Cybercartographic Atlas for the Antarctic Project

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Chapter.
Climate Variability and Global Warming impact on Antarctic Ecosystem structure and functioning.

Argentinean -Belgian Cooperation

Argentina - Centro Nacional Patagónico (CENPAT-CONICET)

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1- INTRODUCTION

On an annual basis, the Antarctic seasonal pack-ice zone is the most productive zone in terms of phyto- and zooplankton biomass (Hempel 1985, Brierley et al. 2002) Its extent is be affected negatively by an increase of the overall sea surface temperature. This increase can be related to short term anomalies such as El Niño or to long term effects of global warming. Increased sea-surface temperatures and decreasing sea ice coverage are suspected to influence Antarctic ecosystem structure and functioning. In remains, however, unclear what the consequences are on higher trophic level organisms. Existing data suggest strong but contrasted effects of large-scale oceanographic processes and sea-ice extent on the demography of pack ice-dependent marine mammals and seabirds.

Concern about the possible impact of global climatic change on the one hand, and direct human impact on the other, creates a need for information on Antarctic ecosystem functioning. Top predators are generally considered suitable indicators, integrating short and long term ecosystem changes. Their reproductive success depends basically on the available amount and distribution of prey. Ecosystem changes as a result of short or long term climatic change necessarily will have a measurable impact on seabird and marine mammal population statuses and trends. Slight seasonal changes in pack ice distribution may have a considerable impact on the breeding or reproductive ecology of species that are since long highly adapted to a different and stable pattern of sea ice dynamics.
Global warming effects are widely accepted and documented. (Vaughan & Doake, 1996; Tynan & DeMaster, 1997), with snow and ice features as first line indicators. Global warming does not only influence the Antarctic pack ice distribution, it is suspected to have a dramatic negative impact on the overall ecosystem productivity. The closed pack ice zone CPIZ, being the major zone of productivity in the Antarctic (Joiris, 2000) is expected to be extremely sensitive to climatic change. The CPIZ may therefore provide suitable and early indicators at different trophic levels.

Penguin numbers and breeding success are considered to be suitable monitors for southern ocean productivity (Trivelpiece et al., 1990, Vergani & Stanganelli 1993). Populations seem to display a high variability, responding to a variety of factors linked to sea ice extend, food supply and direct human disturbance (Croxall., 1992; Micol & Jouventin, 2001). Overall figures on the changes of population statuses show, however, a variety of responses. Overall numbers of Adélie penguin on e.g. Signy Island remained fairly stable within the 1972-1992 period, while population of chinstrap penguin decreased. The number of breeding pairs for both species was identified to respond oppositely to the regional sea ice extend prior to the start of the breeding season (Tratham et al., 1996). Given the idea of a winter habitat segregation of both species, with Adelie penguin in the closed pack ice zone and chinstrap in the marginal ice zone or the open water (Plötz et al., 1991; Joiris, 1991, Ainley et al., 1994), it is to be expected that both species respond in a different manner to changes of the maximal sea ice cover, which is suspected to influence overwinter survival (Fraser et al.,1992). The model proposed by Fraser et al (1992) implicates that the trend of increasing temperature in the Antarctic Peninsula zone and the associated decrease in sea ice cover will eventually favor chinstrap, defavor Adélie penguin populations. It is also suggested suggest that many of the recent population changes in both species might be explained by this different response to changing sea ice conditions.

Large-scale changes of oceanographic processes and sea-ice extent seem, therefore, to have highly contrasted effects on the demography of marine top predator species. A decrease of the maximal ice cover is generally accepted to have a negative impact on the overall ecosystem productivity, in particular on the krill availibility. In the late 1970ies, emperor penguin *Aptenodytes patagonicus* populations in Terre Adélie declined by as much as 50% as a result of a decreased adult survival. These events coincided with a prolonged period of increased sea-surface temperatures and reduced annual sea-ice extent (Weimerskirsch et al., 2001). Recent data analysis for Adélie penguin populations in the Antarctic Pensinsula indicate a sharp decline in fledging survival as a result of a decline in krill availibility at the time of fledging (Wayne & Trivelpiece, 2001). This feature is again linked to a reduction of the occurrence and persistence of winter pack ice.

Short term phenomena, commonly known as "rare ecological events", type El Niño or La Niña, might equally play an important role on a more regional scale. Rare ecological events are loosely defined as environmental stress which induce major deviations of birth, death or migration rate in one or several age/sex classes not related to long-term means. One of the best documented events affecting pinniped and e.g. Humboldt penguin populations was described to have occurred in the eastern Pacific with drastic changes in physical parameters and food resources following the 1982-83 El Niño event (Trillmich, 1993).

