An international effort to manage and monitor Admiralty Bay (ASMA No. 1), King George Island, Antarctica

M. J. Borbor-Cordova,[1] T. Brito,[2] R. Montone,[3] P. Gagliuffi,[4] and M. Riofrío[5]

[1]National Center for Atmospheric Research & Instituto Antartico Ecuatoriano, P.O. Box 3000, Boulder, CO 80303, USA. (mcordova@ucar.edu)
[2]Ministério do Meio Ambiente, Esplanada dos Ministérios, Bloco B, Sala 713, 70680-900, Brasilia, Brazil.(tania.brito@mma.gov.br)
[3]University of Sao Paulo, Instituto Oceanográfico, Praça do Oceanográfico, 191- 05508, Sao Paulo, Brazil (rmontone@usp.br)
[4]Instituto Antártico Peruano, Jr. Miroquezada 191 - 5to Piso, Lima, Perú. (pgagliuffi@rree.gob.pe)
[5]Instituto Antártico Ecuatoriano, Blvd. 9 de Octubre 416, 4to piso, Of.402, Guayaquil, Ecuador. (riofrio_monica@hotmail.com)

Summary Admiralty Bay, the largest bay of King George Island in the South Shetland Archipelago, Antarctica, was formally adopted as an Antarctic Specially Managed Area (ASMA No. 1) by the Antarctic Treaty Consultative Meeting XXIX, in 2006. Brazil, Ecuador, Peru, Poland, and the U.S.A. have active research programs in this Area. In summer 2007, the ASMA Management Group, with representatives from the five countries, met in Admiralty Bay to: initiate coordinated activities, undertake an *on-site* review, discuss the actions related to the Management Plan and further develop a 10-year joint monitoring program. Thirty years of continuous research carried out in the Area has revealed significant ecological changes. Increasing human local activities have also contributed to environmental changes. Coordination of activities will help to minimize potential impacts. This paper summarizes the main activities related to the implementation of a management plan for Admiralty Bay and the steps towards a joint environmental monitoring program.

Citation: M.J. Borbor-Cordova, T. Brito, R. Montone, P. Gagliuffi and M. Riofrio (2007), An international effort to manage and monitor Admiralty Bay (ASMA No. 1), King George Island, in Antarctica: A Keystone in a Changing World – Online Proceedings of the 10th ISAES X, edited by A.K. Cooper and C.R. Raymond et al., USGS Open-File Report 2007-1047, Extended Abstract 184, 4 p.

Introduction

The geographic isolation of Antarctica enhances its value for climate change research because the continent remains relatively free from anthropogenic impact (Callaghan et al., 1992). However, even small climatic shifts and local human activities (research and tourism) have a significant impact on the biological habitats and ecology of the Antarctic ecosystem (Melick and Seppelt, 1997; Vincent, 1997; Weber & Montone, 2006).

Admiralty Bay, the largest Bay of King George Island (KGI), South Shetland Archipelago, is characterized by a magnificent glaciated mountainous landscape, varying geological features, rich seabird and mammal breeding grounds, diverse marine ecosystems, and terrestrial plant habitats. In this area, human activity started as early as 1819 with early explorers and hunters of whales and seals (Gurney, 1997). Scientific research has continued for about 30 years based at the Polish Henryk Arctowski Station, at the Brazilian Comandante Ferraz Station, and at the field camp Copacabana (former Pieter Lenie) of the U.S.A. Antarctic Program. Research activities at the Peruvian Machu Picchu Station (at Crepin Point) and at the Ecuadorian refuge República del Ecuador (at Hennequin Point) have occurred intermittently during summer in the last 20 years (ATCM XXX/IP 111, 2007). Despite the high density of scientific activity (in 9 research stations) in the island, there was no integration of scientific information into a systematic multidisciplinary framework to study trends of cumulative impact caused by human activities (local and regional).

