PRIMARY PRODUCTION PROCESSES IN THE ROSS SEA (ANTARCTICA): LIMITING FACTORS AND SYSTEM CARRYING CAPACITY

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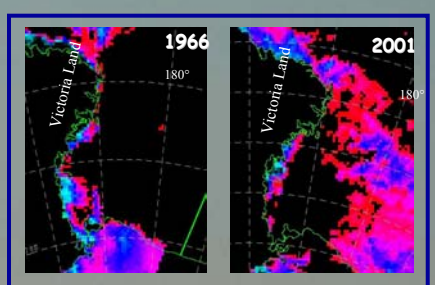
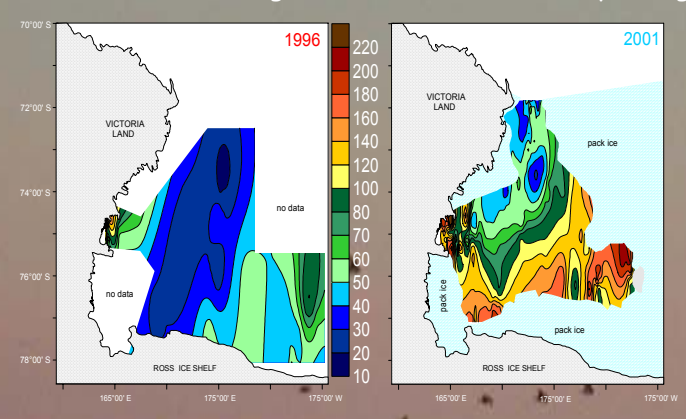
Antarctica with the study area

The Ross Sea is one of the most productive areas of the Southern Ocean, with pronounced seasonal variations in phytoplankton biomass and production. Highest values of primary production are recorded in austral spring till early summer. Two oceanographic campaigns were carried out in the Ross Sea in summer 1996 and 2001. Major differences in environmental conditions characterized the two campaigns. In particular, in 1996 the entire offshore area was free of ice and in 2001 extensive ice coverage occurred.
We present micro- and macro-nutrient concentrations, spectrofluorometric Chl*a*, HPLC pigments, primary production, P*vs*E (14C) experiments and Fast Repetition Rate Fluorometer (Fast Tracka) profiles.



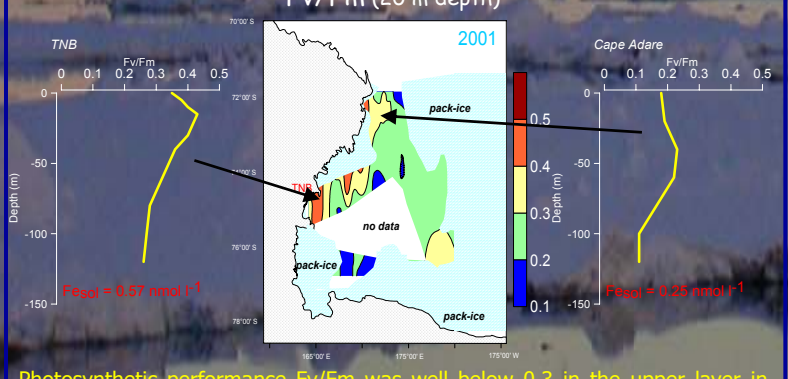
Satellite ice maps

Chl*a* distribution, integrated over the 0-100m layer (mg m^{-2})

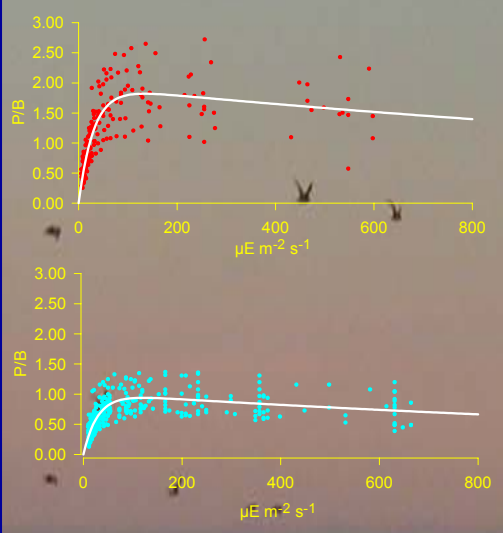


Biomass concentrations were two- to fivefold, on average 2.5 times over the 0-100m layer, in 2001 as compared to the 1996 recordings. Diatoms dominated phytoplankton populations over the entire Ross Sea in both years. Fucoxanthin (HPLC) was by far the predominant pigment, in general Fuco/Chl was > 0.5. In both campaigns, nitrate and phosphate were never limiting, >10 µmol l-1 and >1 µmol l-1, respectively.

