Changes in the Antarctic observed from Poland's H. Arctowski Research Station

Icy Greenhouse

Prof. Stanisław Rakusa-Suszczewski observes how Antarctic ecosystems react to global warming

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In its eternal battle against winter in the South Shetland Islands, summer is slowly beginning to gain the upper hand. The warmer ground and water are causing extensive changes in the land and sea ecosystems, which are further complicated by human activity

Marking the 100th anniversary of the *Belgica* expedition (the first to winter in the frozen Antarctic), a circle of individuals involved with polar research met at the Department of Antarctic Biology, Polish Academy of Sciences, in 1989. Among them was Baron Gaston de Gerlache, the son of the Belgian expedition's leader, as well as Dr. Alfred McLaren, president of the Explorer's Club, formerly a high-ranking US Navy officer and the commander of nuclear submarines that plied the waters of the Antarctic and the Siberian shelf. During his underwater journeys he had arrived at an important discovery: the thickness of the Arctic ice cap has been shrinking continuously over the past 50 years. This finding constituted one of the first credible signals of the rapid climactic change underway in the Arctic. Similar changes, although not as explicit, are likewise being observed at the Earth's opposite pole.

Arctowski Station Archives

A birds-eye view of the Arctowski Research Station, which was founded in 1977 on the coast of Admiralty Bay, on King George Island


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Adelié penguins against a backdrop of lichens: Antarctica can be a colorful place!

The main base for the Polish research work in the Antarctic is the Arctowski Research Station, which was founded in 1977 on the coast of Admiralty Bay, on King George Island near the Antarctic Peninsula, and was named after Henryk Arctowski, a Polish researcher involved in the *Belgica* expedition. The research that has been underway there for 28 years now is already helping us to predict certain directions of change in the coastal and shelf ecosystems. The work now planned as part of the International Polar Year 2007/2008 will aim to verify these predictions.

Thawing permafrost

The changes observed in the South Shetland ecosystems are very unstable: each successive year brings new surprises. Nevertheless, certain regularities do emerge from the long-term trends, indicating that the natural environment is being transformed by both climactic change and direct human activity.

A link has been confirmed between the physical and biological phenomena observed in the Admiralty Bay region and El Niño (ENSO), a phenomenon occurring on average once every few years that involves an eastward shift of warm waters and monsoon rains in the tropical zone of the Pacific. And so, we can expect to see significant fluctuations in the occurrence of warm and cold years in the Admiralty Bay region, within a several-year cycle.

The coming decades will see a further increase in average air temperature rise of 0.02-0.04°C per year, mainly as a result of higher winter temperatures. Yearly average ground temperatures are now already positive, and like the air temperatures they will continue to rise, causing the permafrost to thaw down to a depth of about 1 meter. Temperature variations proceed much more slowly in the ground than in the air. As a result, the ground is now already thawed for about 6 months of the year, and this period will be growing longer and longer. Overall, the higher air and soil temperatures will lead the ground to freeze and thaw more frequently, a fact of fundamental significance for land flora and fauna.

On land, the most visible effect of climatic change in the Admiralty Bay region is the process of deglaciation, whereby perennial ice melts and the permafrost thaws. This entails quite rapid change in the land ecosystem biodiversity of the Antarctic tundra. We should expect to see the further regression of glaciers, the melting of old ice in exposed moraines, and permafrost receding to a greater depth. This will cause first the hydration, then the dehydration of tundra areas in the coastal areas of the bay - leading to changes in the makeup and development of ecosystems, and causing mosses to be supplanted by vascular plants. This will also be accompanied by changes in the composition of the freshwater and land-dwelling microfauna and mesofauna.

Moreover, the melting ice could release harmful substances that have remained trapped inside the ice for years, such as PCBs and DDT, and cause the recontamination of waters and suppress primary production. The melting of older glacier ice and permafrost might likewise reintroduce extinct microorganisms into the land and sea environment.

Fertilizer exchange

In the climatic conditions that prevail in the Antarctic waters surrounding King George Island, the functioning of the coastal and shelf ecosystem hinges upon the amount of matter circulating between the sea and land. Deglaciation causes changes in the relief of the terrain and in the line of coastal ice, therefore modifying the drainage area and surface area of Admiralty Bay. Deglaciation likewise intensifies processes which transport matter between land and sea, in both directions. More and more mineral matter is now flowing and blowing from land out into Admiralty Bay, changing the conditions present in the bay waters as well as near their outlet, the Bransfield Straight. The water transparency is dropping, entailing changes in primary production and increased mineral sedimentation on the sea floor.