In 2006 Admiralty Bay was formally adopted as an Antarctic Specially Managed Area (ASMA No. 1) by ATCM XXIX to improve the level of mutual assistance and co-operation among Parties operating in the Area; avoid or minimize the risk of mutual interference and cumulative impacts on the terrestrial and marine environments; manage potential or actual conflicts of interest between different activities, including science, logistics and tourism; improve the understanding of natural processes, to protect the environment from unnecessary disturbance; protect important physiographic features, and the outstanding biological, ecological, historical and aesthetic values; and safeguarding the long-term scientific research in the Area.

Characteristics of Admiralty Bay (ASMA No 1)

ASMA No. 1 covers an area of 362 Km^2 that includes ice cover (165 Km^2), land free of ice, and the bay (135 Km^2) (Weber & Montone, 2006) (Fig 1). Meteorological conditions of the area are controlled by cyclonic systems originating in the Bellingshausen Sea, which generate high cloudiness and warm temperatures (Stezer & Hungria, 1994; Rakusa-Susczewski, 2005). The annual mean temperature is -2.8^oC, with a mean of 0.9^oC during summer and -7^oC during winter (Ferron et al, 2004). The relative humidity mean is above 80%, with about 500 mm of annual precipitation (Rakusa-Susczewski, 2005). The geological substrate of this site is conformed by sedimentary rocks covered by volcanic rocks from the Jurassic and Cenozoic (Birkenmajer, 2001). The glaciers morphology may be characterized in three types; soft glaciers whose mass is structured in form of ice cliffs and discharged as ice walls, glaciers sitting in short and narrow valleys with high slopes, and the glaciers that end up in land free of ice, presenting moraines deposits in their cover front (Bremer, 1998; Simoes, 2004).

