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.

SCAR-GIANT (Development of the Antarctic Geodetic Infrastructure) and SCAR-KGIS (King George Island Geographic Information System) projects.

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The activities to be developed are framed in two international cooperation projects promoted by SCAR: SCAR-GIANT (Antarctic Geodetic Infrastructure) and SCAR-KGIS (King George Island Geographic Information System). The main objective is to establish and maintain a High Precision Geodetic Infrastructure, in order to be able to georeference any geographical object located on the earth's surface. With the installation of semi-permanent and permanent Passive (boundary markers) and Active (CORS) Stations, it is possible to study different geodesic and geophysical components (tides, movements and cortical deformations, marine currents, wind, temperature, atmospheric pressure, humidity, others) as well as to carry out topographic, geodesic, photogrammetric and geophysical surveys for different technical and scientific purposes. At the same time, it is intended to implement a Geographic Information System of King George Island (KGIS) with the main purpose of maintaining an integrated and updated cartographic and geospatial information base regarding King George Island. It is expected to make a digital surface model, a digital terrain model, contour lines every one meter (1m), an ortho-mosaic, and a 3D reconstruction of the environment of the Artigas Antarctic Science Base.

Monitoring of the average sea level in Peninsula Fildes, King George Island.

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This project encompasses two sub-projects that are carried out by the Military Geographic Service (MGS) and the Navy Oceanographic, Hydrographic and Meteorological Service (SOHMA). Through the installation of sensors and passive (landmarks) and active (CORS) stations, the aim is to determine with precision the variability through time of the Mean Sea Level (NMM), in the first instance until completing a nodal cycle (18.6 years), mainly in Maxwell Bay near the Artigas Scientific Antarctic Base (BCAA). The data obtained will allow to know the tidal regime in the area, help in the prediction and publication of the tide table for the BCAA, contribute to the historical database of mean sea level, and support logistic activities related to the coastline.

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

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The ExoMars mission is scheduled for March 2022 with the main objective of detecting possible evidence of past or present life on Mars and knowing the geological history of water on the red planet (ESA, 2013). Collecting the most valuable samples on Mars requires the ability to recognize the traces of habitability, their modifications over time, their significance and their preservation potential. A current and innovative approach to detecting past biological activity is the use of molecular markers as proxies. Molecular biomarkers are natural products that can be assigned to a particular origin, the most useful being organic compounds with high taxonomic specificity (limited number of sources and well defined) and high conservation potential (recalcitrant against geochemical changes). The structural and isotopic information in biomarkers allows them to be distinguished from abiogenic organic compounds, thus constituting an important tool in the search for extraterrestrial life. The main objective of this project is to characterize geochemically (biomarkers, isotopes and minerals) extreme environments present in King George Island and to 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 ESA's ExoMars 2022 mission.

LIFE SCIENCES

AntarPLAST: Plastic and microplastic waste in marine and coastal areas of Fildes Peninsula, King George Island (Antarctica).

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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. While 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, which does not escape this problem. Although not a significant source of plastics, these residues (macro- and microplastics) are accumulating along Antarctic coastal marine ecosystems, becoming a significant threat to their fragile biota and ecosystems.

Within the framework of this project we will generate an integral diagnosis (for a future monitoring program) of plastic and microplastic residues in Antarctic marine-coastal areas, focusing on the Fildes Peninsula but extending the study radius to other islands of the South Shetland and Antarctic Peninsula in coordination with other Antarctic Programs. To this end, the presence of these residues will be evaluated on beaches and rocky coasts, in surface marine waters, and on the seabed. We will also analyze the terrestrial contribution of these residues through the glacier melting ravines, as well as the consumption of microplastics by zooplankton and seabirds, as well as 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.

Evaluation of the structure of the sound landscape and the incidence of anthropogenic noise on Ardley Island (Maxwell Bay).

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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.

Production of polymers from Antarctic microorganisms.

