

Marine Ecosystems

The Southern Ocean makes up ten percent of the world's oceans and this enormous mass of water not only isolates the Antarctic continent but also its organisms, from the warmer waters further north.

This isolation has lasted 35 million years and has resulted in many organisms living only here (endemic species) and having special adaptations to the low temperatures, long periods of darkness and the seasonal growth of sea ice.

These adaptations include some remarkable behaviours such as:

- some sea-floor species (benthic) spawning in early winter, so that their young hatch in time for the algal blooms of spring.
- open ocean (pelagic) species making full use of the short summer to feed and breed.

Life on the sea floor

The sea floor around Antarctica includes some of the least known regions of our planet. With an average depth of 450 m deep, its continental shelf is almost twice as deep as most others.

The surface waters are frequently disturbed by sea ice formation, fierce storms and passing icebergs, but on the sea floor it is a consistently cold and quiet environment, with abundant and varied life. Even three kilometres below the surface there are over 4100 different species, many of which are invertebrates, some of which have become giants in the oxygen rich waters. However the cold makes movement difficult and many larger animals simply sit and filter the passing water for food, with even the predators among them only moving perhaps a metre a week. Although the cold slows the chemistry of growth and repair, it also slows the chemistry of ageing - so much so that some invertebrates (animals without backbones) can be over a hundred years old.

Living on the sea floor also means all your food rains down from above, but this food supply depends heavily on

- the day length
- the existence of sea ice, as phytoplankton drift down from open water or algae from the underside of the ice.

However in the Southern Ocean, like a garden without fertiliser, the sea water itself has so little sediment that the supply of nutrients is often poor. As a result food chains are often short and most organisms living on the sea floor are herbivores.

Surprisingly on the sea floor there are very few predators, which can break or drill into the bodies of the resident shellfish and snails.



An Antarctic Krill (2cm long). Image Uwe Kils, Wikicommons.

Life in the open ocean

The surface waters of the Southern Ocean produces enormous quantities of food which supports some of the largest and most diverse concentrations of life anywhere on Earth.

This occurs mainly because:

- the cold water carries 1.8 times more oxygen than the tropics.
- upwellings of water bring nutrients up from the sea bed to feed microscopic algae at the surface.
- the formation of sea ice provides a stable surface on which microscopic plants and animals can grow.

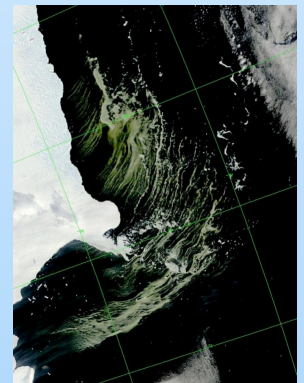
Even so food chains of the Southern Ocean are often remarkably simple - for example microscopic algae being food for krill, which in turn are eaten by fish, squid, whales, seals and birds.

Compared to the varied life on the sea floor, in the open ocean there are few species of fish.

Algal blooms

Life in the Southern Ocean depends on photosynthesis carried out by single celled organisms. Even though the number of such organisms is often low, under the right conditions they reproduce so rapidly that they can form some of the greatest algal blooms and food supplies on Earth.

However such population explosions are limited to a few summer months, when the light intensity is high enough for rapid photosynthesis. Even though all conditions seem ideal, one factor often limits the growth rate of populations - in this case it was thought to be the supply of iron. To test this scientists fertilised parts of the Southern Ocean with iron compounds, and the resulting increase in photosynthesis was truly spectacular.



Wind blown snow containing traces of iron has caused this (green) algal bloom off Antarctica. Photographed from space in March 2012, the bloom covers an area of about 100 km by 220 km. Image: NASA.

Adapted from material by José Xavier, *Institute of Marine Research, University of Coimbra, Portugal.* by Donald Reid, *iMatters.co.nz* in association with *Gateway Antarctica, University of Canterbury.*
Curricula: Science L3 - 8

Southern Ocean food chains

Krill, a keystone species

Krill are especially important to all the food chains of the Southern Ocean. In fact krill are so important they are described as a '*keystone species*', because they are a key step in the food chain between micro-organisms and larger predators such as penguins and whales.