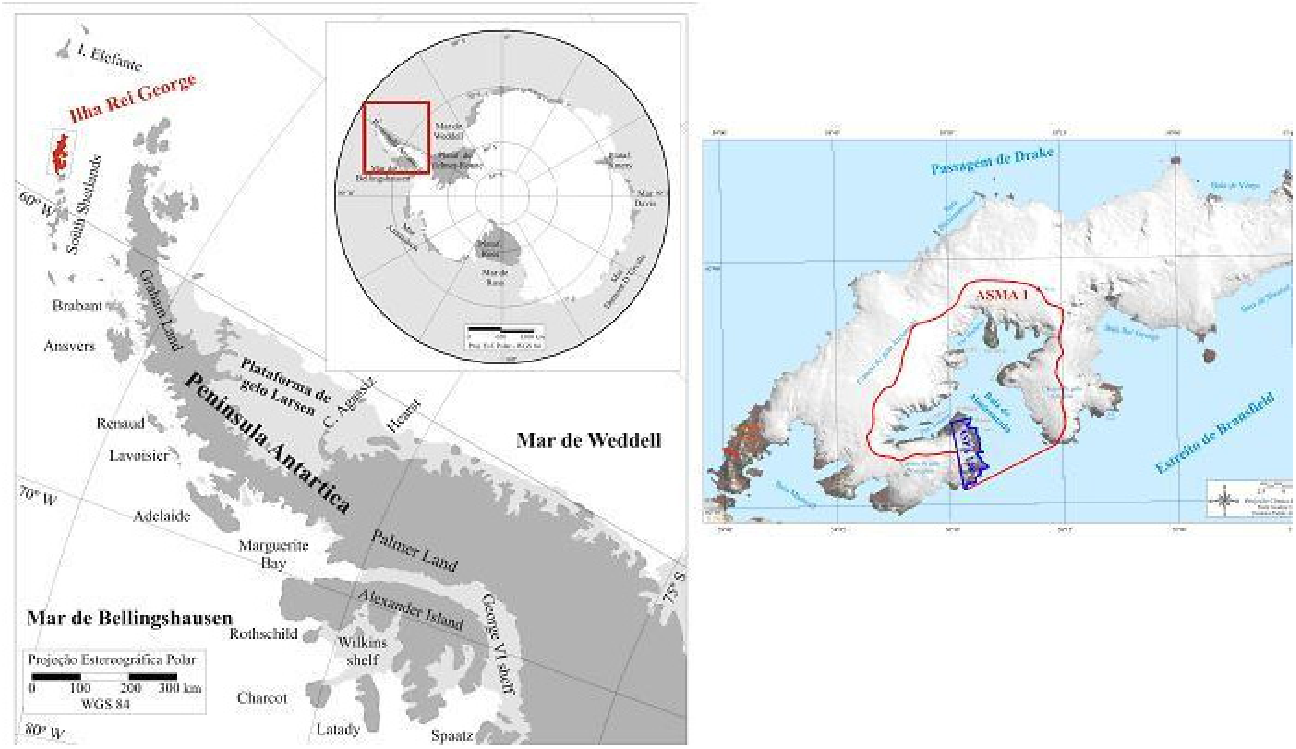

Figure 1. Location of King George Island and Admiralty Bay (ASMA No 1).

Ecological studies: Some main findings

Research developed in this site has included a diversity of scientific disciplines and country participants. Long term ecological studies have revealed significant quantitative changes and specific trends in the system's variability Rakusa-Scuszczewski et al, 2005; ATCM XXX/IP 111, 2007; Robinson et al., 2003). The ice-free areas have enlarged threefold during the last 20 years, creating conditions for inhabitation and succession (Olech and Masalkim, 2001; Robinson, 2003). The number of penguins has decreased in the area, the Adelie (*Pygoscelis adeliae*) and chinstrap penguins (*Pygoscelis antarctica)* found an overall decline by roughly 57% in the last 30 years (Hinke et al. in preparation; Sander et al., 2007; Naveen et al., 2000) the population of gentoo penguin (*Pygoscelis papua*) decreased 62% since 1977 (Ciaputa and Sierakowsky, 1999). The numbers of fur seals change in multi-annual cycles. The abundance of elephant seals has kept stable, whereas those of Weddell and crabeater seals has declined (Salwicka and Sierakowsky, 1998)

Long term monitoring of atmospheric and air temperature records undertaken by Brazilian researchers has revealed an increase in the mean air temperature of 1.1 ^{o}C from 1956 to 2000 (Ferron et al., 2004). This increase in temperature has been associated with a 12% frontal glacier retreat during the same period (Arigony, 2001). Polish scientists have observed, in the King George Island, a retreat of the valley-type tidewater glaciers front by 1 km since 1956 which has occurred against a background of climate warming by 1.4°C, while the Larsen glacier advanced by 0.6 km and the northern ice-cap margin on KGI was approximately stationary (Macheret and Moskalevsky, 1999). Retreat of glaciers in the middle and outer parts of Admiralty Bay has exposed new ice-free coastal areas suitable for breeding grounds of some species of seals (Simoes et al., 2004; Birkenmajer K., 2002).

Due to warmer temperatures, winter sea-ice duration in the region is shortening (Parkinson, 2002) impacting spawning and nursery areas of krill (*Euphausia superba).* The decrease in krill population has been found to coincide with an increase in salps (*Salpa thompsoni*) in lower-latitude groups with lower food requirements (Atkinson, 2004; Loeb, 1997). These changes among key species have profound implications for the food web of the KGI. Penguins, albatrosses, seals and whales have wide foraging ranges but are prone to krill shortage (Sander, 2007; Naveen et al., 2000; Fraser & Hoffman, 2003). Thus, strong correlations between indices of penguin and krill recruitment suggest that penguins may live under an increasingly krill-limited system that has disproportionate effects on the survival of juvenile birds (Hinke et al., in preparation).

