Scientific projects

NATIONAL ANTARCTIC PROGRAM

2018-2021

This document summarizes the scientific projects that Uruguay is currently developing in Antarctica. They are structured around four major areas of work: Geosciences, Life Sciences, Physical Sciences and Environmental Monitoring, constituting the first three, areas of high priority study for the Scientific Committee on Antarctic Research (SCAR).

GEOSCIENCES

Effect of glacial retraction on productivity and trophic status of Fildes Peninsula lakes: a paleolimnological approach.

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The objective of these investigations is to reconstruct the paleolimnological conditions of several lakes of the Collins Glacier for the last millennium, with special emphasis on the variability of sedimentation rates associated with changes in the magnitude of melt, which affect the chemical, physical and biological historical conditions.
For this purpose, sediment cores will be taken and dates will be made (210Pb, Cs 137, 14C, TLD), sedimentology will be analyzed, micropaleontology, stable isotopes (δ C, δ N, δ S), heavy metals, mineralogy and element scanning through XRF. Extractions of ancient DNA from sediment cores will also be performed to analyze the structure of microbial communities based on the presence of phylogenetic marker genes and the structure of communities between lakes will be compared.
Based on the above information, changes in sedimentation derived from melting ice, the impact of environmental changes on microbial communities and therefore on the trophic conditions of lakes, etc. will be inferred. The scientific information generated is important to understand the effect of glacial retraction/advance on the historical paleolimnological conditions of the Fildes Peninsula lakes, especially on organic matter composition, trophic status and productivity, and historical microbial communities. Therefore, it constitutes an

important input for the planning of conservation strategies and management of lakes in the Fildes Peninsula.

Physical properties and geological features in the surroundings of the Artigas Antarctic Scientific Base (BCAA), King George Island.

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The planet Earth, both inside and on its surface, is composed predominantly of rocky material that occurs in different states (rigid, disaggregated, in fusion, semifusion, etc.). Therefore, the study of the properties of soil and rocky materials, as well as geological and tectonic processes, are of special relevance when constructing the evolutionary history of the Earth.

Within this conceptual framework, this project seeks to study the physical properties and geological characteristics in the vicinity of the Artigas Scientific Antarctic Base (BCAA). In particular, it is intended to obtain more information about the type of rocks found in the region, study the behavior of the magnetic field (of special importance for telecommunication systems), make a magnetometric map, study the properties of the subsoil, the variation of temperature and humidity in depth and over time and determine the thickness of the glacier. This will generate relevant statistical information on temperature variations as a function of depth (geothermal gradient) and over time, which will serve as input for future planning of the facilities of the Uruguayan Antarctic base. These objectives, in addition to being of scientific-academic interest, are important for the BCAA since the study of the properties of the subsoil will allow, among other things, to determine the stability of the same for the constructions of the BCAA.

In order to meet these objectives, different geophysical (physical properties of materials) and geochemical (chemical properties of materials) research techniques will be used, with the use of diverse sensors such as scentilometer, magnetometer, georadar antennas, tomographs, temperature and humidity sensors, among others. All these methods are

non-invasive techniques, so no modifications will be generated in the environment that damage the natural dynamics of the site.

Topographic, geodetic and geophysical surveys for the development of the Antarctic Geodetic Infrastructure, the International Geodetic Reference System and the King George Island Geographic Information System.

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The activities to be developed are framed within the SCAR-GIANT and SCAR-KGIS Projects. The main objective of the Geodetic Infrastructure Development Project (GIANT Program) is to establish and maintain a High Precision Geodetic Infrastructure. The SGM has installed and observed semi-permanent and permanent Passive (milestones) and Active (Continuous Operation Reference Systems) Stations, which are used as reference for topographic, geodesic, photogrammetric and geophysical surveys for technical and scientific purposes. In addition, the main objective of the King George Island Geographic Information System Project (KGIS) is to maintain an integrated and updated cartographic base and geospatial information referring to King George Island.

Extreme Environments in Planetary Exploration: geolipids, stable isotopes and associated mineralogy on King George Island.

Responsible: PhD. Daniel Carrizo

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For 2020 there are two programmed missions to Mars, with the main objective of finding traces of past or present life on the red planet. For this, it is possible to use biomarkers (molecules or organic compounds) that are indicators of past or present biological activity. The main objective of this project is to characterize geochemically (biomarkers, isotopes and minerals) extreme environments present in King George Island and use them in space

research activities. The data set generated will be used to expand the spectrum library and validate the data obtained by Raman instrument from the rover vehicle of the ESA ExoMars 2020 mission.

