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Annual cycle of distribution of three ice-associated copepods along the coast near Dumont d'Urville, Terre Adélie (Antarctica)

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ABSTRACT

In polar regions sea ice is a site of enhanced primary production during winter and provides important habitat for small grazers, such as copepods. We sampled zooplankton from the sea ice and water column throughout 2005, near Dumont d'Urville station (Terre Adélie, Antarctica). Three species of ice-associated copepods were found: two calanoid copepods *Paralabidocera antarctica* and *Stephos longipes* and the harpacticoid copepod *Drescheriella glacialis*. *P. antarctica* was the most abundant of the three and was closely associated with the sea ice during most of the year. This species had a one year life cycle with a probable over-wintering period in the sea ice as nauplii and a short copepodite phase in spring. Reproduction and spawning occurred in early summer. A comparison with two other populations (near Syowa and Davis stations) along the east coast of Antarctica showed that there was a temporal shift in the life cycles of the three populations, which was linked to variability in sea ice conditions. *D. glacialis* was the second most abundant copepod and was more common during the winter than during summer, indicating its preference for the sea ice habitat. In autumn, the presence of *D. glacialis* in the deeper part of the water column suggested that this species colonised the sea ice from the benthos. *S. longipes* was found only in the water column near Dumont d'Urville and was not very abundant. In Terre Adélie particular environmental conditions, such as the absence of a permanent sea ice zone throughout the year, a longer time of open water, strong katabatic winds and the presence of polynyas, have influenced both the abundance and distribution of the three common ice-associated copepods.

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1. Introduction

Sea-ice is the dominant feature of the Antarctic marine ecosystem, covering up to 20 million km^2 at its maximum extent (Fetterer and Knowles, 2002; Comiso, 2003) (Fig. 1). The ice plays a critical role in large-scale atmospheric and oceanographic processes and, at smaller scales, provides an important habitat for many plants and animals. The interstitial spaces that form the brine channel system in sea ice provide both a refuge from predators and a foraging ground for small grazers. Ice algae can grow at very low levels of illumination and extend their growing season well beyond that of phytoplankton in the water column. For example, algae were present in measurable quantities in spring fast ice at least one month before phytoplankton appeared in the water column near Davis Station (68°35′S, 77°58′E, Fig. 1). Similarly, in autumn the growth of ice algae extended well beyond that of phytoplankton (Swadling et al., 2004). Another possible function of sea ice for small grazers is as a refuge from predation. Fish such as *Pagothenia borchgrevinki* and *Trematomus newnesi* are associated with the undersurface of ice in coastal habitats (Williams, 1988; Dewitt et al., 1990; Vacchi and La Mesa, 1995). These species occupy crevices in the ice and prey on small copepods that live in or near the under ice surface (Hoshiai et al., 1989; La Mesa et al., 2000).

The biomass of metazoan grazers found associated with sea ice is dominated by crustaceans. Small copepods are abundant within the sea ice interstices, while amphipods, copepods and euphausiids are important at the ice–water interface (Arndt and Swadling, 2006). To date, the three most frequently observed copepod species have been the calanoids *Stephos longipes* and *Paralabidocera antarctica* and the harpacticoid *Drescheriella glacialis* (e.g. Hoshiai and Tanimura, 1986; Swadling et al., 1997, 2000; Schnack-Schiel et al., 2001), and the highest abundances have been recorded from Prydz Bay (Swadling et al., 1997, 2000). Although all three species appear to have a circum-Antarctic distribution there are differences in their dominance around Antarctica. *S. longipes* dominates in the Weddell, Amundsen and Bellingshausen Seas (Fig. 1), reaching abundances up to 200,000 individuals m^{-2} (Schnack-Schiel et al., 1995, 1998), while along the coast of east Antarctica it has not been observed to exceed 20,000 individuals m^{-2}

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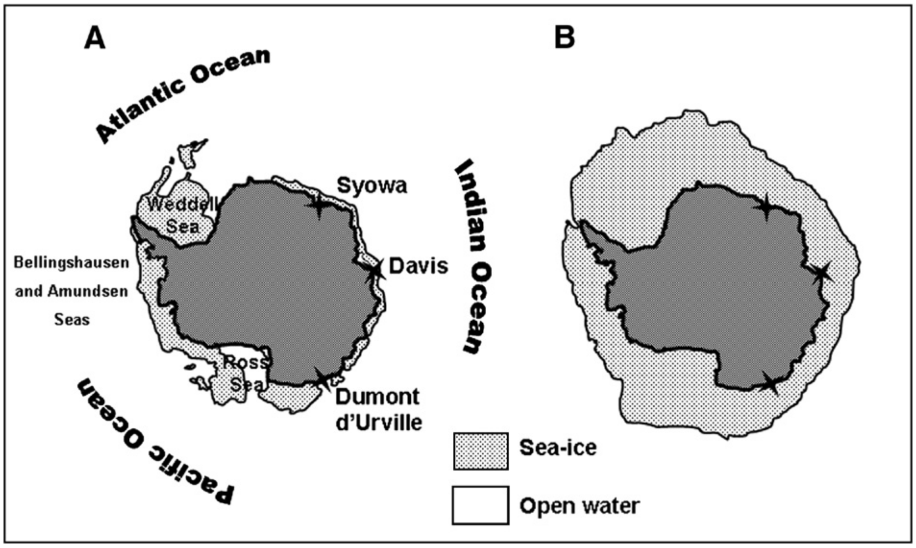

Fig. 1. Maps of sea-ice extent in January (A) and July (B) 2005 in Antarctica (ftp://sidads.colorado.edu/DATASETS/NOAA/G02135/). Shows location of places, oceans and main seas described in the text.