It is estimated that there are about 1.5 billion tonnes of krill in the Southern Ocean, making them an enormously rich food supply for squid, penguins, albatrosses, seals and baleen whales.

Surprisingly with more sea ice there are more krill, as sea ice provides:

- a nursery for young krill
- cover from some of their predators
- a rich source algae living on the underside of the ice.

Octopuses, squid and fish

There are over 70 species of octopuses and squid unique to the Southern Ocean. The octopuses are very varied and tend to be found nearer the Antarctic coast where they prey on bottom dwelling species, grow slowly and are long lived. Squid however are free swimming and hunt in both open waters and under sea ice.

Both octopuses and squid are important in Southern Ocean food chains as they form the link between fish and crustacea with predators such as seabirds, seals and whales. These predators consume approximately 30 million tonnes of squid and octopuses each year.

Fish, after krill, are the second most important energy source for consumers in the Southern Ocean. Amongst these fish Lantern fish and Antarctic silverfish are the most important.



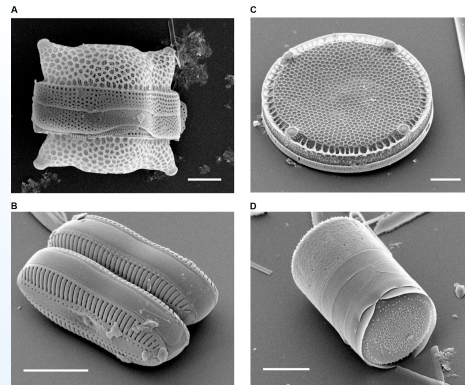
Orca are top predator's, which feed on Minke whales, penguins, fish, squid and seals - including aggressive leopard seals. The annual growth of sea ice forms a barrier between this predator and some of its prey. Image Public domain: Wikicommons

Types of predators

Predators feed on other animals. 'Top' or 'apex' predators are not preyed upon, but affect the whole food chain as their presence causes some species to thrive, while others are threatened.

Which species make up the top predators changes with location, for example:

- near the Antarctic continent the Leopard seal is a top predator as it feeds on penguins, fur and elephant seals
- in the north of the Southern Ocean the top predators are albatrosses, King, Macaroni and Gentoo penguins or Antarctic fur seals



Tiny phytoplankton are the '*plants of the sea*' and the start of many food chains. For example the size of these photosynthetic diatoms, with their delicate silica walls, can be judged by the white bar each of which is 20 millionth of a metre long.

Image: Mary Ann Tiffany. Wikicommons.

Whales as top predators

Both Baleen and Toothed whales are found in the icy and ice-free areas of the Southern Ocean, but all migrate here from other oceans.

- *Baleen whales* filter food from the water using sieve like plates. Although these whales breed in warmer waters, they migrate to Antarctic waters in the summer to feed on the abundant krill. So rich is this food supply that, after feeding for about four months, it can sustain them for the rest of the year. Amongst the baleen whales the most frequently recorded are Blue, Fin, Sei, Minke', Humpback and Southern Right whales.
- *Toothed whales* have sharp teeth to feed on more slippery prey. Of these the Southern Bottle Nose and Killer whales are most abundant at the ice edge, whereas Sperm whales occur in more open water where they feed on squid and fish.

Task: Make a food web

Introduction

Use a webcam showing the Southern Ocean or an edge of Antarctica, to build a food web.



What to do

1. Identify sufficient species to make a food chain.
2. Combine at least two food chains to create a food web.

How it works

Antarctic food webs are heavily influenced by the seasons, the migration of species and extent of sea ice.

Seals able to maintain a breathing hole can remain far away for predators hunting at the ice edge - at least until the sea ice breaks up.

Relevance

The Southern Ocean is important because it:

- affects all other oceans (physically, biologically).
- has 'simpler' food chains, meaning species often depend on one food source.
- has unique species with adaptations to cold.
- contains long lived and slow growing species which evolve slowly.
- contains some of the most iconic animals known to science.