LIFE SCIENCES

Molecular ecology of King George Island penguin populations.

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The current scenario of climate change and increased human pressure in Antarctica may alter the stability of animal communities. It is therefore important to develop medium- and long-term monitoring tools. Landscape features and changes in the environment can affect or modify the genetic characteristics of populations. The data obtained through molecular ecology allow us to understand the evolutionary processes of species and populations, and contribute to the understanding of the factors that influence them. Penguins play an important role in the Antarctic ecosystem and are often used as indicator species. In recent years, numerous investigations have been carried out on these species, requiring their capture and manipulation. This generates stress in the animals, besides a high logistic and equipment demand. We propose to analyze the population structure, sex determination and diet of the three penguin species that nest in the Fildes Peninsula and surroundings, by using non-invasive samples (dead animals, fecas, pellets) in order to generate a sustainable monitoring tool in time that allows access to information needed to minimize the disturbance generated on the target species. In addition, the creation of a Uruguayan bank of genetic material of Antarctic birds will be initiated, which will remain available for other investigations according to the needs or concerns that may arise in the future.

Feeding habits in Antarctic top predators: tracking possible effects of climate change on the trophic structure.

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Antarctica is the system most affected by climate change, with consequences for the community trophic structure. Krill (Euphausia superba) is a key species, a major component of zooplankton (estimated biomass ~500,000,000 tonnes) and a link between primary production and top predators. The decrease in their abundance is associated in part with the increase in temperature and acidification of the water, negatively affecting the recruitment of larvae. This has a profound effect on the rest of the food web. Among the top predators that consume krill are the pinnipeds (represented by a species of fur seal and 5 species of seals). During lactation, the females of the fur seal (4 months) feed and their offspring remain in the colony. Seals, on the other hand, fast (~15 days), generating different dependence on nearby resources. The objective of this project is to study the feeding habits of Antarctic top predators as a function of the change in zooplankton composition associated with krill replacement by other species, evaluating lactation strategies. In this sense, the female fur seals are proposed as sentinels of the state of the local Antarctic food web.

The breeding and resting colonies on King George Island will be explored to collect faeces and obtain skin samples from individuals of these species to perform stable isotope analysis using darts shot with an air rifle at a distance. The niche width for each species/sex/year will be estimated, evaluating its overlap and the composition of the diet will be estimated by combining both sources of information (isotopes and faeces). This information will be contextualized in relation to krill abundances (www.ccamlr.org) and environmental variables. While long-term projections of climate change have focused on habitat change and krill decline, their most immediate impacts include alteration of the upper trophic level community structure. In order to minimize the long-term impacts of climate change, the first step is to know the interactions between the different species that make up the community and the intensity of the trophic connections.

Plastic and microplastic waste in marine-coastal zones of the Fildes Peninsula, King George Island (Antarctica).

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Nowadays plastic is an almost indispensable and omnipresent material in our economy and daily life, with multiple functions that are fundamental to human well-being. However, since the late 1980s, plastic waste has been identified as hazardous materials and a threat to the coasts and seas where it tends to accumulate. Constituting 80% of marine litter, plastic waste is transported long distances by ocean currents, trapped in ocean currents, stranded on beaches and/or degraded into micro (and nano) plastics. This accumulation of plastic waste is beginning to alter the physical, chemical and ecological functioning of marine and coastal ecosystems around the planet. Although this pollution is a global threat, very little is known about the distribution and sources of plastics and microplastics in the polar regions, including Antarctica (including the southern ocean, archipelagos and mainland south of 60 degrees latitude) which does not escape this problem.

In the framework of this project we will generate an integral diagnosis (for a future monitoring program) of plastic and microplastic residues in marine and coastal areas of the Fildes Peninsula, on King George Island (Antarctica). To achieve this, the presence of these residues will be evaluated on beaches and rocky coasts, in surface marine waters, and on the seabed. The terrestrial contribution of these residues will also be analyzed through the glacier melting ravines, as well as the consumption of microplastics by zooplankton and seabirds, and also the composition and concentrations of contaminants in the plastic residues found. In this way, from the data of occurrence, abundance and distribution of macro and microplastics, their possible sources, and their interactions and consequences with marine and terrestrial biota, we will know the current levels of this contamination in our study area. Through the generation of this new baseline information we seek to contribute to the objectives and challenges that the Antarctic Treaty System currently faces due to this 'common global evil'.

