Abstract

Phytoplankton concentration in the fall and winter is a crucial parameter to estimate food availability for krill larvae during periods of ice coverage west of the Antarctic Peninsula (March to August). Field sampling indicates a dynamic exchange between ice formation and decay and suspended algae resulting in cells being entrained into ice to become the sea ice microbial community (SIMCO). Due to the inability to estimate chlorophyll via remote sensing during periods of low sun angle, we propose modeling as the best tool to estimate phytoplankton during this time period. We have modeled chlorophyll from a primary production based on irradiance, photosynthetic efficiency and daylength for areas along the Peninsula, Marguerite Bay (68°S) and Anvers Island (64°S). The model was parameterized with estimates of photosynthesis vs. respiration, euphotic zone depth and biomass concentration obtained during the 2001 and 2002 Southern Ocean Globec and Palmer LTER field seasons (See Data and Results). Larval krill grazing can consume fall phytoplankton biomass at mid shelf but not in Marguerite Bay (Table1).

Introduction

The fall season is critical to phytoplankton dynamics in coastal Antarctic waters (Figure 1). Shortening days and decreasing irradiance (Figure 2), increasing storminess and ice formation combine to decrease the input, and maximize the loss, in phytoplankton photosynthesis and accumulation. It is a transition period between maximum solar irradiance in December and January (18-24 h) and the short days or darkness characteristic of winter (0-4 h). High phytoplankton biomass in the austral summer decreases to a low of 0.01-0.2 mgChla m⁻³ in fall and winter (Figure 3a,b). Primary production is consistently low, from 136 mgC m⁻³ d⁻¹ to only 1.6 mgChla m⁻³ d⁻¹, attributed to low chlorophyll concentration and low incident irradiance as photosynthetic potential maximum photosynthetic rate is high, 1.1 mgChla L⁻¹ h⁻¹ (Figure 4).

Data and Results

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Model

Fall and winter phytoplankton biomass and primary production were collected in 2001 and 2002 at Palmer Station, Anvers Island (64°S, 64°W) and on the shelf off Marguerite Bay (68°S). The model was parameterized with irradiance in situ, daily incremental changes of temperature, chlorophyll and krill larvae abundance. The model was validated by comparing the model predictions with two sets of field data: net phytoplankton growth and cell number (Mag Bay IV GUV) and krill larvae abundance (2001 SO GLOBEC). Fall and winter phytoplankton concentration and temperature. Primary Production estimated in April is 800-1,000 mgC m⁻³ d⁻¹ and in May at 1,000-1,200 mgChla m⁻³ (see Figure 3a,b). Phytoplankton abundance were obtained from 2001 SO GLOBEC study (Allchin et al., 2004) and are considered maximum abundance for the region.

The life history of Euphausia superba, the Antarctic krill, and a key species in the food web of the Southern Ocean ecosystem, is intricately involved with seasonal sea ice dynamics. The correlation found between sea-ice cover in the winter and population size suggests that the life history of krill is an important determinant of krill population size (Palmer et al., 1982). Antarctic krill release their embryos during the austral summer, and the larvae develop into juveniles during the following 11 mo (Ikeeda 1984). During the winter, food in the water column is scarce (Smith et al., 1996), and the low starvation tolerance of the larval krill necessitates an alternate food source. Over a decade ago, several investigations (e.g. Daly 1994) suggested that krill microalgal communities (SIMCOs) might be an essential food resource for winter survival, but both behavioral and physiological evidence continues to support this concept (e.g. Marshall 1988, Frazer et al. 2002).

References

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Modeling phytoplankton biomass (chlorophyll a) during fall and winter of 2001 and 2002 at 64° and 68°S in coastal waters west of the Antarctic Peninsula

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Table 1 - Grazing estimates by krill larvae affect phytoplankton fall biomass at mid shelf but not in Marguerite Bay. Krill larvae (F4) grazing estimates based on situs temperature, grazing rates as a function of temperature (Ross and Quetin, in preparation), estimated phytoplankton biomass of 1 to 2 mgChla m⁻³. It is assumed that krill feeds during light hours (12 h of daylight) and that the efficiency of grazing is only dependent on phytoplankton concentration and temperature. Primary Production estimated in April is 1,120-1,060 mgC m⁻³ d⁻¹ and in May at 890-1,200 mgChla m⁻³ (see Figure 3a,b). Phytoplankton abundance were obtained from 2001 SO GLOBEC study (Allchin et al., 2004) and are considered maximum abundance for the region.

Data and Results

Phytoplankton decline is calculated from phytoplankton consumption corrected for in situ growth.