SeaWiFS satellite derived measurements of chlorophyll-a in the Scotia Sea: spatial and interannual variability of phytoplankton blooms

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Introduction

The Scotia Sea is a High Nutrient Low Chlorophyll region which experiences intense summer phytoplankton blooms. The average depth is greater than 2000m with a complex bathymetry due to ridges, plateaus and islands. The ACC flows through the region carrying a uniquely high nutrient content. Continental shelves may supply the current with iron, thus enhancing spring and summer primary productivity. A synoptic study of such a vast region is possible only via satellite imagery, although winter darkness does not allow measurements between April and July; nevertheless, remote sensing remains for this region the key observational tool where weather and sea-state conditions strongly limit high resolution in-situ measurements.

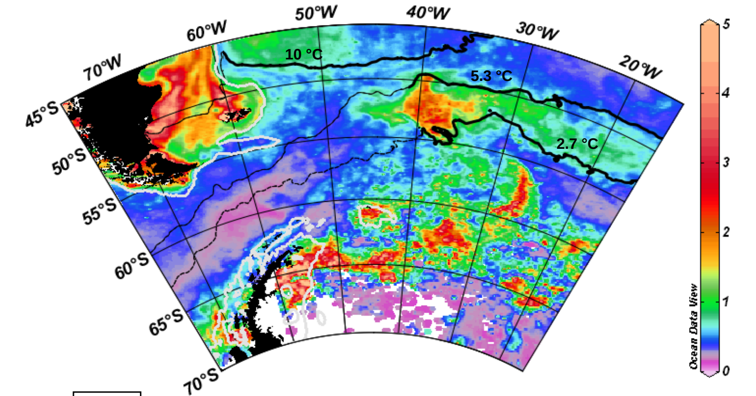


Fig. 1 **Climatological average of SeaWiFS derived Chl-a for December. SST and 500m bathymetry contours.** SST contours (black solid line) are derived from Aqua-MODIS satellite measurements. They confine the plume extending east of the South Georgia island. The western limit and the shape of the intense bloom (>2mg/m^3) north of South Georgia appears to be regulated by circulation patterns, as pictured and explained in Figure 2. The 500m bathymetry contour (white solid line) limits the extension of the Argentine bloom (Chl-a >4mg/m^3) as well as the one around the Antarctic Peninsula. The standard deviation of the climatological average for December is pictured in Figure 3c. *Units are mg/m^3.*

Methods

SeaWiFS estimates of surface Chl-a were obtained from the Goddard Distributed Active Center. Level-3, monthly composites at 9 km resolution were retrieved for the period between January 1998 and December 2007. Each monthly Chl-a image was combined into a climatological average, and the standard deviation was then calculated. Satellite Aqua-MODIS SST were also retrieved, at 4Km resolution.

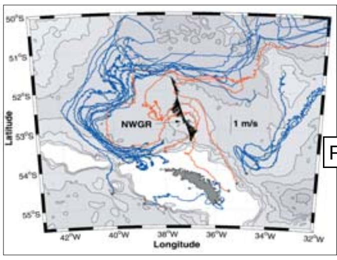


Fig. 2 **Trajectories of surface drifters around the South Georgia Basin**. The trajectories of these drifters, drogued at 20 and 50m, track local circulation patterns; the shape of the bloom north of the island (Figure 1) appears to behave similarly, remaining confined within the basin.
The image is taken from Meredith *et al.* (2003) GRL, vol. 30 , n. 20.

Seasonal and inter-annual variability

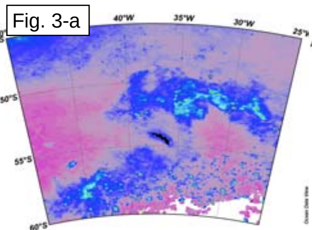
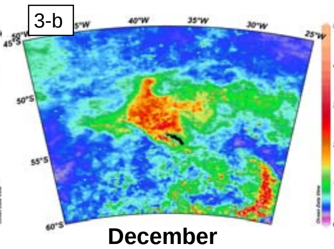
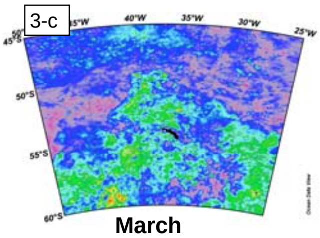


