Gauthier Chapelle at work in a colony of emperor penguins.

Aboard the Polarstern

In March 2002, as a result of global warming, more than 3000 km² of the Larsen B ice-shelf, along the Antarctica Peninsula, broke up, revealing a new and unexplored area of sea bed. The Polarstern, an icebreaker belonging to the Alfred Wegener Institute (AWI) in Germany, has just carried out the first in-depth exploration of these sea beds. This took place as a preview to the Census of Antarctic Marine Life (CAML) programme, which is on the menu of the International Polar Year. Gauthier Chapelle, from the International Polar Foundation, reports on this expedition, which took place during the 2006-2007 southern summer.

1 December 2006. Eight days since our vessel left the Cape heading for the Far South. One week on an almost constantly stormy sea (of particular note, the winds of 12 on the Beaufort scale during a heavy storm in the 'howling fiftieth'). But the *Polarstern* is a sturdy icebreaker some 120 metres in length (Europe's largest scientific vessel), which is familiar with Polar Regions.

This week has also allowed the scientists to get to know one another, between unpacking cases, setting up lab equipment and providing details of the various research missions scheduled. Among the fifty or so researchers present on board, most of them specialists in marine biology, 40 come from eight European Union countries (27 of them are from Germany), and the remaining handful represent six other non-European countries.

Here we are, studying the subject 'in the flesh'. Following our first encounter with an iceberg, we reach the ice field under a finally calm sky. At dawn, we sail through groups of ice floes, but very soon the sheet of ice covering the sea becomes more and more dense. At the same time, polar wildlife makes its appearance. We see our first chinstrap penguins and our first seal. It goes without saying that this introduction, which the researchers have anticipated for so long now, brings everyone up on deck.

Below the ice sheets, there is life

Every scientific expedition to the Antarctic stems, first of all, from lengthy preparation and coordination, necessary in order to fine-tune and coordinate the programmes for the various teams of biologists. The common global objective of this campaign is an extensive study of forms of life on seabeds that have seen little exploration to date, and which have now been 'revealed' as a result of global warming. It is the disintegration of vast ice shelves located on the fringes of the Antarctic Peninsula (jutting out towards Tierra del Fuego), which has been in progress for the last three decades, that has revealed the seabeds.

The ice shelves are vast accumulations of ice, thousands of years old, which 'overflow' from the coasts of Antarctica, to form platforms reaching out over the ocean. These extend some tens, or in some cases, hundreds of kilometres into the sea. It is from the edge of this sheet that icebergs break off.

Over the last half-century, this region of the Peninsula has experienced considerable global warming, by more than 2°C – one of the largest increases measured anywhere on the surface of the Earth. Since the 1970s, rising temperatures have therefore given rise to the gradual separation of an area of 13 500 km² into two parts, unimaginatively called *Larsen A* and *Larsen B*. Seven years after the death throes of Larsen A, the collapse of the Larsen B ice-shelf, in February 2002, became the most recent and most important of these cataclysmic events. It has uncovered a 3 250 km² area of ocean, which had been covered for at least 12 000 years by a sheet of ice two hundred metres thick. Taking scientists by surprise, this seismic event also opened up an incredible research field for biologists specialising in the marine fauna of the Antarctic.

A mine of information

'The forms of life that exist beneath the ice shelves belong to the best preserved ecosystems on the planet, given their inaccessibility,'

New coastline at Larsen B following disappearance of the ice shelf.

Large catch of siliceous sponges on the deck of the Polarstern.

Marbled rock cod brought up by the trawl.

Julian Gutt, a marine ecologist with the AWI and the senior scientist on the expedition, points out. 'Knowing which species live under the ice and how fauna is evolving now that the ice has disintegrated, provides a wealth of important scientific knowledge. And it may also serve as a barometer for identifying the effects of climate change on polar seas.'

6 January 2007. It is the end of the afternoon and one last trawl has just deposited its catch on the working deck. The first to be served are the ichthyologists, who quickly set aside the fish necessary for their studies (see box). By scraping the seabed, the trawl has, as usual, brought up other organisms – this is the by-catch – providing samples and identification work for those who specialise in *benthos* (organisms that live at the bottom of the sea). This catch is dominated by an impressive quantity of enormous siliceous sponges, and all their associated fauna.

'There are numerous small organisms which take advantage of the cavities in sponges,' Armin Rose from Senckenberg Research Institute (DE) explains: 'When dissecting these filter animals, we have found several species of copepods – a very diverse range of minute crustaceans, some of which live in symbiosis with the sponges.'

Starting with a 'state zero' ecosystem

The main aim of the *Polarstern* expedition is to provide an initial contribution to the Census of Antarctic Marine Life (CAML), the largest international biological research programme undertaken during the 2007-2008 International Polar Year (IPY). Another twelve expeditions will also take place under its auspices between now and the end of the IPY. The CAML should fill in the considerable gaps that still exist in our knowledge of marine organisms in the Antarctic. The researchers' aim is to produce a satisfactory inventory of the 'state zero' ecosystem, which is essential for being able, in the future, to detect the impact of climate change.