Human activities and impacts at Admiralty Bay

The effects caused by human activities have been studied and monitored by the stations according to their environmental management plans and specific research themes. Some changes have been observed in the terrestrial areas, especially in the Facilities Zones, such as the diversity and abundance of fauna and flora (Weber & Montone, 2006; ATCM XXX/IP 111, 2007, Oleech & Massaleski, 2001). There has been a decline in breeding areas of flying birds in the region, especially those of the giant petrel (*Macronectes giganteus*), whose population has been reduced almost completely in some areas (Weber & Montone, 2006; Jablonski, 1986; Bugoni et al., 2004). Conversely, the populations and breeding areas of opportunistic and predator birds, such as skuas (*Catharacta maccormicki)* and kelp gulls, have increased considerably (Mascarello et al., 2004; Weber & Montone, 2006). However, it is no clear if human activities have contributed to such changes.

The main potential sources of pollution in the Bay are the by-products of the burning of oil (emissions) into the marine environment and into the atmosphere (Leal et al. unpublished); and sewage discharge into the sea from the scientific stations. In the marine environment, minimal local changes in the benthic community structure near the station have been identified, indicating that the impact from human activities on the benthic system is still minor and related to organic enrichment in the food web. In general, natural processes, such as anchor ice and ice-scours, rather than anthropogenic processes, are still the main cause of environmental changes in this system (Weber & Montone, 2006; ATCM XXX/IP 111, 2007).

Despite the fact that human impact is still a minor problem in Admiralty Bay, being restricted to the surroundings of stations, it is important to consider that this is a site of increasingly diverse human activities, which are continuously growing and becoming more complex. Better planning and coordination of existing and future activities will help to avoid or to reduce the risk of mutual interference and minimize environmental impacts, thus providing an effective mechanism for the conservation of the valuable features that characterize the area.

The Management Plan and the strategy for a monitoring plan

The Management Plan of ASMA No 1 established a Management Group, with representatives from Brazil, Ecuador, Peru, Poland and U.S.A. to oversee and coordinate activities in Admiralty Bay. The group identified as main priorities: the development of an on-site review to define the baseline information; the identification of current relevant ecological, historical and scientific values; the investigation of cumulative impact, trends and changes in the environment; the standardization of methodology, indicators and parameters for the Monitoring Program; the sharing of information on activities conducted in the area; the enhancement of collaboration for the International Polar Year; and finally the dissemination of information on environmental and scientific activities in the area. An initial Matrix of Environmental Indicators (EI) was developed using the framework of Pressure-State-Response (UNESCO, 2006) that would be applied in the Monitoring Programme.

The second meeting of the Management Group was held in Admiralty Bay, King George Island, Antarctica, in January, 2007. An on-site review was undertaken based on the checklist for inspections recommended in the Resolution 5, 1995 (ATCM XIX, Seoul) and on a draft checklist for inspecting protected areas in Antarctica proposed by New Zealand, the United Kingdom and the U.S.A. at the Committee of Environmental Protection IX. The main conclusions from the field survey were that ecological, historical and scientific values were still relevant, although some changes on ecological sites have been observed. Fauna concentrations and breeding areas have varied. Human activities and infrastructures of the stations generate environmental impacts at different levels, being the most evident the noise pollution, generated by power generation. Wastewater discharged from the sewage treatment plants of the stations has still a low impact in the biochemistry of the surrounding marine area. The impact is chronic, local and very restricted in range (maximum 200m from the shoreline). However, it was recommended that a permanent monitoring program be created to track any ecological changes in the surrounding area of the outflow. Finally, the solid waste generated by the stations is classified before final disposition and transportation. The organic combustible wastes are burned in incinerators provided with filters to reduce harmful emissions. The solid residue of such incineration is removed from the site, together with all the other solid wastes, which are compacted and adequately stored for transportation. Monitoring of emissions into the atmosphere of the Bay, discriminating local anthropogenic sources from those coming from South America (regional), has been highly recommended (Field Survey, 2007; ATCM XXX/IP 111, 2007).

