Carbon dioxide production rates in the Ross Sea (Antarctica)

Maurizio Azzaro[1], Leonardo Langone[2], Giovanna Maimone[1], Rosabruna La Ferla[1]

[1]*Institute for Coastal Marine Environment (IAMC) of Messina, CNR (National Research Council), Italy;
[2] Institute for Marine Science, (ISMAR) of Bologna, CNR, Italy.
* CORRESPONDENCE: Dr. Maurizio Azzaro (maurizio.azzaro@iamc.cnr.it)

Microbial respiratory activity in several sites of the Ross sea was studied in the framework of the Italian National Research Programme in Antarctica (PNRA), with the aim of evaluating the biological pump efficiency and the carbon flux transported by microbes throughout the water column.

Recent studies have demonstrated that dissolved organic carbon (DOC) is an important component of the biological pump that assumed in the deep waters a key role as main organic fuel of microbial respiration (1, 2). Such evidence seem overturned in the Southern Ocean, where Wiiebinga and De Baar (3), by estimates of apparent oxygen utilization and DOC, asserted that DOC pool accounted for < 10 % of the remineralization in deep waters. Another study demonstrated (4) that the euphotic zone of the Ross Sea yielded only a small portion of primary production as DOC (11%), so that DOC removal by deep convection could be not an important export term due to the small quantity of DOC that accumulates there. Furthermore other authors (5), also by sedimet trap studies, suggested that very little organic remineralization occurred between 250m and the bottom of the Ross Sea, which implies a rapid delivery and/or reduced bacterial remineralization.

The purpose of this study was to investigate the supply and utilization of organic carbon in the aphotic zone of the Ross Sea by evaluation of microplankton respiratory activity and to compare the vertical carbon balance to different estimates of export production from the same area and other oceanic regions.

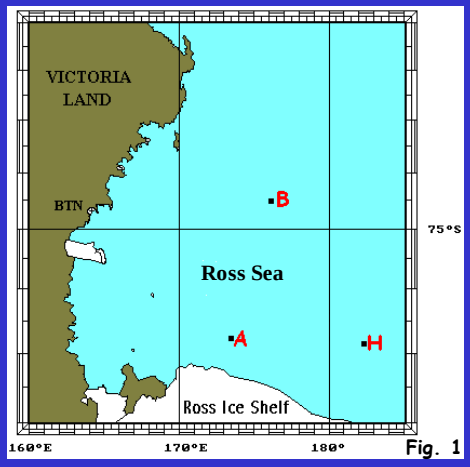

Fig. 1

In the context of the ABIOCLEAR project an oceanographic cruise was carried out (January-February 2005) in three sites of the Ross Sea (Fig. 1).

Microbial respiratory activity (<200μm) was determined according to the ETS (Electron Transport System) assay and converted to carbon dioxide production rates (CDPR) using the factors described in Christensen et al. (1).

Details on oceanographic cruise and procedures of water sampling are indicated in Azzaro (2005; 6). The samples were immediately stored in liquid nitrogen until assayed in the laboratory (<3 months). The results were converted to in situ temperature using the Arrhenius equation (activation energy – 11 kcal mol^{-1}).

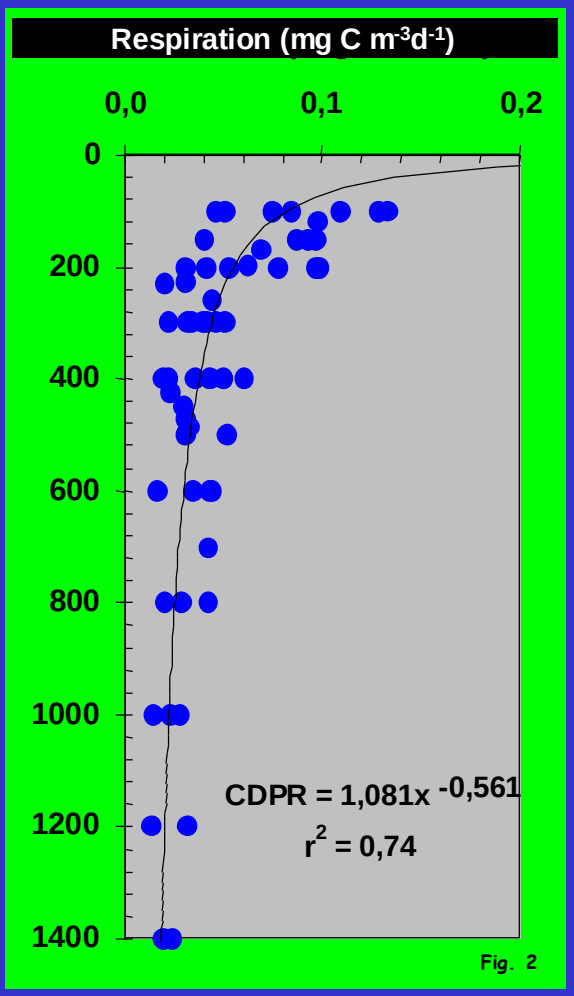

Fig. 2

ETS results were converted in oxygen utilization rate (OUR) and then in CO_2 production rate (CDPR) using the conversion factors reported by Packard et al. (1988; 7). The ETS data points versus depth are shown in figure 2 together with the curve computed for the Ross Sea. Microplankton ETS activity ranged from 0.012 to 0.139 μl O_2 m^{-3}h^{-1} on a volume basis in the layer between 100 and 1400m. ETS-based CDPR calculated in the Ross Sea, decreased with depth according to the power function:

$$CDPR\ (mg\ C\ m^{-3}\ g^{-1}) = 1.081 \times Z^{-0.561} \qquad (r^2=0.74\ n=73)$$