ENSO fluctuations appear to be linked to fluctuations in Western Antarctic peninsula WAP air temperature and sea ice extent (Smith et al., 1996). Seasonal variations of the marginal pack-ice zone under the influence of ENSO were proven to influence the breeding success of the southern elephant seal *Mirounga leonina* (Vergani & Stanganelli 1990, Stanganelli & Vergani, 2000). More recently, an overall cooling associated with the cold La Niña event was proven to result in an increase of average elephant seal weaning weight, linked to a higher female average weight upon arrival at the breeding sites. Analysis of a ten-year time series (1985-1994) of weaning mass of King George southern elephant seals showed high values associated with La Niña, low with El Niño (Vergani et al 2001).

While the breeding success for southern elephant in the Atlantic and Indian Ocean sectors has been declining over the past decades (Marion Isl. Births –80% ; Pistorius et al., 1999) others populations were reported to remain fairly stable or to increase slightly in time (Laws, 1994; Boyd et al., 1996). Declines were linked to a reduced juvenile survival, probably as a result of the sexual and age-class overlapping of pelagic foraging, hence of an increased competition for prey (Stewart et al., 2001). From the analysis of life tables the duration of the period taken by the entire cohort to reach the sexual maturity (full recruitment) of southern elephant seals from the Atlantic, Pacific and Indian Oceans seems to be the key factor of population size stability. For the Atlantic population, the shorter period needed to reach full recruitment leads to a mean generation time one year shorter in the Atlantic (8) than in the Pacific (9) and Indian (9) populations. (Stanganelli and Vergani 2000). According to the findings of Stanganelli and Vergani (2000), the stability or decline of elephant seal populations are strongly associated with recruitment and hence with population growth patterns (Vergani and Stanganelli 2002)

All data suggest strong but contrasted effects of large- and small-scale oceanographic processes and sea-ice extent on the demography of pack ice dependent marine mammals and seabirds. Most species are therefore considered to have a potential high susceptibility to small and large scale ecosystem changes.

2 OBJECTIVE

The particular objective of this proposal is the integration of biological and physical data in a geographical and climatological context in order to study the impact of climate change and climate variability on Antarctic and subantarctic ecosystem functioning. To accomplish this, it is necessary to establish a solid time series on populations which are suspected to be vulnerable to this type of short or long term impact. Two key species were selected for this purpose: Southern Elephant Seal and Adélie Penguin.

3- BACKGROUND

Elephant Seal

The identification of the ecological changes responsible for the population declines of Southern Elephant Seals in the Pacific and Indian Ocean sectors as they occurred over the last 50 years, is still an important question to be answered by Antarctic researchers . Already during the 1986 Fifth Meeting of the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR), the Argentinean delegation called for attention over the specific topic (Page 45 of the Report SC-CAMLR V). During 1991, a special workshop, held in Monterey USA, called upon by SCAR and CCAMLR, was held with regards to the same phenomenon. The workshop analysis was presented at the Tenth CCAMLR Meeting in Hobart, Australia 1991 (page 57 of the Report SC-CAMLR X, Document SC-CAMLR-X/BG/3).

The main decision taken by the Monterey Workshop was that an international research effort was to be established, with Australia, U.K., South Africa and Argentina as participating countries. The research would focus on elephant seal pup weaning mass as an indicator of food availability in the three sectors of the Southern Ocean (Atlantic, Indian and Pacific) and its possible connection to the trend of population decline. The conclusions were presented at the VIth SCAR Symposium on Antarctic Biology held in Venice, Italy, 1994 (Burton, Boyd, Bester, Vergani and Wilkinson, 1997).
In 1993, the World Bank granted further research in the frame of a Masters' Program in Fundamental and Applied Marine Ecology at the Vrije Universiteit Brussels, Belgium, carried out by MSc. Zulma Stanganelli: Searching for causes of Southern Elephant Seals Population Decline (Masters thesis, Stanganelli, 1996). Results were presented at the VIIth SCAR Symposium of Antarctic Biology in Christchurch, New Zealand, 1997 and published as Stanganelli and Vergani (2000).

Adélie penguin

The strategic importance of the proposed project lies in the position of high trophic level indicator species to assess possible impact of global change, climatic variability or human impact on Antarctic ecosystems. Higher vertebrate species can be used to evaluate food availability, and therefore biodiversity -number of species, but also expressed as biomass- of all underlying levels of the food web. As aimed for by the targets of the Belgian Antarctic program, information will be obtained on the diversity of higher trophic levels and on how high level predator species respond or adapt to changing ice and surface temperature conditions.
Penguins numbers and penguin breeding success are considered useful monitors for southern ocean productivity (Trivelpiece et al., 1990, Vergani and Stanganelli 1993). As to how exactly Adélie winter survival responds to seasonally shift in ice conditions, thereby influencing food availibility at the climax point of the breeding season, is yet still unclear. As to winter survival, Fraser et al (1992) predicts a negative response of Adélie populations –pack ice zone wintering- as opposed to chinstrap, with an open water and marginal ice zone winter strategy area (Plötz et al., 1991; Joiris, 1991, Ainley et al., 1994).

