

Molva molva), rare species became common and extended their ranges (*Pollachis virens*, *Salmo salar*, *Squalus acanthias*) and Arctic species no longer occurred in southern areas, but shifted their range northwards (*Mallotius villosus*, *Gadus ogac*, *Reinhardtius hippoglossoides*). Thus, climate can cause extensive shifts in species distribution and in local biodiversity.

In the North Sea, fishing has reduced life expectancy of several species, most notably plaice and sole, from around 10 years to two and cod, haddock and whiting from about four years to one year or less. Fishing tends to selectively remove large individuals and species. The Scottish August Groundfish Survey has shown that maximum fish size in the North Sea has declined by a factor of nearly eight between 1920 and 2000. The southern North Sea is at the edge of the cod's southern climatic range and the combination of warming and overfishing has led to a dramatic reduction in numbers. Cod spawning biomass in the North Sea is at a historic low, but Barents Sea populations are still strong.

Climate change and fisheries can impact on biodiversity in several ways. At the most obvious level, they can cause species extinction. They can cause stock extinction, which may or may not entail the loss of alleles or genotypes, and adverse changes in genotypic frequency. They can change distribution and abundance and we have most evidence for this. Climate change and sea level rise effects are probably severe for some sensitive systems, such as coral reefs and mangroves, and these will also affect fish populations. It is also becoming clear that the North Atlantic Oscillation has a strong, but not necessarily simple, effect on phytoplankton, zooplankton and fish dynamics.

Figure 1. Landings of cod (green lines) and sea temperatures (red lines) at Greenland during the 20th century. Several large changes in cod landings coincide with changes in sea temperature. However, since the early 1970s, cod landings have been low relative to expectations from sea temperature.

