LONG-TERM MONITORING OF ANTHROPOGENIC IMPACTS FROM THE BRAZILIAN ANTARCTIC STATION "COMANDANTE FERRAZ" (KING GEORGE ISLAND): ISOTOPIC ANALYSIS OF C AND N

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Thais Navajas Corbisier, Sandra Bromberg, Paula Foltran Gheller,
Maria Cláudia Yuri Ujikawa, Mônica Angélica Varella Petti

Instituto Oceanográfico, Departamento de Oceanografia Biológica, Universidade de São Paulo – USP,
Praça do Oceanográfico 191, CEP 05508-120 São Paulo, SP, Brazil

*e-mail: tncorbis@usp.br

Abstract: *Stable isotopic analysis has been used for assessing anthropogenic influence in marine communities. The variation of stable C and N isotope signatures in sources of organic matter and benthic invertebrates was investigated at the nearshore zone in front of the Brazilian Antarctic Station (EACF - Estação Antártica Comandante Ferraz) (Martel Inlet), to attend a long-term monitoring program. Suspended organic matter (SPM), the algae Desmarestia, sediment, and selected invertebrates of different trophic levels (suspensivore, depositivore, grazer and carnivore) were sampled in the subtidal zone (up to 25m) in three summers since 2000/01. The $\delta^{13}C$ values for consumers ranged from -26.70 (Laternula elliptica) to -12.34‰ (Nacella concinna), and the $\delta^{15}N$ from 2.86 to 10.71‰ (L. elliptica and Parborlasia corrugatus, respectively). Linear regression lines fitted to the data (R > 69%), and there were differences between the sampling periods. The results suggested some influence of the sewage organic matter on benthic communities in the coastal area near the Brazilian Station, mainly in the first summers analysed, and a slight increase towards the end of the summer.*

Keywords: Stable Isotopes, Benthic Communities, Long Term Monitoring

Introduction

Stable isotopes have been utilized to trace the transference of organic matter of different origins along the trophic web (Peterson, 1999). The isotopic signatures in consumer tissues are, in general, related to the isotopic composition of their diet, occurring an enrichment of heavy isotopes, *e.g.* of carbon ($^{13}C/^{12}C$) and nitrogen ($^{15}N/^{14}N$) around 1‰ and of 3-4‰, respectively, between the consumer and its food (Peterson & Fry, 1987). The carbon and nitrogen ratios (expressed as $\delta^{13}C$ and $\delta^{15}N$) are generally utilized to indicate the organic matter source and the $\delta^{15}N$ the trophic level, as well.

Eutrophication or increased load of organic matter in marine nearshore environments can be attributed to anthropogenic inputs of sewage effluents. Stable-carbon or stable-nitrogen isotope analysis are also becoming useful to identify the source, extent and the fate of biologically available sewage carbon and nitrogen (Peterson, 1999; Costanzo *et al.*, 2001; Waldron *et al.*, 2001; Gartner *et al.*, 2002; Rogers, 2003). Scientific and logistic activities in Antarctica have introduced anthropogenic compounds in otherwise pristine areas (Martins *et al.*, 2005). Sewage isotopic signatures of C or N have already been detected in sediment and in some benthic organisms near McMurdo Station (Conlan *et al.*, 2006).

The influence of sewage, aliphatic hydrocarbons (AHs) and polycyclic aromatic hydrocarbons was observed only near the sewage outfall close to the Brazilian station (EACF).

Their presence was detected within a distance of 200 m in the water column and of 400 m (human sterols) and 700 m (hydrocarbons) in the sediment. Nonetheless, the dispersion of the sewage plume in the shallow coastal zone of Martel Inlet is favored by the hydrodynamics, mainly influenced by the tides. As a result, the contamination in Admiralty Bay is assumed to be punctual and restricted to the proximities of EACF, especially concerning the sewage outlet (Martins *et al.*, 2005; Bicego *et al.*, 2009).

The area in front of EACF, which is slightly influenced by sewage and oil, showed significantly lower $\delta^{13}C$ values for some invertebrates than other reference areas in Martel Inlet (Corbisier *et al.*, unpublished).

We analyzed the variation in the isotopic signature of selected benthic organisms to verify if there was anthropogenic influence off the Antarctic Brazilian Station (sewage and hydrocarbons), in four summer periods, since 2000/2001. These trophic web studies using stable isotopes were part of studies done in the summers of 2000/2001 (Bromberg, 2004), 2003 (Network 2 - Weber & Montone, 2006) and 2005/2006 (INCT-APA programs). More recent data, from the summer of 2010/2011, will be included in future comparisons.

