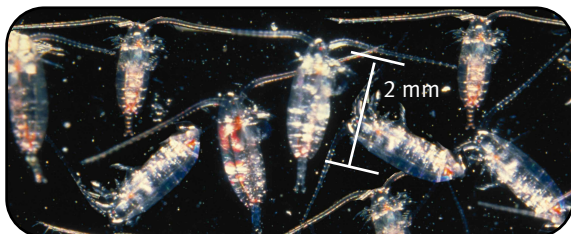


Zooplankton and Climate Change – the *Calanus* Story



Calanus finmarchicus

Background

Calanus finmarchicus is an omnivorous copepod – a microscopic crustacean – and an important part of the marine zooplankton in the northern North Atlantic. *Calanus* eggs are about 0.05 mm in diameter, and hatch in two to three days (see Figure 1). The hatchlings develop through six naupliar stages and five copepodite stages before becoming adults. At typical spring sea temperatures this takes around 30-40 days. The adults are about 2 mm long, rich in lipids and fatty acids and are actively grazed by juvenile and adult stages of many fish, especially herring.

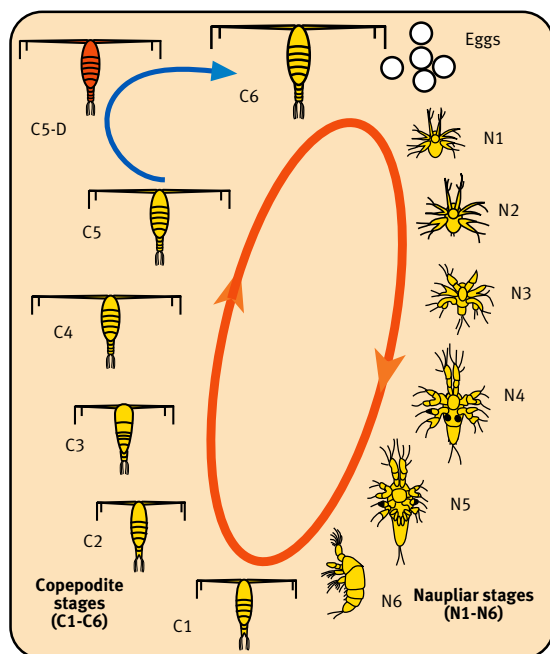


Figure 1. Schematic representation of the *Calanus* life cycle. The eggs hatch into nauplii which develop through 6 moult stages (N1-N6) and then 5 copepodite stages (C1-C5) before becoming adults (C6). At certain times of year, stage 5 copepodites may enter a dormant state (C5-D) in which they may remain for many months before awakening and developing into adults.

An unusual feature of the *Calanus* life cycle is its ability to hibernate without feeding for up to six months during the winter. During mid-late summer, pre-adult stages become dormant (diapause), sink out of the surface waters and come to rest at depths of 500-2,500 m in the ocean. They remain there until the following spring when they awaken and swim back to the surface.

North Sea Food Web

The planktonic copepod *Calanus finmarchicus* is an important component of the North Sea food web, channelling energy from primary production to harvestable fish resources, and is therefore an indicator of the state of the marine food web. During the 1960s the biomass of *Calanus* in summer constituted up to 70% of all zooplankton in the northern North Sea, but since then its abundance has declined, so that in the late 1990s its biomass is only around 50% of that found 30 years earlier.

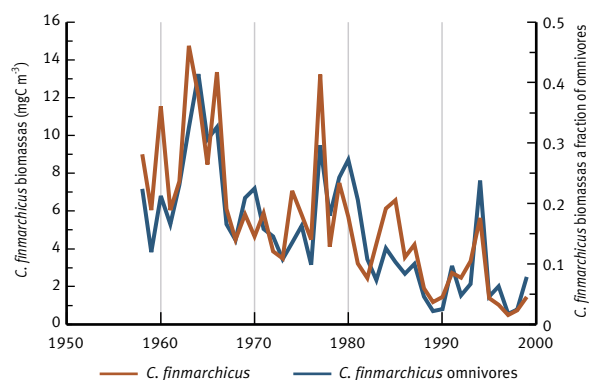


Figure 2. Declining abundance of *Calanus finmarchicus* in the northern North Sea, and a proportion (by weight) of all omnivorous zooplankton, between 1958 and 1999. Compiled from data supplied by the Sir Alister Hardy Foundation for Ocean Science.

There is a strong statistical relationship between the abundance of *Calanus finmarchicus* in the northern North Sea and an atmospheric index of climate in the North Atlantic – the North Atlantic Oscillation (NAO) index. Research at Fisheries Research Services (FRS) has identified the likely oceanographic basis for this relationship as a combination of changing wind patterns in spring, and a steady decline in the volume of cold



Towed sampling equipment developed by FRS for surveying *Calanus* in the deep ocean during their winter hibernation phase.

bottom water in the Faroe-Shetland Channel. In the winter, at depths greater than 600 m, the bottom water contains large numbers (up to 650 m⁻³) of hibernating *Calanus finmarchicus*. In the spring these copepods ascend to the surface waters again, and many are carried into the North Sea, maintaining the productive summer stock. The FRS studies indicate that the changes in wind patterns and declining volume of bottom water have effectively reduced the supply of copepods to the North Sea. The bottom water is formed at high latitudes in the Greenland Sea by a process of cooling at the sea surface and sinking. Since the 1960s the intensity of this process has been decreasing due to warming and increasing freshwater inputs from Arctic rivers and ice melt. The NAO is a symptom of large scale climate fluctuations, of which the changing wind patterns and rate of bottom water formation in the Greenland Sea are also a part.

Proving the Link

The abundance of overwintering *Calanus* in the bottom water of the Faroe-Shetland Channel is a key component of the explanation outlined above for the declining *Calanus* abundance in the North Sea. There are no data on *Calanus* abundance in winter in the Faroe-Shetland Channel, other than those collected during the FRS research programmes. Hence, in 1998, sampling for *Calanus* abundance was included as a standard component of the FRS hydrographic

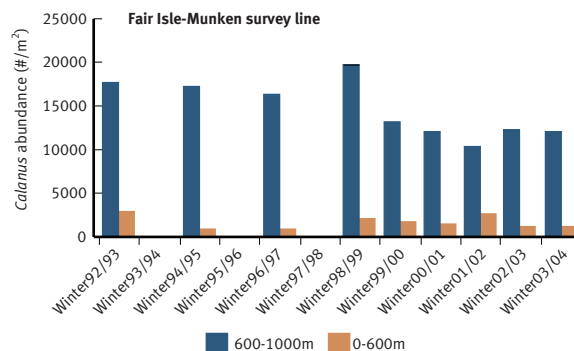


Figure 3. Abundance numbers below 1m² of sea surface) of overwintering *Calanus* in the Faroe-Shetland Channel during December since 1993, from the FRS monitoring programme.

monitoring programme in the Faroe-Shetland Channel. The results show that since 1993, as the volume of bottom water has continued to decline, so the abundance of overwintering *Calanus* has also declined.



Herring in the North Sea, Norwegian Sea, and around Iceland feed intensively on *Calanus*.

Further Investigations

The connection between climate change and the abundance of *Calanus finmarchicus* in the North Sea is now well established. FRS is collaborating with other institutes around the North Atlantic to establish the larger-scale connections between climate and *Calanus* as part of the International GLOBEC* programme. The interest in *Calanus* is a consequence of its importance in the food web and the link between primary production and fisheries. Other aspects of the FRS ecosystem research programme are focused on the link between *Calanus* abundance and the productivity of fisheries.

*Global Ocean Ecosystem Dynamics