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Assemblages of micronektonic fishes and invertebrates in a gradient of regional warming along the Western Antarctic Peninsula

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ABSTRACT

Micronektonic fishes and invertebrates were sampled with 32 midwater trawls at nine sites along the Western Antarctic Peninsula (WAP) in the austral fall (March–April) of 2010. Study sites were located within four hypothesized hydrographic regions: near Joinville Island in Region I, at Croker Passage, near Anvers Island, and near Renaud Island in Region II, within Marguerite Bay and the Marguerite Trough in Region III, and near Charcot Island in Region IV. A total of 62 taxa representing 12 taxonomic groups of pelagic invertebrates and 9 families of fish were captured, but assemblages were dominated by only a few species. The most numerically abundant taxa were the euphausiids, *Thysanoessa macrura*, *Euphausia superba*, and *E. crystallorophias*, combining to contribute nearly 79% of the total catch. Biomass dominants included *E. superba*, which contributed more than 44% of the total catch, the notothenioid *Pleuragramma antarctica*, and the salp, *Salpa thompsoni*. A comparison of total catches among sites revealed that the largest volumetric abundances and biomasses were captured at the Marguerite Bay site.

Cluster analysis of abundance data identified distinct multispecies assemblages at Joinville Island in Region I, Croker Passage in Region II, Marguerite Bay in Region III, and Charcot Island in Region IV. A fifth distinct assemblage included samples from sites near Anvers and Renaud Island in Region II, and from the Marguerite Trough in Region III. Assemblages at Joinville Island and Croker Passage were both dominated by *E. superba* and *S. thompsoni*, but hydrographic conditions at Joinville Island favored a neritic assemblage, underscored by substantial numbers of *P. antarctica*. The assemblage at Croker Passage was more oceanic in nature with major inputs from the myctophid, *Electrona antarctica* and the hyperiid amphipod, *Themisto gaudichaudii*. Marguerite Bay and Charcot Island were well-mixed assemblages with strong representation by both neritic and oceanic fauna. The mid-peninsula assemblage was oceanic in character, being overwhelmingly dominated by *Thysanoessa macrura* and *T. gaudichaudii*.

Pleuragramma antarctica were captured at five sites: Joinville Island, Croker Passage, Marguerite Bay, and the two sites near Charcot Island. They were completely absent at the two sites near Anvers Island, at Renaud Island, and in the Marguerite Trough. One fish was captured in Croker Passage. The majority of fish captured in Marguerite Bay were larger than 150 mm standard length (SL), with very few fish of smaller size present. If resident populations of *Pleuragramma* reproduce and recruit locally rather than being sustained by larval advection, those populations will be highly susceptible to local disappearance. This may be the causative factor behind the absence of *Pleuragramma* from the mid-peninsula region. Continued warming and subsequent sea ice reductions may not only cause *Pleuragramma* population collapses in the Marguerite Bay and Charcot Island regions, but may also change the character of the faunal assemblages along the WAP to those of an oceanic system.

1. Introduction

Three regions of the globe are undergoing recent rapid regional warming: Northwestern North America, the central Siberian Plateau, and the Antarctic Peninsula and Bellingshausen Sea (Vaughan et al., 2003). All three have exhibited significantly higher increases in mean

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annual temperature during the twentieth century than the global mean of 0.6 ± 0.2 °C (X ± SD) (Vaughan et al., 2003). On the Antarctic Peninsula, mean annual air temperatures have warmed at a rate of 3.7 ± 1.6 °C century^{-1} (Turner et al., 2005; Vaughan et al., 2003) and sea surface temperatures have increased by more than 1 °C (Meredith and King, 2005) over the past 50 years, resulting in decreased winter sea ice and a change in the timing of its advance and retreat in the WAP, specifically in the vicinity of Anvers Island (Ducklow et al., 2007). Reductions in sea ice could directly impact population dynamics of fauna which, like the silverfish *Pleuragramma antarctica* (Vacchi et al., 2004) and the krill *Euphausia superba* (Marr, 1962; Quetin and Ross, 1991) have life history stages that rely on the presence of sea ice (Clarke et al., 2007). Freshwater inputs from increased glacial meltwater may impact phytoplankton assemblages by shifting dominance from diatoms to smaller cryptophytes (Moline et al., 2004). This in turn may impact grazing efficiencies of zooplankton causing further shifts in faunal composition and distribution, e.g. the encroachment of salps and other oceanic fauna into regions previously dominated by neritic species (Atkinson et al., 2004).

Several unique physical properties of the Western Antarctic Peninsula (WAP) shelf make it one of the most productive and diverse regions in the Southern Ocean. The bathymetry of the Antarctic shelf, which is much deeper than in other oceanic systems (200–500 m vs. <200 m; Dinniman and Klinck, 2004), enhances faunal mixing by effectively removing a natural barrier to deeper dwelling oceanic fauna (Eastman, 1993). Another attribute, which is unique to the WAP shelf, is the absence of a slope front zone and its associated steep temperature and salinity gradients. In other Antarctic coastal regions, water column temperatures are uniformly cold (−2 °C), and oceanic species are excluded from the shelf (DeWitt, 1970; Donnelly et al., 2004). The WAP is the only region of the Antarctic where oceanic fishes, primarily lanternfishes (Myctophidae), are prevalent on the shelf despite their lack of biological antifreezes (Cullins et al., 2011). Hydrographic conditions on the WAP shelf are also influenced by the proximity of the Antarctic Circumpolar Current (ACC) to the shelf break. As the ACC flows northeasterly along the shelf break, it encounters deep cross-shelf troughs and depressions that allow intrusions of warm, nutrient-rich Circumpolar Deep Water (CDW) onto the shelf (Dinniman and Klinck, 2004; Klinck et al., 2004; Smith et al., 1999b) providing yet another mechanism for enhanced faunal mixing in that region.

