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Andrew Syred/SPL

Food webs uncoupled

As part of your GSCE science course you learn about food chains and food webs. You also study evidence for global climate change and consider possible causes. This article examines how climate change might affect food webs. The evidence is provided by a long-term study which started in 1931.

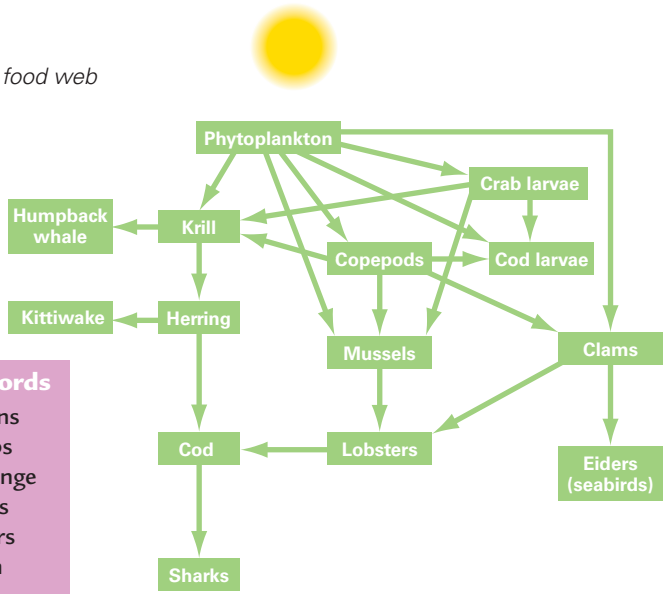
Figure 1

Figure 2

Figure 3

A typical ocean food web

Source: SAHFOS



GCSE key words

Food chains
Food webs
Climate change
Producers
Consumers
Plankton

Food chains show the feeding relationships between organisms. The position of an organism in a food chain defines its **trophic level**. The organisms at the start of a food chain are described as **primary producers**; the ones which feed on them are known as **primary consumers**; these in turn are eaten by **secondary consumers** and so on.

Food chains

Consider the food chain shown in Figure 1. This seems pretty straightforward. Sycamores photosynthesise to produce raw materials for growth. Aphids feed on sap from veins in the leaves. Blue tits catch the aphids and either eat them or take them back to their young. They themselves may be caught and eaten by a sparrowhawk. But this food chain is seasonal – sycamore trees are deciduous (i.e. they lose their leaves in winter) and temperatures may drop so low that many aphids die. The blue tits need to find other sources of food during the winter, as well as living off fat deposited in their bodies when food was more abundant. Several events are synchronised to achieve this food chain and the blue tits breed when most food is available.

Ocean food chains

Let's look at another food chain, shown in Figure 2. Plankton are microscopic free-floating plants (phytoplankton) and animals (zooplankton). They are the base of the food web in the oceans, a habitat that covers two thirds of our planet. Phytoplankton undertake about 50% of the total photosynthesis on Earth, providing food for zooplankton and other

marine organisms and removing carbon dioxide from sea water. Much plankton production each year is transferred to the ocean floor, either by dead plankton falling directly downwards or via food webs. As a result, carbon dioxide, which is in balance between surface sea water and the atmosphere, is lost to the deep ocean. This is an important part of the global carbon cycle, which in turn is linked with the maintenance of steady average global temperatures. Figure 3 shows how this food chain fits into a typical ocean food web.

Changes

How are marine organisms affected by changes in their environment? How do these changes affect food chains and webs? Plankton are monitored on a routine basis in parts of the world's oceans by using Continuous Plankton Recorders (CPRs). (You can find out more about these on the back page.) This has been going on since 1931 so the survey has a large database comprising results from 190 000 samples taken over 9 million km of ocean transects. What has been learned from this?