Materials and Methods

Water, macroalgae (*Desmarestia* sp), sediment and invertebrates of different trophic levels (suspensivore *L. elliptica*, depositivore *Sterechinus neumayeri*, grazer *N. concinna* and carnivores *Paraserolis polita* and *P. corrugatus*) were sampled at the subtidal zone (up to 25m) off the Brazilian Station (EACF), under the sewage outfall influence area, in Dec/2000-Jan/2001, Nov-Dec/2003, Nov/2005 (beginning of summer), and Feb/2006 (end of summer) (Figure 1).

The benthic samples were obtained on board of the R/B SKUA, using a van Veen grab, a dredge, or by Scuba diving. Surface water samples for suspended particulate organic matter (SPM) analysis were obtained with bottles. Methods followed those of a previous study (Corbisier *et al.*, 2004) with the addition of the $\delta^{15}N$ analysis. The stable isotope measurements were performed by the Stable Isotope Facility of the Department of Agronomy and Range Science, Davis, California, USA, using a Europa Hydra 20/20 isotope ratio mass spectrometer. Stable isotope ratios are expressed in δ notation as part per thousand (‰) according to the following relationship:

$$\delta X = [(R_{sample}/R_{standard}) - 1] \times 10^3$$

where X = ^{13}C or ^{15}N, and R = $^{13}C/^{12}C$ or $^{15}N/^{14}N$ (Peterson and Fry, 1987). The standard reference for carbon is Pee Dee Belemnite (PDB) and atmospheric N_2 for nitrogen.

Dispersion graphics and linear regression lines were made considering $\delta^{13}C$ and $\delta^{15}N$ mean values (or single values) of sources and consumers in order to verify long term variations.

Results

The R values for $\delta^{13}C$ and $\delta^{15}N$ data linear regressions were high for the sampling periods (> 69%) showing that the data fitted to a linear model (Figure 1).

There was a tendency of increasing $\delta^{13}C$ values and decreasing $\delta^{15}N$ values from 2000/2001 to 2005 in the beginning of summer (Figure 1). Data from the end of summer in 2006 were intermediate between 2000/01 and 2005.

Discussion and Conclusion

In front of the Brazilian station (EACF), the set of $\delta^{13}C$ and $\delta^{15}N$ values for some selected components of the community differed between the four sampling summer periods, which could suggest that there had been a temporal variation in contribution of sewage organic matter since 2000/2001. The material originated from sewage has usually low $\delta^{13}C$ (Peterson, 1999; Waldron *et al.*, 2001; Rogers, 2003; Conlan *et al.*, 2006). The $\delta^{15}N$ values for sediment under the sewage influence are more enriched and can be related to a higher ammonia concentration of anthropogenic origin (Peterson, 1999; Waldron *et al.*, 2001; Conlan *et al.*, 2006).

The differences between the summer periods in EACF suggest a decrease of sewage contribution to the benthic community from past summers to more recent ones, and a slight increase of its influence towards the end of the summer.

In the summer of 2010/11 a new sampling, including the sewage, was undertaken directing the monitoring of Admiralty Bay in the scope of INCT-APA program. For a better understanding of the anthropogenic influence, the

