 2004 show that spawning Arcto-Norwegian cod again visited the eastern parts of Finnmark. Recent reports from East Finnmark show that the same is now happening in spring 2005. Hence, there exists an interdecadal shift in the spawning locations of Arcto-Norwegian cod towards north in warm periods and towards south in cool periods (Figure 2).

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Figure 1. Upper panel: Roe indices (liters of roe delivered per tons of gutted cod during the spawning fishery) from Arcto-Norwegian cod caught at the southernmost spawning district Møre, and the two northernmost spawning districts Troms and Finnmark. Time series ended during the mid 1970s. The blue arrow indicates qualitative observations on new cod spawning fishery in East Finnmark during the spawning seasons of 2004 and 2005. Lower panel: Temperatures in the Barents Sea

represented by the Kola Section. The three curves are annual means, 5-years running mean and 30-years low-pass Butterworth filter.

Figure 2. Feeding areas of Arcto-Norwegian cod in the Barents Sea and spawning areas along the Norwegian coast. During interdecadal warm periods the intensity of spawning is displaced northwards along the coast (red arrow). During interdecadal cool periods the intensity of spawning is displaced southwards.