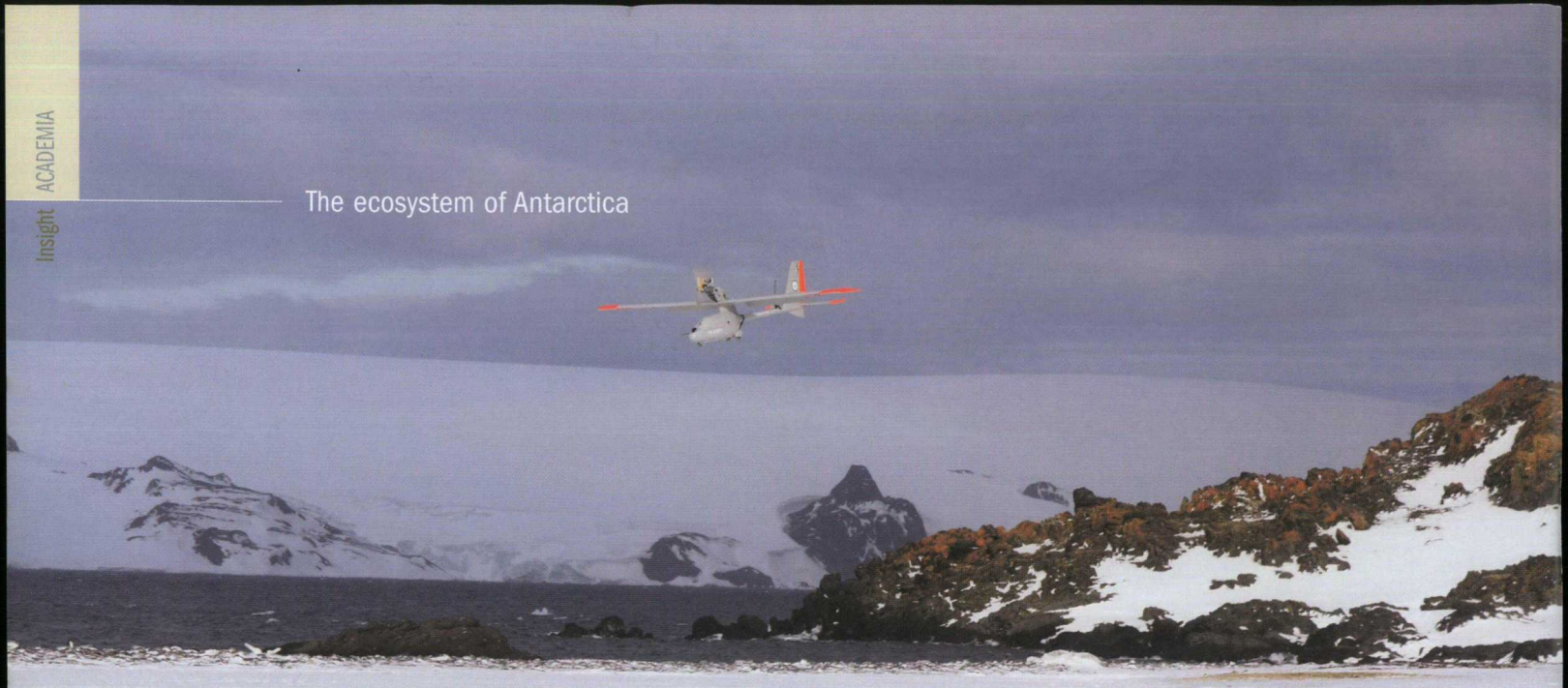

UAV Antarctic Survey

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How can we make the most of Antarctica's marine resources without damaging the delicate balance of the ecosystem? The answer may lie in an interdisciplinary monitoring system using Unmanned Aerial Vehicles (UAVs) and geoinformatic tools

The commercial exploitation of the Southern Ocean resources started in the late 19th century, initially through the sealing and, subsequently, whaling industries. In the 1970s intensive development took place in fishing for krill and fish. Poland was also among the countries interested in fishing for fish and krill in the region. During the 1980s it was widely believed that an annual catch of 50 million metric tons of krill would not disturb the ecosystem of the Southern Ocean, although the estimate turned out to be wrong. The Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) was founded in 1982 to regulate fishing, introduce control measures and put in place a system of quotas.