Effects of the Collins Glacier melting on the Antarctic marine coastal ecosystem.

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The increase in freshwater intake due to glacial melting is a consequence of Climate Change and the reduction in ice cover on the Antarctic Peninsula in recent decades. Increased freshwater discharge increases the stratification and turbidity of Antarctic coastal marine waters, as well as the transport of sediment and organic matter from land to sea. Marine organic matter represents a protein-rich food source for marine consumers, while terrestrial organic matter has a low food value. The quantity and quality of organic matter available to marine consumers is controlled by various environmental and biological factors that act both locally and regionally, and are also dependent in the long term on global processes such as Climate Change. Therefore, in a scenario of continuous glacial melting, a decrease in the quality of food available to marine consumers in Antarctic coastal waters is possible. It is necessary to first understand the local scale variability in the composition of organic matter (terrestrial vs. marine) and its potential ecological and functional consequences in Antarctic coastal marine ecosystems as an input to reach a perspective of future regional and global patterns. The main objectives of this work are (i) to characterize the quantity and composition of organic matter exported by melting the Collins Glacier towards the adjacent marine environment (both through surface runoff and ice block detachments); (ii) to establish its influence on the quality and availability of food for marine consumers (zooplankton, macro and meiofauna); and (iii) the effects on the ecological and functional structure of these communities.

Elaboration of a sound map of King George Island: towards the use of acoustic landscape monitoring as an environmental indicator in Antarctica.

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It is very well reported in the literature that anthropogenic sounds present diverse threats to the species, mainly due to the disruptive effect on their communication systems that in turn affect social interactions, reproduction and care of offspring, feeding, among others. Recent research shows that the responses of organisms begin to manifest at sound levels that humans consider comfortable. In addition, many systems that seem to have little alteration present significant anthropogenic background noise profiles. In this context, this project proposes to focus on carrying out a baseline of the spatial and temporal extension of anthropogenic sounds and associated noise levels in the Fildes Peninsula (King George Island), with projection to an acoustic monitoring system in this Antarctic island. A second objective focuses on exploring the potential effect of noise generated by human activities on local biological communities. This project aims to obtain quality information that contributes to understanding the magnitude and severity of noise impacts, broadening the taxonomic, geographic and ecosystem range of which information is currently available. On the other hand, the spectrum of scientific information generated in Antarctica will be amplified, with an important potential to improve the management of human activity in that continent.

Plant growth promoting microorganisms present in Antarctica.

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In Antarctica there are only two native species of vascular plants: the Antarctic grass (Deschampsia antarctica) and the Antarctic carnation (Colobanthus quitensis);

Polytrichastrum alpinum moss is also abundant. In this project we are studying the bacteria that live in the roots of these plants. Some of these bacteria have the ability to help plants nourish themselves and protect them from disease. This occurs in different plants, but is especially relevant in Antarctica, as the conditions are more adverse than in other ecosystems.

In the southern summer campaigns, we collect grass and carnation plants at various sites on King George Island. In the Microbial Ecology Laboratory of the IIBCE we study the bacteria that live in their roots. Some of these bacteria increase the supply of nutrients such as phosphorus or iron. Others produce plant hormones that improve plant development. Others produce antibiotics and enzymes that affect the growth of pathogenic fungi, preventing them from producing diseases. Some very special bacteria have several of the activities described and we identify them to know which species they belong to. We also want to study how they behave when we add them to the roots of plants, and see that they can improve their growth. For this, we are currently growing the plants under controlled laboratory conditions.

Although microorganisms are the most abundant organisms in Antarctica, they have not been much studied. It is likely that there are a large number of them that are not yet known or that present new and interesting activities to discover.

Red algae as sources of pigments in solar cells based on the use of natural colorants.

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Solar cells based on the use of natural dyes are a form of technology developed in Switzerland, first reported in the 1990s. In these batteries, the colored pigment is responsible for capturing the energy from sunlight and transforming it into electrons, thus generating an electric current. Several pigments have been used for this purpose, both of natural origin and synthesized in the Laboratory, achieving efficiencies comparable to those obtained with traditional silicon panels.