'In the group of amphipod crustaceans, at least 15 of the 150 species already identified on this expedition are new,' explains Cédric d'Udekem from the Royal Belgian Institute of Natural Sciences. 'That means that there are still discoveries to be made, since, in addition to the identification of species, we now need to describe their geographical distribution, their methods of reproduction, their diet, etc.'

23 January 2007. We are at one of our last harvesting stations, intended for serving as a reference for comparison with data gathered in the Larsen A and B areas, which we ●●●

The fate of the marbled rock cod

Initially, the *Polarstern* expedition concentrated on the assessment of fish stocks around the South Shetland Islands, close to the Peninsula. Russian trawlers carried out widescale commercial fishing here between the end of the 1970s and the start of the 1980s which essentially targeted two species: the marbled rock cod (or Antarctic cod) and the Antarctic ice fish. Stocks of rock cod quickly plummeted, which resulted in the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) banning fishing in this sector.

More than 20 years later, re-establishment of these stocks is still not complete, as witnessed by Karl-Hermann Kock, from the Seafisheries Institute in Hamburg: 'Catches we have obtained are still small. I believe we shall be forced to advise against the recommencement of fishing when we put forward a complete analysis of our results at the next meeting of the CCAMLR, which takes place in six months' time, at Hobart, in Australia.'

have just left after two weeks of particularly intense work. Julian Gutt's team has just launched the ROV (remotely operated vehicle), a small remotely operated submarine fitted with several video cameras and a still photo camera. After descending for some 20 minutes or so, there is amazement among the biologists waiting in front of the control screens: sponges, corals, sea anemones, starfish, and sea urchins mingle with other creatures with even more exotic names, such as *bryozoairs*, *ascidiae*, *crinoids* and *pycnogonids*, forming a complex coloured landscape that almost completely covers the sediment on the seabed, at a depth of 300 metres. What a contrast from previous dives!

A species of as yet unidentified amphipod crustacean, 10 cm in length.

Abyss sea cucumber, which is plentiful in the Larsen B area.

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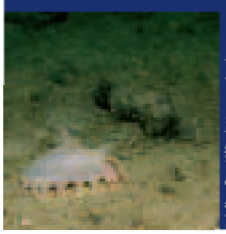
The IPF, interface between the poles and society

The International Polar Foundation (IPF) was set up to serve as an interface between science and society in the field of research devoted to the Polar Regions and the climatic changes they are undergoing. The IPF also aims to establish a new research station of ecological design at the heart of the continent of Antarctica.

It is within the framework of the International Polar Year (1 March 2007 to 1 March 2008) that the AWI, CAML, Team Cousteau and the Polar Embassy are working together, with a view to providing the maximum visibility for this *Polarstern* expedition.

www.polarfoundation.org

Launch of the remotely operated vehicle, with its video cameras.



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Lessons from the deep

Observations from the seabed, in the area where the old Larsen B ice shelf disintegrated, are very different. Here, the fauna is far less abundant, and the substrate, which is rocky or silty, is always clearly visible. Biologists were expecting this. The ice shelf, some two hundred metres thick, which existed until five years ago, prevented light from reaching the top of the water column, and therefore prevented any growth of phytoplankton (or vegetable plankton) and the zooplankton that feeds on it. It is precisely this surface community that, through its excrement and remains, normally feeds the ecosystems that exist on the seabed. Something that took researchers by surprise, however, was the presence, in Larsen B, of several species normally associated with abysses. 'We found at least one species of sea urchin, two species of *holothurides* (or sea cucumbers) and one species of *pedunculated crinoids* (or sea lilies), which are normally only found in deep waters, at a depth of 2 000 m or more,' explains Thomas Saucède from Dijon University, a specialist in echinoderms. 'It is likely that the combination of low temperatures (fluctuating around 0 °C) and the dearth of resources – with deposits only provided by lateral currents – broadly imitates the conditions encountered in abysses, which suit these species,' Enrique Isla, from Barcelona University, adds. He is a specialist in exchanges between water columns and the seabed.

But the other fundamental discovery lies in the evolution of these communities. Since the disintegration of these ice shelves, light has returned and, with it, has come the reappearance of the plankton ecosystem. Suddenly, benthoic species that are dependent on 'planktonic rain' are also returning.

At Larsen B, we observed large colonies of a pioneering, fast-growing species of *tunicata*. At Larsen A, where the ice shelf disappeared over ten years ago, even slow-growing siliceous sponges are coming back, Julian Gutt explains. 'We are therefore directly witnessing the impact of climate change, in the form of the invasion of one living community by another. Further expeditions will confirm whether, as we suspect in terms of biodiversity, the initial fauna will be completely replaced, or not, by these new arrivals.'

www.awi.de/en/home/
www.sciencepoles.org.