Faunal assemblages are influenced by local circulation patterns in the WAP region. Large-scale circulation on the shelf is clockwise, driven by the northeasterly flowing ACC at the shelf break and the southward flowing coastal current (Hofmann et al., 1996). Smaller sub-gyres also exist along the WAP shelf (Fig. 1) which may limit advection and locally retain fauna, especially in inner shelf regions (Murphy et al., 2012; Piñones et al., 2011, 2013a). A primary objective of this study was to test the hypothesis that four distinct hydrographic regimes exist from north to south along the WAP continental shelf (Fig. 1) and that the

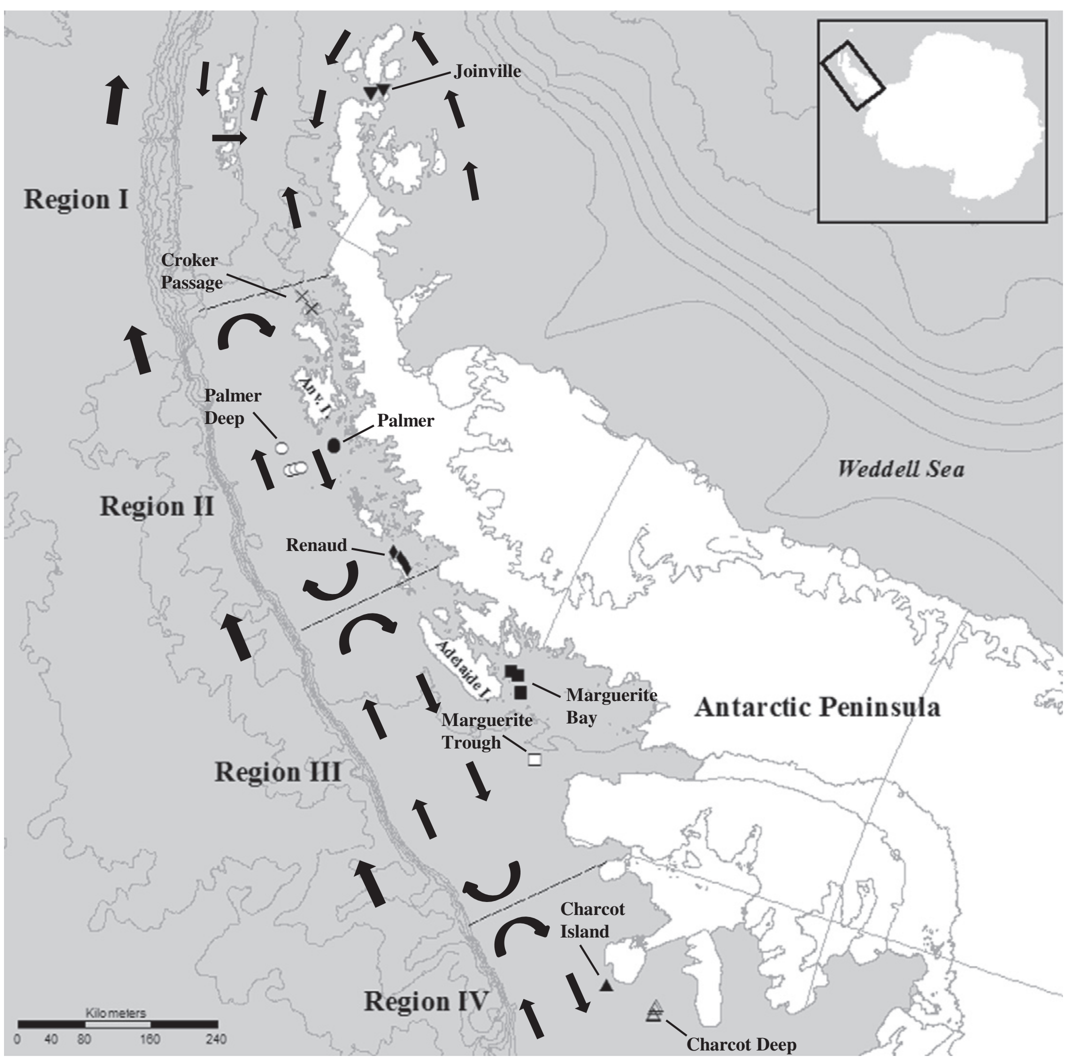

Fig. 1. Trawl, site, and region locations along the Western Antarctic Peninsula in 2010. Arrows indicate general water circulation patterns within the four regions (adapted from Hofmann et al., 1996; Piñones et al., 2011). Coastline and bathymetry data from the SCAR Antarctic Digital Database.