The aim of this project is to adapt this type of technology that allows the use of pigments extracted from Antarctic algae to capture the energy of sunlight. Red algae abound in Antarctic territory, and the pigment that is responsible for giving them that color is easily extracted and can be purified and used to assemble these panels. Using this type of pigment has two advantages: 1) it is extremely abundant during the summer season on King George Island and 2) it implies the use of autochthonous species, preventing the entry of species alien to those existing in this area of the Planet.

Solar cells based on the use of pigments use the visible energy of the spectrum of sunlight, and can be placed under a roof for use. In addition, as the visible spectrum is wider than the ultraviolet, they need less radiation to work than silicon panels. They can be installed in windows because they are transparent and do not darken the room, thus taking better advantage of incident light. This technology can then be placed inside the Base installations, protecting the mentioned panels from the inclemency of the weather.

Functional diversity of microbial communities and bioprospecting of microorganisms with potential technological applications in Antarctic samples.

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The research group is dedicated to the study of microbial communities in some Antarctic niches, as well as the search for genetic material for the development of biotechnological products. For this purpose, microorganisms with novel biochemical properties are isolated, they are identified in molecular form, their genomes are sequenced and then the information collected from those genomes is used for the development of goods of industrial and pharmaceutical interest. These projects include: 1) the isolation of microorganisms resistant to UV radiation, and the identification of enzymes responsible for repairing DNA damage; these enzymes, called photoliases, have potential use in the pharmaceutical and cosmetics industries. 2) the isolation of microorganisms producing cellulases, laccases, and proteases, and the purification and biochemical characterization of these enzymes, with emphasis on the study of their application in the biofuel industry,

paper industry and detergents, as well as in functional foods. 3) Purification and chemical identification of microbial pigments for the development of antiproliferative and healing agents. 4) The study of the mechanisms of adaptation to cold through proteomic and transcriptomic strategies. 4) sequencing and annotation of microbial genomes.

Among the niches that the group has recently begun to study are cryoconites. These are structures found in polar areas and snowy peaks. They are holes in snow or ice sheets, with a dark background formed by mineral and biological material. These are produced by the deposition of dust, which absorbs light and thereby increases heat and melts snow forming holes, where microbial communities develop. In this project it is proposed to study the microbial communities of cryoconites and their margins, with emphasis on their functional activity, as well as the content of pigments and the isolation of microorganisms with biotechnological potential. With these results it is also expected to contribute to the knowledge of the role of cryoconites in the biogeochemical cycles of Antarctica.

Production of polylactic acid (PLA), through polymerization with lipases obtained from Antarctic microorganisms.

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The growing environmental pollution caused by the indiscriminate use of plastic containers has led to a growing interest in research into biomaterials. PLA, a polymer formed by the polymerization of lactic acid molecules, is presented as the most promising bioplastic for this purpose. Therefore, the general objective of this proposal is to evaluate different lipases coming from Antarctic microorganisms for the polymerization of lactic acid, as well as to contribute to the knowledge of Antarctic microbial populations and their potential biotechnological application.

Microbial ecology and effects of climate change in Antarctica.

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This subprogramme covers different projects aimed at studying the contribution of microorganisms in the Antarctic environment to the biogeochemical cycles of elements such as N, P, C and their behaviour in the face of climate change scenarios. The objectives of the projects are as follows: to study which bacteria denitrify at low temperatures in Antarctica; to determine the effect of global warming on N2O emissions in Antarctica; to determine the responses to climate change of Antarctic microbial communities, taking as a study model the microbial mats established in the thaw gullies of the Collins Glacier (Peninsula Fildes); and to study the mobiloma in microorganisms of the Antarctic environment, including elements of horizontal gene transfer (THG) and associated genes, which can give an adaptive advantage to the environment.

Biogeochemical cycle of methane in Antarctic sediments.

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Climate change is a major global environmental concern. Global warming, caused mainly by the increase in the concentration of greenhouse gases in the atmosphere, requires in-depth study in order to achieve its reduction. Methane is one of the main gases contributing to this effect. It originates from emissions mainly from natural wetlands and various anthropogenic activities. The cold environments (mainly polar regions), suffer an acceleration in their warming compared to other areas of the planet and therefore can be an important source of methane emission in the near future. This is due to the fact that when the ice of frozen lakes melts, the methane accumulated beneath its surface is released

into the atmosphere and there is also an increase in the speed of emission due to an increase in temperature. This project aims to study the biological processes of methane emission and consumption (methane cycle) in freshwater sediments of the maritime Antarctic (King George Island), a place in which it has not been studied previously.

