A Modelling Approach to the Ross Sea Plankton Ecosystem

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ABSTRACT

A conceptual and numerical model adapted to the local plankton ecosystem (ECOHYDROMVG) has been developed on the basis of the information acquired during various oceanographic cruises in the Ross Sea. The construction of the biological/physical coupled 1-D model of the upper water column ecosystem is presented. The model takes into account the control of the plankton ecosystem by ice cover, ice edge dynamics, atmospheric forcing and surface circulation, nutrients being non-limiting factors. Ice-edge thickness, retreat and melting determine the initial conditions for the spring bloom (ice algae concentration, vertical structure of the water column) and allow the biological processes of primary production in the water column to start. The combined effects of wind and solar irradiance determine the depth of the upper mixed layer and quantitatively control photosynthetic levels.

In this approach, biological variables are limited to diatoms, *Phaeocystis* and smaller cells, depending on local conditions. Grazing activity forcing by *Euphausia superba*, copepods, *Limacina helicina* and amphipods control the phytoplankton variables.

The model is used to determine a standard state of the Ross Sea plankton ecosystem and numerical results accurately simulate the vertical stabilization of the water column within the Ross Sea marginal ice zones during the ice-melting period, and the biological structure of the upper layers. It simulates primary production and the selection of the type of phyto- and zooplankton communities. It is applied to local situations controlled by different wind conditions, ice cover and initial content of ice algae, and accurately reproduces field observations.

Introduction

The productivity and biodiversity of the Southern Ocean ecosystem is to a large extent determined by the specific environmental features of the Seasonal Ice Zone. As shown by satellite images, highest plankton productivity is associated to that area (Comiso 1991) in the marginal ice zone where ice algae are released by ice melting and where the stabilization of the water column enhances productivity (Smith and Nelson 1985). The maximum phytoplankton bloom and ice-algae releasing occurs during the ice-melting period when radiation and photoperiod are highest. This melting process which releases a variable quantity of ice algae induces especially a stabilizing surface buoyancy flux, a subsequent decrease of the mixed layer depth and an increase of plankton production (Sullivan et al. 1988; Ackley and Sullivan 1994).

The food web in the Southern Ocean is unique among ocean ecosystems in that it is characterized by the dependence largely, in many areas, of a single key species, the Antarctic krill (*Euphausia superba*), which can strongly limit diatom standing stocks. Like many species of the food web, krill depend on sea ice during some or all of their life history and on hydrodynamical processes on a larger scale (Priddle et al. 1988).

The ring shape around the polar continent, isolation by circumpolar fronts, zonal transport by strong circumpolar currents coupled with the seasonal changes in the light regime and sea-ice cover impose a relative homogeneity in species composition and the concept of a Southern Ocean Seasonal Ice Zone Ecosystem has been suggested

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