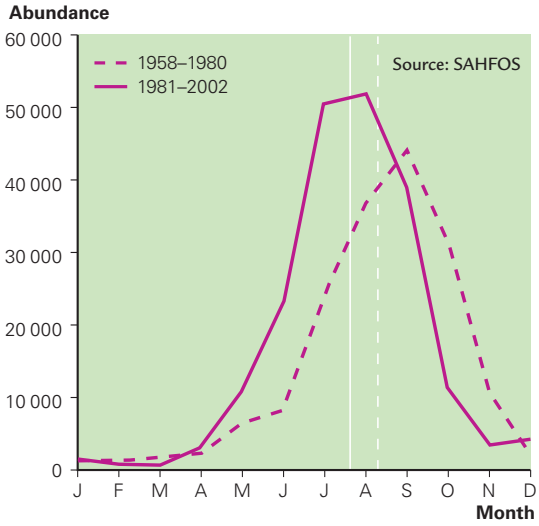


Figure 4 *Timing of growth for* Ceratium fusus, *1958–2002*

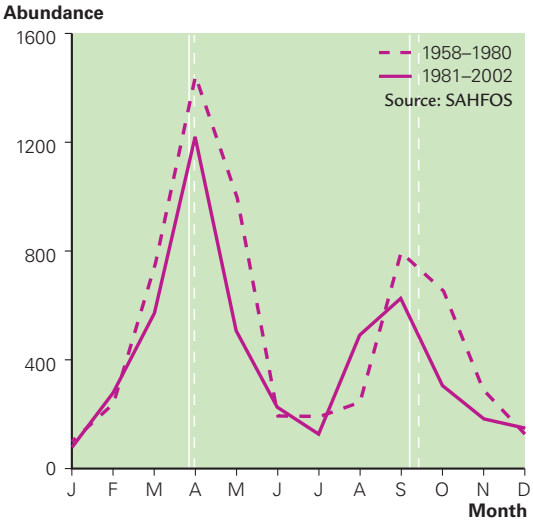


Figure 5 *Timing of growth for* Cylindrotheca closterium, *1958–2002*

Phytoplankton

Primary production in the sea is largely based on the growth of algae. CPR runs in the North Sea show that until 1987 algal growth was seasonal — taking place in spring and autumn (Figure 6). Since 1987 phytoplankton growth has continued throughout much of the year. Growth is still much slower in January and February, but this is explained by the low levels of light at this time of year. However, although there appears to be more primary production, this does not necessarily mean there is more food for the primary consumers — the herbivorous zooplankton — because the timing of their development and life cycles may not match the increase in primary production.

The CPR data have recently been analysed to see what has happened to 66 of the species that are present in plankton and if the timing of their growth has altered at all. Many species that peak in the summer now peak earlier. Figure 4 illustrates this change for one species (*Ceratium fusus*). Figure 5 shows the abundance levels of another species (*Cylindrotheca closterium*) which normally has a spring and summer peak — the timing of its peaks has not changed significantly.

Zooplankton

Copepods and larval fish are both types of zooplankton, even though larval fish, such as larval cod, eat copepods. Young cod like eating a copepod called *Calanus finmarchicus*. This is a spring-breeding cold water copepod. The North Sea has warmed up and as a result *C. finmarchicus* has moved north (Figure 7a). It has been replaced by another copepod, called *Calanus helgolandicus* which breeds in the autumn and is happy in warmer water (Figure 7b) — but this is no

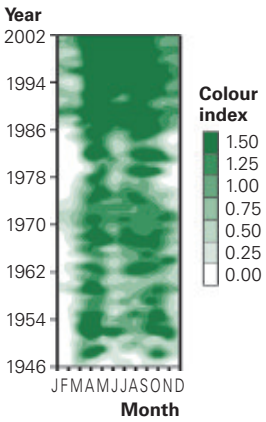


Figure 6
Phytoplankton in the North Sea recorded by using the Continuous Plankton Recorder, 1946–2002. The stronger the colour, the more phytoplankton are present
Source: SAHFOS