On land, as the ice-free terrain expands and becomes fertilized by animals and seaweed, the plant biomass increases. In the future, however, the tundra ecosystem will see a reduction in the percentage of its biomass that is of marine origin and is transferred from the sea to land (i.e. allochthonous biomass), in favor of biomass that arises in the deglaciated coastal areas themselves (i.e. autochthonous biomass).

Interestingly, even though there is an expanding area in the Antarctic coasts offering accessible nesting sites for birds of flight and penguins, and rookery grounds for elephant seals and sea lions, in fact the numbers of such animals have not been increasing. Long-term observations of penguins indicate that their numbers can fluctuate by as much as 30% from one year to the next, and that variations in the numbers of the three species found in the region do not correlate with each other. There are also fluctuations in the numbers of penguins present at the individual colonies and nesting sites - not only in the Admiralty Bay region, but also in the vicinity of neighboring bays and islands. Because the overall number of penguins in this terrain is going down, the mass of penguin fecal matter deposited on land is also diminishing. Fertilization by pinnipeds is likewise diminishing: even though for the time being their numbers have remained stable, their population is becoming more thinly spread out across the expanding coastal terrain. In the future we should therefore expect sea lion numbers to rise, and they should also begin to reproduce in this region, something they have not previously done.

Seaweed boom

As the length and diversity of the coastline increases and the area of the Admiralty Bay floor expands, the number of macroalgae (seaweeds) covering the floor will rise. The remains of such organisms will likewise be deposited on land by the wind in increasing quantities. As a result, the proportions of the sea-to-land flow of fertile organic matter will alter - decreasing amounts of excrement deposited by birds will be balanced

Arctowski Station Archives

The main building of Poland's Arctowski Station

by an increasing influx of macroalgae. This will have an impact on the propagation of biogenic substances, such as nitrogen and phosphorous salts, spurring the development of bacteria communities, microfauna, and plants in the tundra biome.

Primary production in Admiralty Bay depends on climatic changes, and also, indirectly, on such factors as the stability of the water column, its transparency, and the intensity of UV-B radiation. Phytoplankton have a great adaptive capacity and do react to increased radiation caused by the "ozone hole," yet for the time being primary production is decreasing because the activity of algae living in and under the ice is diminishing - as a consequence of the warmer climate, which is causing the marine ice-pack to shrink along Antarctic coasts.

The absence of ice-pack alters the composition and cyclical appearance of phyto- and zooplankton, as well as their seasonal diversity within the water column. A shortage of plankton, in turn, leads to smaller quantities of krill, a key organism in this ecosystem, and thus entails serious consequences for many of its consumers - such as the crabeating seals and leopard seals, which prefer ice as a stable habitat and reproduction site.

The human impact

The predatory exploitation of biological resources has played a significant role in the history of Antarctica. Sea lions and whales were decimated by hunting in the 19th and early 20th centuries, touching off vast changes in the marine ecosystems of the entire world. In the later 20th century, intensive fishery and krill fishing in the region gave rise to a true ecological catastrophe, whose consequences will be evident in the Antarctic biological world for many years to come.

Another example of large-scale anthropogenic impact is to be found in the appearance of bluegrass (a species of the *Poa* genus, foreign to this ecosystem) in the vicinity of the Arctowski Research Station, which previously only knew a single species of grass: the Antarctic hairgrass (*Deschampsia antarctica*). Sudden growth in the number of tourists to the region will encourage the further uncontrolled introduction of species.

Eleven of the 19 Antarctic stations which report meteorological and climatic data noted a temperature increase in 2005, while 7 reported a drop. The region to the west of the Antarctic Peninsula is definitely growing warmer at a pace of some 0.05°C per year, and this is confirmed by the published Polish observations, although this warming trend is growing weaker. Yet the situation is quite different in the eastern Antarctic, where precipitation and snow accumulation are on the rise, leading to a sea level reduction of 0.12 mm per year. Nevertheless, winter satellite pictures show that the ice-pack surface is shrinking around the entire continent.

Climatic changes in Antarctica do not have political repercussions, since under the Antarctic Treaty the region remains under international control. However, they do have an impact on this unique ecosystem. While ice-free areas constitute a small percentage of the surface of Antarctica, what is happening there serves as a litmus test of changes that are underway both regionally and globally. The region of the South Shetland Islands, where the Arctowski Research Station is situated, is an ideal location for researching these changes. ■

Arctowski Station Archives

An elephant seal: a constant neighbor of the station

Further reading:

Rakusa-Suszczewski S. (2002). *King George Island - South Shetland Islands, Maritime Antarctic.* Ecological Studies vol. 154: L.Beyer and M.Bölter (eds.), *Geoecology of Antarctic Ice-Free Coastal Landscapes.* Springer.