The depth-integrated CDPR calculated by the above power function, amounted to 25.8 mg C m^{-2}d^{-1} in the depth range 100-1000 m. Our CDPR later-summer estimates were enclosed in the range of ETS-derived $CDPR_{(200\text{-}1000m)}$ (21.8-105.6 mg C m^{-2}d^{-1}) determined in the Indian sector of the Southern Ocean during early spring (8), but was 2,5 fold lower of their averaged CDPR.

Finally comparing CDPR determined in this study with that obtained by sediment traps in the Ross Sea (9) it resulted that about 63% of organic carbon remineralized by respiration derived from POC pool (Fig. 3). Such a large percentage should be considered too high observing that derived from a daily sediment trap study based on an annual research, while CDPR study regarded two months amounts and neglected the remaining poorer months of year.

Future studies on remineralization and the fate of organic matter of the Ross Sea must primarly asses the amount of POC and DOC exported and oxidized in the deep sea and must furthermore highlight the relationship between the very low flux of carbon through the DOC pool in the euphotic zone and the very high percentage of POC pool oxidized in the aphotic zone as registered in this study.

POC or DOC as source of water-column remineralization?

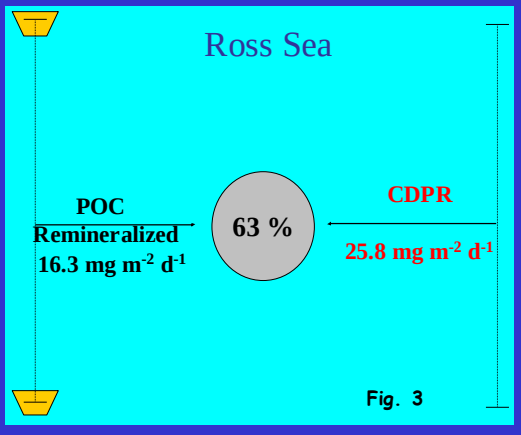

Fig. 3

REFERENCES

1-Christensen J.P., Packard T.T., Dartch F.Q., Minas H.J., Gascard J.C., Richez C., and Garfield P.C., 1989. Carbon oxidation in the deep Mediterranean sea: evidence for dissolved organic carbon source. Global Biogeochemical Cycles, 3:315-335.
2-Lefèvre D., Denis M., Lambert C.E., and Miquel J.C., 1996. Is DOC the main source of organic matter remineralization in the ocean water column? Journal Marine Systems, 7:281-291.
3-La Ferla R., and Azzaro M., 2001. Microbial respiration in the Levantine Sea: evolution of the oxidative processes in relation to the main Mediterranean water masses. Deep Sea Research I, 48: 2147-2159.
4-Wiebinga C.J., and de Baar H.J.W., 1998. Determination of the distribution of dissolved organic carbon in the Indian sector of the Southern Ocean. Marine Chemistry, 61: 185-201.
5-Carlson C.A., Hansell D.A., Peltzer E.T., and Smith W.O.Jr., 2000. Stocks and dynamics of dissolved and particulate organic matter in the Southern Ross Sea, Antartica. Deep Sea Research II, 47: 3201-3226.
6-Azzaro, 2005. Rapporto sulla Campagna Antartica, estate australe 2000-2001, XVI spedizione ANT 01/01.
7-Packard T.T., Denis M., Rodier M., and Garfield P., 1988. Deep-ocean metabolic CO2 production: calculations from ETS activity. Deep Sea Research I, 35: 371-382.
8-Arístegui J., Denis M., Almunia J., and Montero M.F., 2002. Water-column remineralization in the Indian sector of the Southern Ocean during early spring Deep Sea Research II, 49: 1707-1720.
9-Nelson D.M. DeMaster D.J., Dunbar R.B., and Smith W.O.Jr., 1996. Cycling of organic carbon and biogenic silica in the Southern Ocean: estimates of large-scale water column and sedimentary fluxes in the Ross Sea. Journal Geophysical Research, 101: 18519-18532.

Acknowledgements
The study was carried out in the framework of the ROME, CEFA and ABIOCLEAR projects. We are grateful to the technical staff of IAMC-CNR Messina: Mr. Alessandro Cosenza, Mr. Michele Furnari and Mr. Enrico Armeli Minicante.