Assessment of phosphocalcic and thyroid metabolism in the Uruguayan Antarctic population.

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The inhabitants of the Antarctic detachments are exposed to extreme temperatures, low relative humidity, increased electromagnetic radiation and social isolation, experiencing prolonged periods of solar deprivation and UV exposure in the period from March to September. Previous Antarctic studies have focused on the study of Vitamin D and thyroid hormones. They have observed that serum Vitamin D levels decrease approximately half of the initial values during the winter months, and that prolonged stays in Antarctica are associated with a decrease in the concentration of T3 at the end of summer and an increase of the same during winter, with little hypophysarial response to these changes, a phenomenon described as Polar T3 Syndrome. Thyroid hormones play an important role in thermoregulation, contributing to cellular, cardiovascular and neuropsychiatric metabolism, as well as adaptation to environmental influences. This project pretends to understand the phosphocalcic and thyroid matebolism of the national Antarctic missions, in order to draw up strategies for monitoring and prevention in the health of the Uruguayan Antarctic endowments.

Human circadian rhythms challenged by Antarctic environmental conditions.

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In living beings, a periodic and quite predictable internal clock marks the passage of physiological, biochemical and behavioural functions that present daily rhythms called circadians. This internal clock has an endogenous character, since these rhythms persist even in conditions of constant illumination or darkness, but are synchronized daily with the cycle light-dark environment. Light is the timed environmental key par excellence and in human beings the most conspicuous circadian rhythm is the alternation between sleep (usually night) and wakefulness (usually day). Melatonin is a key hormone in these rhythms, and its secretion (by the pineal gland) is inhibited by exposure to light.

The conditions of constant darkness in winter and prolonged days in summer that occur in Antarctica generate a "natural laboratory" for chronobiological studies, especially when analyzing prolonged residences such as those performed by base crews that remain throughout the year. This residence exposes people to altered light conditions: excess light in summer and absence of light in winter. The most frequent symptoms reported in polar expeditions refer to circadian desynchronization, sleep disorders, cognitive performance impairment, negative affectivity and interpersonal tension associated with altered light conditions. In some cases, light therapies have been successfully applied to improve the well-being and performance of the people who make up the Antarctic endowments. This proposal constitutes the first approach to the study of changes in circadian rhythms and sleep habits in the members of a crew living on a Latin American Antarctic base.

PHYSICAL SCIENCES

Atmospheric monitoring of trace gases.

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The objectives of the project are: to carry out measurements using the DOAS technique, to investigate the presence of halogenated radicals and stratospheric ozone; to carry out measurements using the ToTaL-DOAS technique, using different elements of the landscape as targets; to study the technical feasibility of setting up a permanent measurement equipment at the base.

ENVIRONMENTAL MONITORING

Monitoring the presence of the non-native diptera *Trichocera (Saltrichocera) maculipennis* Meigen, 1818 (Diptera: Trichoceridae) at the Antarctic bases on and around King George Island.

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In the last few years the presence of non-native species has been recorded in Antarctica, being *Trichocera maculipennis* one of them. This insect belongs to the non-native Diptera Order of the Antarctic ecosystems, and its presence has been documented in that continent since 2013. Its biology, physiology, adaptation to the cold environment and the observation of adult specimens since 2006 in different Bases suggest an apparent successful adaptation in the Antarctic natural environment. However, according to Antarctic policies it is necessary to make the greatest effort to eradicate or control the populations of non-native organisms

in the area. Faced with this situation, this project proposes to provide useful information for the eradication and/or control of this invasive species in the Antarctic ecosystem. The objectives are: to contribute to the current knowledge of non-native diptera species, through systematic identification, on King George Island (Maritime Antarctica), focusing especially on *T. maculipennis*; to establish areas with reproductive activity whether spawning, emergencies and development of *T. maculipennis*. maculipennis; record emergency peaks to evaluate breeding seasons; provide an approximation of the dispersal radius of the species in maritime Antarctica; study the genetic structures of the population and possible demographic history after the Antarctic invasion of *T. maculipennis*; provide information to establish whether the presence of *T. maculipennis* on King George Island has been the result of one or more colonization events.