The review of the state of the environment and the preliminary matrix of EI developed in previous meetings by scientists of Brazil, Ecuador and Peru were presented to representatives from Poland and U.S.A., partners in the management of ASMA No 1, and was further developed. The EI include a number of biophysical parameters to assess air quality, soil conditions, fresh and sea water quality, sediment pollution, vegetation distribution and abundance, and wildlife health. To evaluate the impact of anthropogenic activities, the EI would include ecological footprint, fuel consumption, aircraft/vehicle operation, solid and liquid waste generation, wastewater volume and components, noise level, stations population, number of field activities, Environmental Impact Assessment (EIA)/permits compliance, and introduced organisms. The EI are considered logistically feasible within a time frame appropriate for each parameter (annual, biannual, quinquenial). The systematic of long-term monitoring, with detailed information, resources and timetable of activities is in preparation and the monitoring programme is to be implemented in 2008.

Summary

The establishment of the ASMA No 1, and the interaction among the countries at the site, has definitely improved the level of mutual assistance and co-operation among parties. This is crucial for the successful implementation of the Environmental Management Plan and of the long term joint Monitoring Program.

Acknowledgments. We thank A. K. Cooper and C. R. Raymond co-editors of this extended abstract. We are especially thankful to the Brazilian Antarctic Program, the Instituto Antártico Peruano and the Instituto Antártico Ecuatoriano for the logistical support to develop the first on site review at Admiralty Bay.

References

Arigony Neto J. (2001), Determinacao e interpretacao caracteristicas glaciologicas e geograficas como sistema de informacao geografica na Area Antartica Especialmente Gerenciada Baia do Almirantado. Tesis de Maestrado en Sensoramieto Remoto (UFRGS-CEPSRM) Porto Alegre, pp85.

Atkinson A., Siegel V., Pakhomov E. and Rothery P. (2004), Long-term decline in krill stock and increase in salps within the Southern Ocean. Nature, Vol 432, pp 100-103.

ATCM XXX Information Paper 111, (2007). A Monitoring Programme for the Admiralty Bay Antarctic Specially Managed Area (ASMA Nº 1) In: Antarctic Treaty Consultative Meeting, 30th New Delhi, April, 30 – May, 11, 2007

Birkenmayer K. (2001), Mesozoic and Cenozoic stratigraphic units in part os the South Shethland Islands and Nothern Antarctica Peninsula.

Geological Research of the Polish Antarctic Expedition. Part XIII Studia Geol. Pol. 118: 7-188.

Birkenmajer K. (2002), Retreat of Ecology Glacier, Admiralty Bay, King George Island (South Shetland Islands, West Antarctica), 1956-2001

Bulletin, Polish Academy of Sciences: Earth Sciences, 50 (1): 5-19, and from unpublished data by K. Birkenmajer.Bremer F.P. (1998), Morfologia e baicas de drenagem da cobertura da gelo, da Ihla Rei George, Antarctica. Dissertation de Maestrado en Sensoramieto Remoto (UFRGS-CEPSRM) Porto Alegre , pp119.

Bugoni L., Sander M., Costa E. (2004), Inland displacement and mortality of the Atlantic Petrel. Third International Albatross and Petrel Conference, Montevideo, 2004.

Callaghan TV, Sonesson M, Somme L (1992), Response of terrestrial plants and invertebrates to environmental change at high latitudes. Philosophical Transactions of the Royal Society of London, 338, 279–288.

Ciaputa P. and Sierakowsky K. (1999), Long term population in Adelie, Chinstraps and Gentoo penguin in the region SSS No 8 and SSS No 34, King George Island, Antarctica. Polish Polar Res. 20: 355-365.

Fraser, W. R. & Hofmann, E. E. (2003), A predator's perspective on causal links between climate change, physical forcing and ecosystem response. Mar. Ecol. Prog. Ser. 265, 1−15.

Ferron F. A. , Simoes J.C., Aquino F.E. and Setzer A. (2004), Air temperature time series for King George Island, Antarctica. Pesquisa Antártica Brasileira 4: 155-169

Gurney A. (1997), Below the Convergence: Voyages Toward Antarctica, 1699-1839. W.W. Norton & Company, New York. 315 pages

Hinke J. T., Salwicka K., Trivelpiece S. G., Watters G. M., Trivelpiece W. Z. (In preparation). Divergent responses of Pygoscelis penguins reveal common environmental driver.