Fig. 3-a September



3-b December



3-c March

SeaWiFS derived Chl-a concentration - Seasonal variability. Climatological averages of September, December, and March show the seasonal evolution of blooms. The bloom north of S. Georgia is taken as an example. Chl-a starts increasing in August/September especially along shallower bathymetries and reaches its maximum in December.
Colorbar is equal for all images. Chl-a units are mg/m^3.

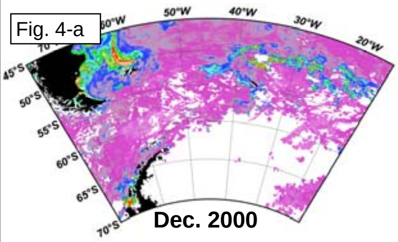
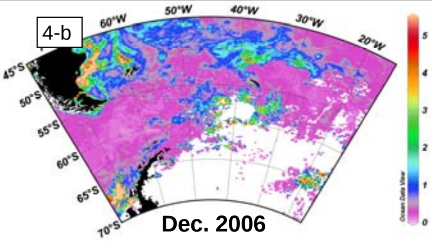
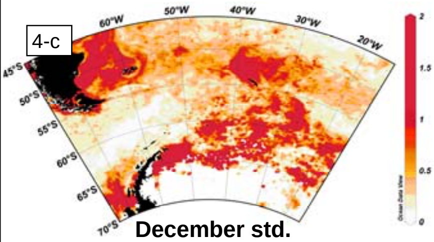


Fig. 4-a Dec. 2000



4-b Dec. 2006



4-c December std. deviation

SeaWiFS derived monthly composites of Chl-a. Two examples of interannual variability: Dec. 2000 and Dec. 2006. December 2000 appears to experience a much lower productivity than the climatological average (Fig. 1) while December 2006 is closer to it. Fig. 4-c shows the standard deviation of the measurement: in red are highlighted the regions with greatest interannual variability. In white are missing values (clouds and/or sea-ice cover).
Colorbar is equal for all images. Chl-a units are mg/m^3.

A case of constant low productivity

The Shackelton Fracture Zone. Climatological average of December vs. its relative error. This region shows constant low Chl-a concentration even in austral summer. The ridge acts as a barrier to the ACC, deflecting the Southern ACC Front westward. The relative error shown in Fig. 5-b (calculated as the standard deviation of all December values divided by the climatological mean), confirms that this phenomenon shows no interannual variability. Its occurrence is possibly regulated by the circulation of the ACC which appears to be poor in micronutrients (i.e. iron).
Chl-a units are mg/m^3.

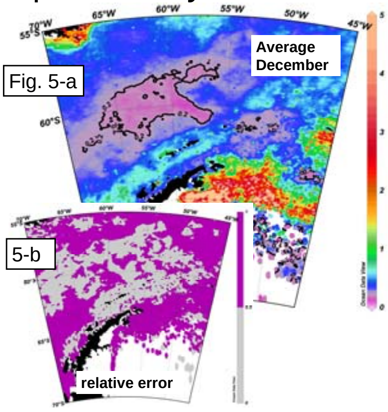


Fig. 5-a Average December

5-b relative error

Conclusions

- ❖ A 10-year long time series of Ocean Color Data shows strong annual variability in the Scotia Sea region, especially close to coastal and island ecosystems.
- ❖ Little variability is found upstream the Drake Passage, east of the South Sandwich Islands, and in the region surrounding the Shackelton Fracture Zone where productivity is kept low.
- ❖ Sea Surface Temperature contours, shelf regions and circulation patterns may control bloom extension and distribution.
- ❖ Seasonal increase of productivity generally occurs in August/September reaching its maximum extent and intensity in December.
- ❖ Cloud cover, sea ice extent, and light conditions sensibly limit data coverage. Analysis of ocean color images needs to be limited to the period included between August and March.