Krill processing technology continues to develop. Krill fishing notifications for the 2014/2015 season have been registered by six countries (Chile, China, Korea, Norway, Poland and Ukraine) with a total of 611,000 metric tons caught. In terms of biomass, krill (*Euphausia superba*) is the greatest source of animal protein in oceans, and it is a key element in the food chain of the Southern Ocean. It is the main source of food for whales, some species of pinnipeds, penguins and other seabirds, fish and cephalopods. Sustainable use of this resource is absolutely essential and must be regulated through limits. These are set by monitoring of populations of certain indicator species, which include Antarctic seabirds, in particular penguins, whose total biomass accounts for 90% of the total biomass of all birds found in the Southern Ocean.

Indicator species

Penguins spend the majority of their life hunting in the open sea. It is only possible to estimate their numbers during the breeding season, by counting the number of nests in a colony. This is a difficult task. Penguins nest on small scraps of the ice-free land along the shore of Antarctica. Those ice-free areas represent just 0.33% (50,000 square kilometers) of the whole of Antarctica. The areas are frequently difficult to access from both the sea and land. Breeding colonies number several thousand nests, and are often located on undulated terrain. The traditional method of counting nests from the ground level can only be conducted in limited areas, and accurate estimates of the numbers of breeding colonies including thousands of individuals are extremely difficult and carry a high margin of error. This is why UAVs are proving to be excellent tools for assessing sizes of populations of indicator species, allowing researchers

Author's materials

The Polish-Norwegian team operating the UAVs: A. Zmarz, R. Storvold (Northern Research Institute), A. Tollefsen (NRI), C. Janas (Air Force Institute of Technology), S. R. Karlsen (NRI), K.S. Johansen (NRI), M. Rodzewicz (Warsaw University of Technology)

A team of observers performing visual counts of penguin nests from the ground level (reference data)

to capture images of regions previously inaccessible to observers.

Bird's eye view

UAV technology is developing nowadays, and UAVs have become a useful tool for scientists working with remote sensing techniques. UAV-based methods are growing more and more significant for environmental monitoring by providing data from areas inaccessible by ground (such as Antarctica), as well as reducing costs and improving the effectiveness of field work.

The project "A novel approach to monitoring the impact of climate change on Antarctic ecosystems - MONICA," started in the austral summer season 2014/2015, used two types of UAVs. One was designed by the Warsaw University of Technology, the PW-ZOOM, with the following basic characteristics: wing span - 3.5 meters, fuselage length - 1.7m, take-off weight - 23 kg, cruising speed - 115 km/h, flying range - 170 km. The other type, the CryoWing, owned by the Northern Research Institute, was adapted to operate in polar conditions. It can carry up to 10 kg in payload and has a maximum range of 500 km and endurance of 5 hours.

The main aim of the project is to study selected impacts of climate change on ecosystems in the Antarctic, mainly based on data recorded with Unmanned Aerial Vehicles (UAV). It is also an opportunity to develop techniques for integrated, interdisciplinary monitoring of Antarctic ecosystems.

The project is being run by two Polish institutions: the Institute of Aeronautics and Applied Mechanics (Warsaw University of Technology) and the Institute of Biochemistry and Biophysics (Polish Academy of Sciences), in conjunction with the Northern Research Institute Tromsø (Norway).

Results in five hours

The UAVs were equipped with autopilot systems enabling them to obtain the fixed heading and altitude on 350 m AGL (Above Ground Level). The UAVs can carry digital cameras for taking images with sufficient overlap to create orthorectified image mosaics. Images of 5cm GSD (Ground Sampling Distance) allowed penguin nests (the indicator species) to be located and counted.

The Polish-Norwegian team carried out eight task flights with a total distance of approx. 1500 kilometers. Images taken during the flights captured over 25,000 *Pygoscelis* penguin nests in seven breeding colonies situated on the shores of Admiralty Bay and King George Bay, and are comparable to a set of estimates made by observations conducted at ground level.

However, while the results are comparable, using UAVs made the monitoring process vastly more efficient. In order to conduct fauna monitoring (census of 17,000 nests) of Antarctic Specially Protected Area (ASPA) 128, six aerial photogrammetric missions were carried out with a total distance of 605 kilometers over a period of 5h 30min; when the same area was studied on the ground level, observers needed to make a total of eight field trips, which took them 13 days and 17 hours. ■

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