Leal, M. A.; Licínio, M. V; Joppert, M.; Dias da Cunha, K.; Evangelista, H.;Geiza Medeiros; Maldonado, J.; Dalia, K.C.; Lima, C.; Barros Leite, C.V.; Correa, S. M., (unpublished paper, 2007), Atmospheric Impacts due to Anthropogenic Activities in Remote Areas: The Case Study of Admiralty Bay, King George Island, Antarctic.

Loeb, V. Siegel, V., Holm-Hansen, O., Trivelpiece, W. and Trivelpiece, S. (1997), Krill and salp dominance in the Antarctic food web. Nature 387: 97-900.

Macheret, Y.u.Y.a.; Moskalevsky, M.Y. (1999), Study of Lange Glacier on King George Island, Antarctica. Annals of Glaciology, Volumen 29, Number 1 pp. 202-206(5)

Melick DR, Seppelt RD (1997), Vegetation patterns in relation to climatic and endogenous changes in Wilkes Land, continental Antarctica. Journal of Ecology, 85, 43–56.

Oleech M. and Massaleski (2001), Plan vegetative development along colonization gradient on glacier moraines. (Maritime Antarctic). VIII SCAR International Biology Symposium, Amsterdam. S2P14.

Naveen, R., Forrest, S. C., Dagit, R. G., Blight, L. K., Trivelpiece, W. Z., and Trivelpiece, S. G. (2000), Censuses of penguin, blue-eyed shag, and southern giant petrel populations in the Antarctic Peninsula region, 1994-2000, Polar Record 36 (199): 323-334.

Parkinson, C. L.(2002), Trends in the length of the Southern Ocean sea-ice season, 1979−99. Ann. Glaciol. 34, 435−440.

Rakusa and Scuszczewski et al, 2005. Book "The Coastal and Shelf Ecosystem of Maritime Antarctica. Admiralty Bay, King George Island. Collected Reprints. Polish Academy of Sciences. Warsaw University Press. Warsaw, 2005. 683pp

Robinson S.A. ,Wasley A., Tobin A. (2003), Living on the edge - plants and global change in continental and maritime Antarctica. Global Change Biology 9 (12), 1681–1717.

Sander Martin, Coelho Balbão M.J. Polito, E.S. Costa and A. Bertoldi Carneiro (2007), Recent decrease in chinstrap penguin (Pygoscelis antarctica) populations at two of Admiralty Bay's islets on King George Island, South Shetland Islands, Antarctica. Polar Biology 30:659-661.

Simões, J.C ., Dani, N., Bremer, U.F., Aquino, F.E., Arigony Neto, J. (2004), Small cirque glaciers retreat on Keller Peninsula, Admiralty Bay, King George Island, Antarctica. Pesquisa Antártica Brasileira 4, 49-56.

Stezer & Hungria (1994), Meteorologia na Peninsula Antartica. Alguns aspectos practicos. Insituto Nacional de Pesquisas Espacias (INPE). Sao Jose do Campos, Sao Paolo, Br.

UNESCO (2006), A handbook for measuring the progress and outcomes of integrated Coastal and Ocean Management. IOC Manuals and guides, 46, ICAM Dossier, 2. Paris UNESCO. 217p.

Vincent WF (1997), Polar desert ecosystems in a changing climate: a north–south perspective. In: Ecosystem Processes in Antarctic Ice-Free Landscapes (eds Lyons WB, Howard-Williams C, Hawes I), pp. 3–14. Balkema, Rotterdam, The Netherlands.

Weber, R. and Montone, R.C. (coords), (2006). REDE 2: Gerenciamento ambiental na Baía do Almirantado, Ilha Rei George, Antártica. Brasília, Ministério do Meio Ambiente/CNPq/SECIRM/PROANTAR. 255 p