Fv/Fm (20 m depth)

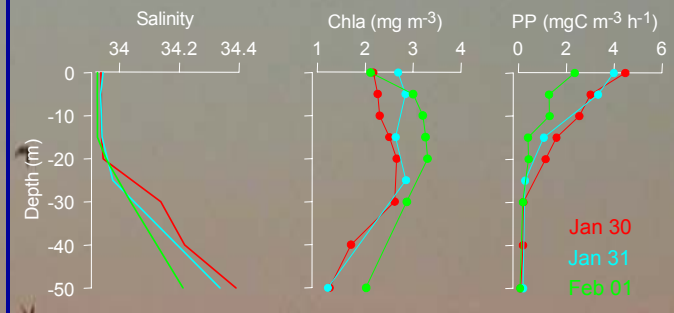


Photosynthetic performance Fv/Fm was well below 0.3 in the upper layer in offshore MIZ areas indicating iron limitation. Higher iron concentrations, > 0.5 nmol l^{-1}, and Fv/Fm > 0.3 was recorded in the coastal area of Terra Nova Bay.

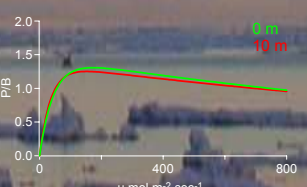


	P^B_{max}	α	β	E_k
1996	1.18	0.054	0.0004	22
2001	0.94	0.035	0.0004	26

PvsE experiment (24 stations in 1996; 30 stations in 2001 at 3-4 depths) showed similar photoacclimation index (E_k) but higher photosynthetic capacity in 1996 as compared to 2001. The low P^B_{max} values recorded in 2001was in sharp contrast to the considerably higher biomass concentrations in the extensive MIZ areas.
In addition, minor variations in P^B_{max} values between stations and depths were recorded in 2001 while greater spreading occurred in the 1996 experiments. This may be related to the relatively deep mixed layer in ice free waters and, as a result of ice melting, the presence of a shallow upper mixed layer and a strong stratification in 2001.



The SW area is reported as one of the most productive areas of the Ross Sea and this area was furthermore a MIZ in 2001.
Replicate sampling over three days showed an increment of biomass accompanied by a decrease in primary production for the subsurface layers.



	P^B_{max}	α	β	E_k
	1.32	0.032	0.0007	41
	1.28	0.037	0.0006	35

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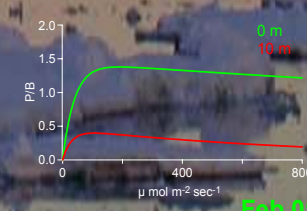

	P^B_{max}	α	β	E_k
	1.35	0.036	0.0003	38
	0.46	0.015	0.0005	31

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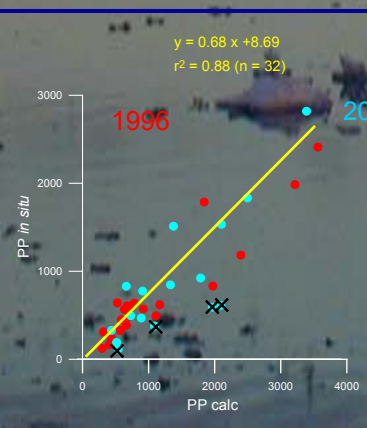
P*vs*E experiments conducted at two days interval showed similar values at surface and a sharp depression of photosynthetic capacity at 10m depth. Macronutrient concentrations did not change; unfortunately, micronutrient measurements were not performed.



An excellent correlation was found between primary production as measured *in situ* and calculated from mean Chl*a*, daily irradiance and photosynthetic parameters determined for different Ross Sea areas. Four data points were cancelled, corresponding to high biomass and low production values recorded in the SW Ross Sea in 2001.

Mean values of integrated Chl*a* and primary production in coastal and off-shore waters

1996 / 2001	Chl*a* mg m^{-2}	mgC m^{-2} d^{-1}	PP/Chl*a*
North	16 / 39	188 / 479	12 / 12
South -West	13 / 82	200 / 707	15 / 9
South-East	30 / 80	600 / 1100	20 / 14
Coastal waters (TNB)	73 / 90	1410 / 1562	20 / 17

Biomass concentrations were higher all over the Ross Sea in 2001 as compared to the 1996 values. In the Northern area, PP/Chl*a* ratio was similar in both years resulting in PP values 2.5 times those recorded in 1996. For all other areas the PP/Chl*a* ratio was lower in 2001 and minimum growth capacity was recorded in the SW ice edge area. Only minor differences were observed in the coastal area, indicating non-limiting condition.

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Concluding remarks:

extensive ice coverage in summer 2001 was associated with very high biomass concentrations. In sharp contrast, low photosynthetic capacity of phytoplankton populations were recorded thus indicating release of microalgae from the melting sea ice rather than in situ growth. Iron limitation, as shown by low iron concentrations and low Fv/Fm ratios, constrained algal growth in the pelagic realm and extensive phytoplankton blooms could not be sustained in the Ross Sea in summer. An increase in ice coverage has been observed in the Ross Sea over the last decades. If this holds true, production and accumulation within the pack ice, where iron limitation do not occur, would increase the carrying capacity of the system as a whole, enhancing atmospheric C drawdown.

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