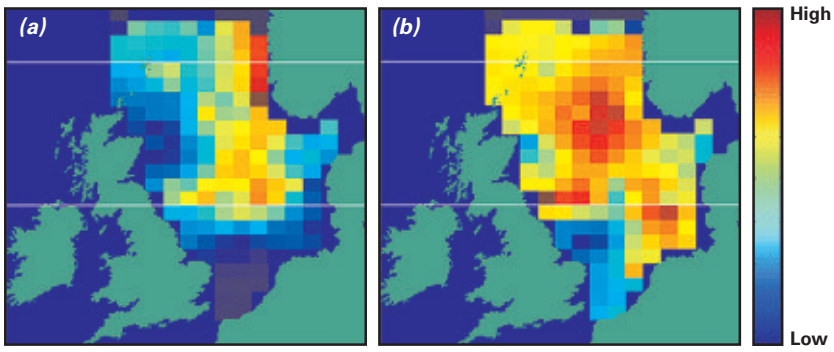


Figure 7 *The distribution of* Calanus finmarchicus *and* Calanus helgolandicus *in the North Sea.* C finmarchicus *used to be found in the southern parts and* C. helgolandicus *was uncommon, frequenting warmer waters to the south*
Source: SAHFOS

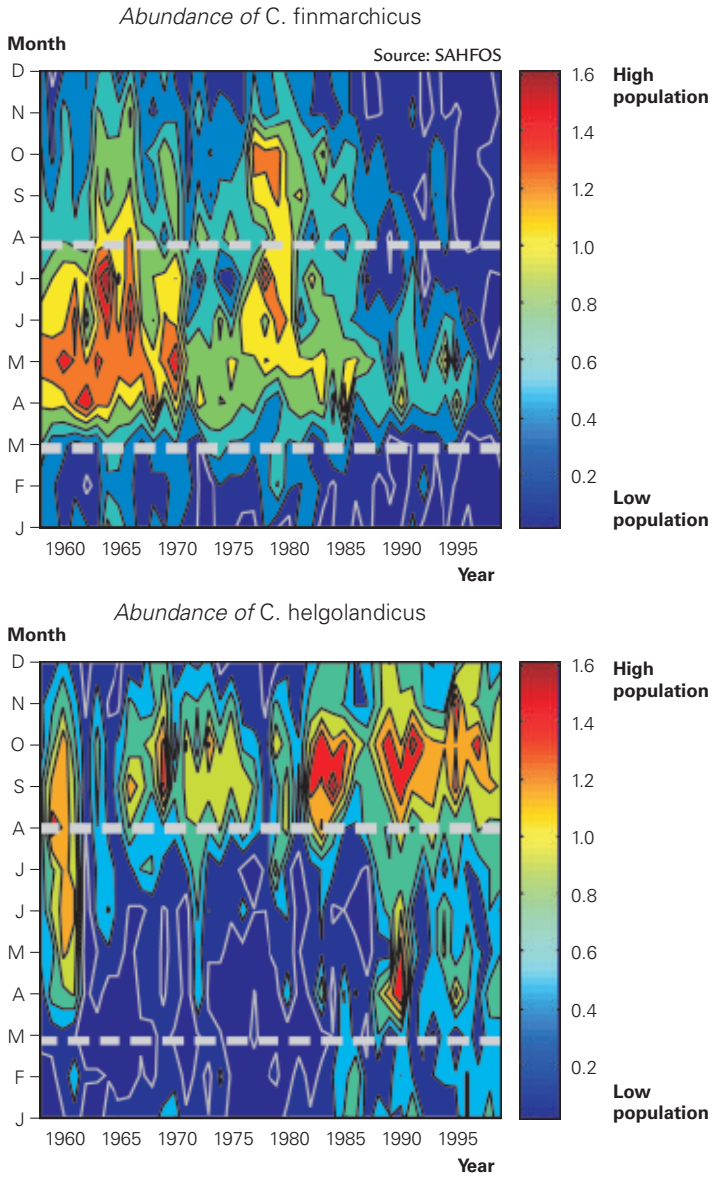


Figure 8 *The occurrence of* Calanus finmarchicus *and* Calanus helgolandicus *in the North Sea, 1958–99*