The project will offer information that can be implemented in a number of scientific and intergovernmental bodies. Input of our data in CCAMLR-EMM models will yield information on possible influences of krill fisheries and krill stocks on seal and other vertebrate predators. CCAMLR-EMM time series on chosen target species such as Adélie penguin are used to predict the impact of fishing activities on Antarctic ecosystems, a necessary step towards possible protective measures of food stocks.
The CCAMLR-EMM intergovernmental Convention for the Conservation of Marine Living Resources, Ecosystem Monitoring Management Programme aims to detect any possible significant changes in key elements of the Antarctic ecosystem; it also aims to determine if changes are due to fishery (harvesting) or natural causes. Within the framework of the CCAMLR convention, implementing conservation principles within an ecosystem full perspective, target species were chosen that were thought to be representative in detecting changes in food availibility or environmental changes. Adélie penguin was identified as a priority species to monitor and assess possible changes in Antarctic marine ecosystems.

3- Methodology.

3.1 Target Area and Historical Data

The target research area , covered by this project, is indicated in Map 1. Previous data on elephant seal and penguin population ecology, which may provide adequate reference values, were collected between 1985 and 1994 from King George Island (25 de Mayo), Hope Bay and Laurie Island as part of the cooperative CONICET-DNA agreement and CNP-IAA Project.

Earlier studies indicate that elephant seal breeding populations at King George Is. depend on feeding areas in the Bellinghausen Sea, colonies on Laurie Is. on feeding grounds in the Weddell sea, while colonies at Hope Bay seem to depend on both sectors. The project target area stretches from South Georgia in the North to Alexander Is. in the South, following the feeding migratory route of elephant seals as described by to McConnell et al. (1992) and McConnell and Fedak (1996).

Research, carried out in the framework of the SECYT - Alfred Wegener Institute (Contract Antar II, Bornemann et al 2000, Vergani et al 2001), concluded that the feeding area of female southern elephant seals in the proximity of Alexander Is. is closely connected to the edge of the pack ice zone.
The at sea, and out of breeding season distribution of Adélie penguin, is well documented for the chosen, Colony size and yearly breeding success are good parameters to monitor the temporal evolutions of Adélie and its response to short or long term climatic changes.
Dietary studies on elephant seal that have been conducted in cooperation with University of Kiel were presented to CIAC 2000 (Aberdeen, UK) by Piatkowsky & Vergani. Re-analysis of data on diet and population fluctuations of Southern elephant seals at King George is. shows changes in principal dietary items related to ENSO climatic variations (Piatkowsky, Vergani & Stanganelli in prep).
Integration of biological and physical data in the Cybercartographic Atlas for the Antarctic-system would provide a better understanding of this phenomenon.

3.2 Climatic Data

The project aims to relate vertebrate species yearly densities and breeding success -including weaning weight- to climatic parameters such as sea surface temperature, ice cover and patterns of circulation.
Climatic are obtained from the World Data Climate Center. Areas and importance of anomalies will be determined for periods and areas of biological interest. Biological data will be combined to ice and oceanographic features into a GIS. The GIS aims link biological parameters (colony size and time of arrival, female elephant seal weight upon arrival at the colonies, reproductive/breeding success, chick/weaning weight) to sea surface temperatures and ice cover, expressed as position and extent. Temporal shifts in the seasonal ice pattern and the seasonality of primary and secundary production might prove critical in Adélie survival. Food availibility at the time of fledging is thought a critical element in overall winter survival. Ice cover prior to the breeding season was already proven to influence the breeding success of the species (Tratham et al., 1996). The resulting database will be linked to the larger Cybercartographic Atlas for the Antarctic database.

3.3 New Information

The application of cibercartography in the acquirement of new data, with a potential of new techniques and combined different sources of information, multimedia systems, internet etc. requires the development of a working model.
The traditional acquirement of biological data is by direct observation; in this stage, in parallel, we will apply video recorder with programmed capture of information and automatic image processing with the idea to connect in the future to the internet trough the CiberAtlas System.
This Ciber Atlas for Antarctica is linked to a second project , the Cyber Atlas of Aboriginal Communities, where people from the Mapuche Tehuelche communities will be trained to work in the Antarctic in order to get skills that can later be applied in Patagonia.

The work model will be developed in Patagonia during 2002/2003 and 2003/2004 elephant seal breeding seasons. Application in the Antarctic is scheduled for 2004/2005.

The target parameters are:

Elephant seals: suckling parameters measured according to Vergani et al 2001 and Vergani & Stanganelli (2002)
Adélie penguin: breeding success measured according standard methods of EMM-CCAMLR.

Logistic Requirement to Antarctica

Date: From September 2004 to February 2005
Team: 2 Researcher (1 Argentina, 1 Belgium), 2 Assistants (Argentina),
1 Student (Belgium), 1 Member of Aboriginal community (Argentina).
Itinerary: Buenos Aires Marambio Station, Jubany Station

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