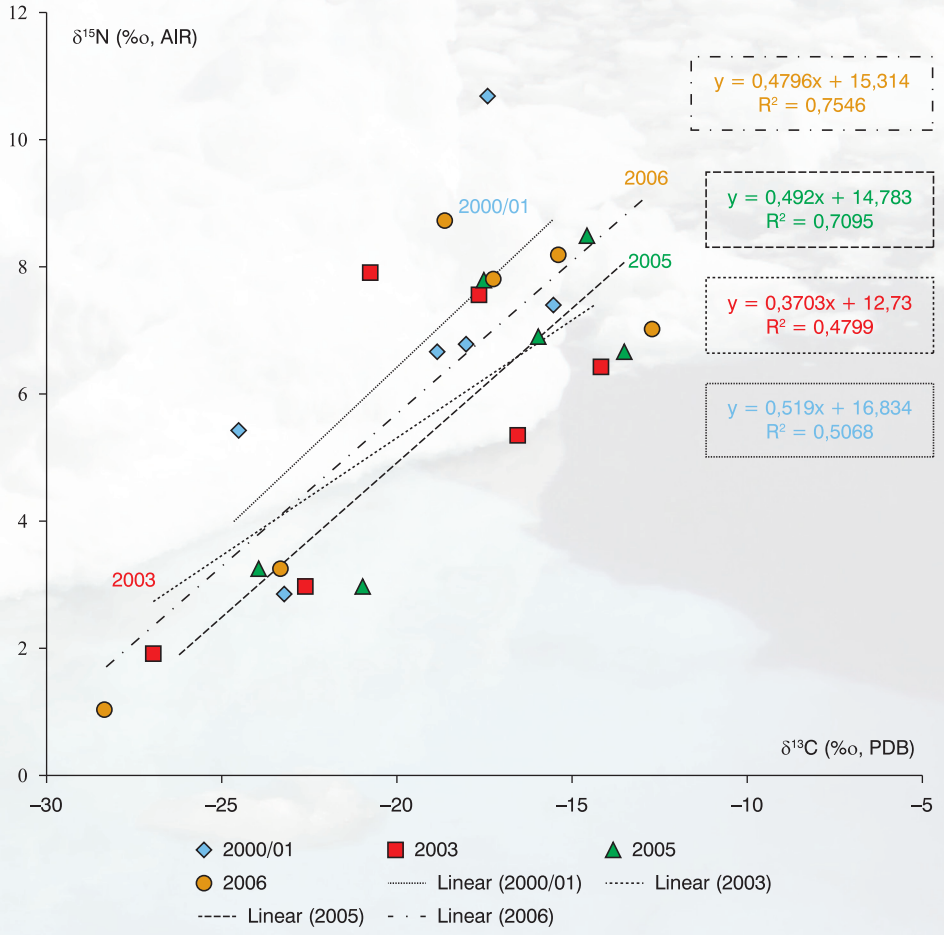

Figure 1. Linear regression lines for $\delta^{13}C$ and $\delta^{15}N$ data from four sampling summer periods.

isotopic signatures of more areas, periods and different organisms need to be analyzed in Admiralty Bay.

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References

Bicego, M.C.; Zanardi,-Lamardo, E.; Taniguchi, S.; Martins, C.C.; Silva, D.A.M.; Sasaki, S.T.; Albergaria-Barbosa, A.C.R.; Paolo, F.S.; Weber, R.R. & Montone, R.C. (2009). Results from a 15-year study on hydrocarbon concentrations in water and sediment from Admiralty Bay, King George Island, Antarctica. Antarctic Science, 21(3): 209-220.

Bromberg, S. (2004). A macrofauna bentônica da zona costeira rasa e o seu papel na trama trófica da enseada Martel, Baía do Almirantado (Ilha Rei George, Antártica). Ênfase para o grupo Polychaeta (Annelida). Tese de Doutoramento, Universidade de São Paulo, Instituto Oceanográfico.

Conlan, K.E.; Rau, G.H. & Kvitek, R.G. (2006). ^{13}C and ^{15}N shifts in benthic invertebrates exposed to sewage from McMurdo Station, Antarctica. Marine Pollution Bulletin, 52(12): 1695-1707.

Corbisier, T.N.; Petti, M.A.V.; Skowronski, R.S.P. & Brito, T.A.S. (2004). Trophic relationships in the nearshore zone of Martel Inlet (King George Island, Antarctica): ^{13}C stable isotope analysis. Polar Biology, 27(2): 75-82.

Costanzo, S.D.; O'Donohue, M.J.; Dennison, W.C.; Loneragan, N.R. & Thomas, M. (2001). A new approach for detecting and mapping sewage impacts. Marine Pollution Bulletin, 42(2): 149-156.

Gartner, A.; Lavery, P. & Smit, A.J. (2002). Use of ^{15}N signatures of different functional forms of macroalgae and filter-feeders to reveal temporal and spatial patterns in sewage dispersal. Marine Ecology Progress Series, 235: 63-73.

Martins, C.C.; Montone, R.C.; Gamba, R.C. & Pellizari, V.H. (2005). Sterols and fecal indicator microorganisms in sediments from Admiralty Bay, Antarctica. Brazilian Journal of Oceanography, 53(1-2): 1-12.

Peterson, B.J. (1999). Stable isotopes as tracers of organic matter input and transfer in benthic food webs: A review. Acta Oceanologica, 20(4): 479-487.

Peterson, B.J. & Fry, B. (1987). Stable isotopes in ecosystem studies. Annual Review of Ecology and Systematics, 18: 293-320.

Rogers, K.M. (2003). Stable carbon and nitrogen isotope signatures indicate recovery of marine biota from sewage pollution at Moa Point, New Zealand. Marine Pollution Bulletin, 46(7): 821-827.

Waldron, S.; Tatner, P.; Jack, I. & Arnott, C. (2001). The impact of sewage discharge in a marine embayment: a stable isotope reconnaissance. Estuarine, Coastal and Shelf Science, 52(1): 111-115.

Weber, R. R. & Montone, R. C. (Coord.) (2006). Rede-2: Gerenciamento ambiental na Baía do Almirantado, Ilha Rei George, Antártica. Relatório final. Ministério do Meio Ambiente/ CNPq/SeCIRM/Proantar, Brasil. 255 p.