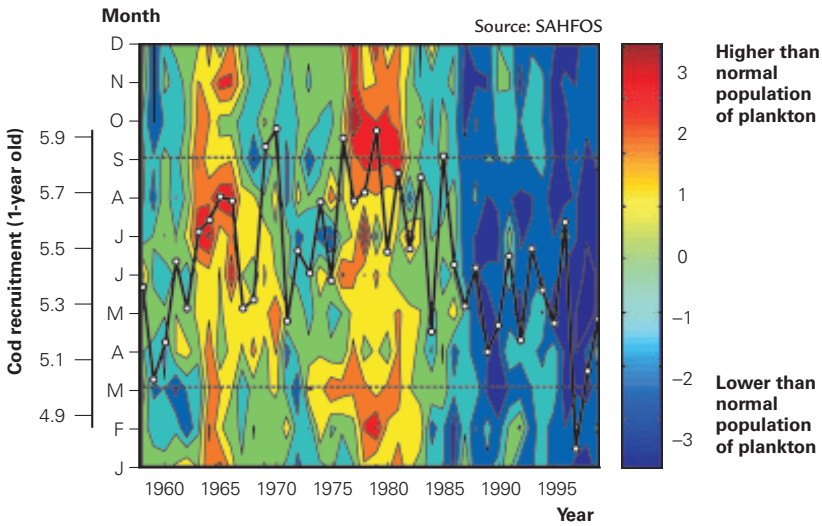
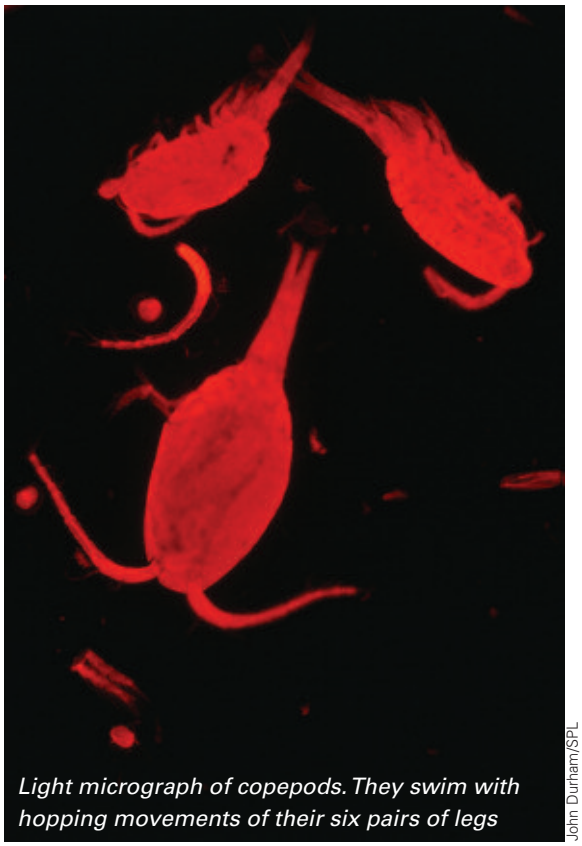


Figure 9 *The recruitment of cod compared with plankton populations*



Light micrograph of copepods. They swim with hopping movements of their six pairs of legs

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substitute as far as larval cod are concerned. Figure 8 shows when these two copepods have been most abundant across each year from the 1960s onwards in the North Sea. You can see that *C. finmarchicus* has disappeared during late spring and summer and *C. helgolandicus* has replaced it in the autumn.

Figure 9 shows the recruitment of cod, taken as numbers of 1-year-olds, across the last 40 years, together with a measure of higher or lower than normal populations of the cods' planktonic food. The drop in numbers from 1987 is clear. It is tied to the decrease in the plankton population, but is also a consequence of heavy overfishing of cod stocks.

Complex dependencies

You are often asked to draw out a food web from some simple information provided in an examination about feeding relationships. Another type of question asks you what the consequences might be if a particular organism in a food web is removed. Often these questions seem far from reality. We hope that this article has given you an insight into the complexity of understanding food webs in a changing climate, heavily impacted by human intervention through overfishing. The cod that you might eat with chips is finding its food is in short supply out in the North Sea. Food for thought!

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