(Hoshiai and Tanimura, 1986; Swadling et al., 2000). *P. antarctica* is abundant in the coastal fast ice of eastern Antarctica, where its nauplii can reach up to 900,000 individuals m^{-2} (Hoshiai and Tanimura, 1986; Tanimura et al., 1996; Swadling et al., 1997, 2000). This species has been observed in much lower numbers in the Weddell Sea: up to 26,000 individuals m^{-3} were recorded from platelet ice in Drescher Inlet (Günther et al., 1999). Finally, the most widely distributed harpacticoid copepod in Antarctic sea ice is *D. glacialis*. It is common in the Bellingshausen and Amundsen Seas, the Weddell Sea and along the coast of east Antarctica (e.g. Dahms et al., 1990; Schnack-Schiel et al., 1998; Swadling, 2001, Fig. 1).

Despite the knowledge that we now have about the broadscale distribution of these key ice-associated species, there are regions where little, if any, information exists. The objective of the present study was to examine the abundance and distribution of the three species over an annual cycle along the coast of Terre Adélie (Fig. 1). The aims were firstly to document the occurrences of the copepods and secondly to compare their distribution and life cycles at this site with other regions along the Antarctic coast.

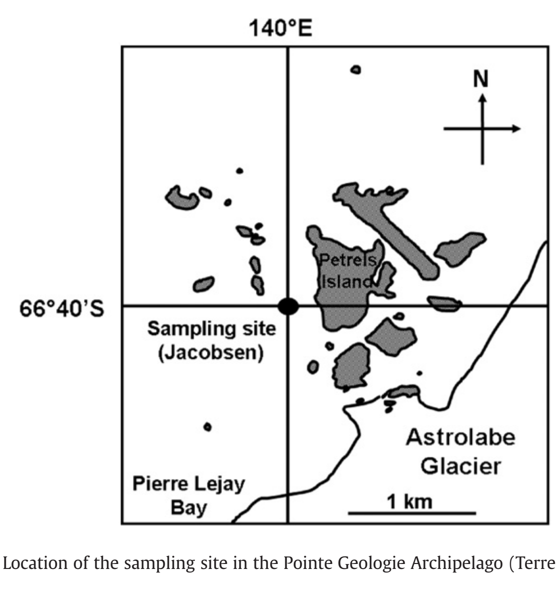

Fig. 2. Location of the sampling site in the Pointe Geologie Archipelago (Terre Adélie).

2. Materials and methods

2.1. Study site

A coastal sampling site facing Jacobsen rock on main Petrels Island (66°40 S, 140°E; Fig. 2) was chosen for the temporal survey. This site was located on the Eastern part of Pierre Lejay Bay in a small trench of 40–60 m depth running northward between the islands. The sampling site had a water depth of 41 m.

In Terre Adélie the sea-ice begins to form in mid March, when air temperatures decrease to approximately −15 °C. Sea ice growth along Terre Adélie is unpredictable as a result of variable meteorological and oceanic conditions. The region is one of the windiest in Antarctica, with frequent katabatic winds, i.e. downslope gravitational strong winds of cold air that come from the continent (Wendler et al., 1997). A maximum of 187 km h^{-1} was reached in August 2005. The occurrence of these katabatic winds means that the sea ice often breaks out frequently during the period from March to July or, in some cases, the ice just weakens, creating ice-free areas known as polynyas. Polynyas are particularly pronounced to the north of Terre Adélie. Strong winds concentrate snow into patches, which induces a rise in temperatures locally and causes the sea-ice to melt at its surface. Finally, in late spring, atmospheric depressions over Terre Adélie, combined with oceanic swell, destabilise the sea-ice even further and the ice usually breaks out by late November. During summer the archipelago is always surrounded by open water, along with icebergs that have calved from the Astrolabe Glacier (Fig. 2).

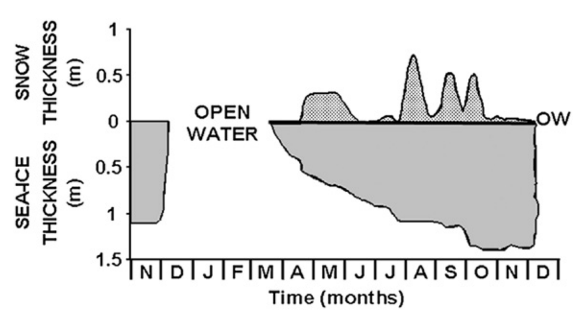

Fig. 3. Annual development of snow and sea-ice thickness at the sampling site from November 2004 to December 2005. (OW = open water).

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