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Trophic interactions within the Ross Sea continental shelf ecosystem

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The continental shelf of the Ross Sea is one of the Antarctic's most intensively studied regions. We review the available data on the region's physical characteristics (currents and ice concentrations) and their spatial variations, as well as components of the neritic food web, including lower and middle levels (phytoplankton, zooplankton, krill, fishes), the upper trophic levels (seals, penguins, pelagic birds, whales) and benthic fauna. A hypothetical food web is presented. Biotic interactions, such as the role of *Euphausia crystallorophias* and *Pleuragramma antarcticum* as grazers of lower levels and food for higher trophic levels, are suggested as being critical. The neritic food web contrasts dramatically with others in the Antarctic that appear to be structured around the keystone species *Euphausia superba*. Similarly, we suggest that benthic–pelagic coupling is stronger in the Ross Sea than in most other Antarctic regions. We also highlight many of the unknowns within the food web, and discuss the impacts of a changing Ross Sea habitat on the ecosystem.

Keywords: Ross Sea; neritic food web; bio-physical coupling; ecosystem function; ecosystem structure; pelagic–benthic coupling

1. INTRODUCTION

The Ross Sea continental shelf is a unique region of the Antarctic, both with regard to its physics and its ecology. Its broad shelf (the most extensive in the Antarctic), extreme seasonality (the region being in complete darkness during winter), numerous significant polynyas, extensive ice shelf (the largest in the Antarctic, covering half of the continental shelf), and substantial vertical and horizontal exchanges provide a dynamic environment for the biota. The food web appears to be substantially different from most other areas of the Southern Ocean, which are mostly pelagic overlying a deep benthos. In addition, the climate of the Ross Sea is changing, albeit not necessarily in the same manner as that of areas like the west Antarctic Peninsula (WAP), where temperatures have increased more rapidly than anywhere else on Earth in the past 50 years (Smith *et al.* 1999). Satellite data suggest that ice extent is *increasing* in the Ross Sea region by more than 5% per decade (in comparison, the reduction in the WAP is approximately 7% per decade; Kwok & Comiso 2002), as is the length of the ice season (Parkinson 2002). However, polynyas are increasing in extent as well (Parkinson 2002). For most of the biota, the impacts of these changes are poorly known, but should the trend continue, significantly altered biological dynamics can be expected.

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2. THE PHYSICAL SETTING

The physical characteristics of the Ross Sea emphasize its unique nature (table 1). It is the largest continental shelf region in the Antarctic, but owing to the isostatic response of the continent to the mass of the ice cap, it remains relatively deep (mean depth is approx. 500 m). The shelf break occurs at approximately 800 m, with the slope reaching 3000 m. The currents on the Ross Sea continental shelf are characterized by a gyre-like circulation (figure 1). This circulation also extends under the ice shelf, although the details of the under-shelf circulation are poorly known. The water that exits is substantially cooled and modified, with potential temperatures less than -2°C (the extreme temperature is possible due to the reduction in the freezing point with increased pressure). Most currents are coherent throughout the entire water column, and substantial seasonal variability in current velocities occurs (Dinniman *et al.* 2003). The deep canyons at the shelf break affect the deep circulation and facilitate intrusions of modified circumpolar deep water (MCDW) onto the shelf.

Much of the Ross Sea's physical oceanography is dominated by the presence of a large area of reduced pack ice cover surrounded by denser ice concentrations, the Ross Sea polynya. In winter, the polynya is formed by strong katabatic winds from the south that advect ice to the north. In turn, cold air temperatures drive significant ice formation, and the resultant fresh water removal creates cold, salty and therefore dense water that sinks, driving convective overturn. Aperiodic intrusions of MCDW also provide heat that increases ice ablation at the surface. Few oceanographic studies