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In recent years, awareness of pollution caused by plastics has led researchers to focus on biomaterials that are more environmentally friendly. Polylactic acid (PLA), a biopolymer obtained by polymerising lactic acid units, has become one of the most studied and promising options to replace plastic, compared to other bioplastics such as PHB (polyhydroxybutyrate) or PBS (polybutylene succinate). PLA is the only bioplastic produced on an industrial scale, as it is much cheaper to produce than the other biopolymers mentioned above. However, what makes this polymer really interesting is the possibility of

being completely degraded under composting conditions, or converted to its monomer for reuse. The current techniques of polymerization of lactic acid to give PLA, require the use of solvents, high temperatures and organometallic catalysts that result in the generation of chemical effluents, not very friendly with the environment. For this reason, the possibility of using enzymes for the polymerization of LA to PLA could result in a more environmentally friendly option, avoiding the generation of toxic residues.

Lipases from Antarctic microorganisms can maintain high levels of enzymatic activity at low temperatures. This feature would reduce or even avoid the generation of toxic residues on the polymer, as well as reduce the amount of chemical effluents and avoid the use of excessive amounts of energy. The general objective of this proposal is to select and obtain lipases from Antarctic microorganisms, capable of polymerizing LA in the production of PLA biopolymer, as well as to contribute to the knowledge of Antarctic microbial populations and their potential biotechnological application.

Biogeochemical cycle of methane in Antarctic lake sediments on King George Island.

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

consumption (methane cycle) in freshwater sediments in maritime Antarctica (King George Island), a place where it has not been previously studied.

Risk factors for human health in the Antarctic: assessment of phosphocalcic metabolism

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The inhabitants of the Antarctic bases are exposed to risk factors such as extreme temperatures, low relative humidity, increased electromagnetic radiation, social isolation, prolonged periods of solar deprivation and UV exposure, in addition to certain pathogens. Previous Antarctic studies have focused on the study of Vitamin D and thyroid hormones. They have observed that serum levels of Vitamin D decrease by approximately half of the initial values during the winter months, and that prolonged stays in Antarctica are associated with a decrease in T3 concentration at the end of the summer and an increase in it during the winter, with little pituitary 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 to adaptation to environmental influences.

There is a great diversity of human pathogenic micromycetes, which inhabit various areas of the planet. Some of these microorganisms use as a source of nutrients the nitrogen contained in the excrements of different birds, bat guano, among others. The increase in the introduction of exotic species in the white continent, either due to the increase in human presence or climate change, could favor the introduction and adaptation of micromycetes fungi species, representing a potential risk for researchers who during the summer months work in close contact with the different populations of marine birds that inhabit King George Island.

This project aims to understand the phosphocalcic and thyroid metabolism of the Uruguayan Antarctic endowments, in order to trace health monitoring and prevention strategies and to evaluate the potential risk of exposure of the different groups of scientists working with penguin colonies on King George Island.

Distribution, ecology and abundance of cetaceans in the Southern Ocean.

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The Southern Ocean is a highly productive ecosystem. Fundamentally in the summer months, in Antarctic waters the optimal conditions of light and nutrients are generated that allow to sustain a high concentration of primary producers. It promotes the development of primary consumers and organisms belonging to higher trophic levels including krill, seabirds, pinnipeds and cetaceans. Like other top predators, cetaceans play a key role in Antarctic ecosystems by structuring communities. Several species of cetaceans, particularly whales, migrate to polar waters during the summer months to feed in their productive waters. The distribution of different cetacean species and their use of Antarctic waters will be influenced by a combination of their evolutionary history, resource requirements, intra- and inter-specific interactions and environmental conditions, as well as by disturbances that may occur through human actions (e.g., Antarctic tourism, krill fishing, pollution). In turn, there is empirical evidence showing how variation in productivity affects marine mammal communities, and its importance in assessing the effects of climate change. It is hypothesized that changes in climate would have an important effect on marine productivity and on the structure of communities belonging to low, medium and high trophic levels. Understanding the distribution patterns of species and identifying their drivers, as well as knowing their density and abundance patterns and how they vary over time, is therefore essential to understanding the effects of climate change on the Antarctic ecosystem and informing spatial conservation planning.

This project aims to contribute to a broader understanding of the basic patterns of diversity, distribution, ecology and abundance of cetaceans in Antarctic waters. Data for this project will be obtained from sightings of cetaceans recorded aboard opportunity platforms, i.e., boats sailing in Antarctic waters. The study area will include the proximities of the Antarctic Peninsula, mainly the areas of the Bransfield Straits, Gerlache and the area to the east of that peninsula. Using a cluster modeling approach, which combines different species

distribution modeling methods, the distribution patterns of cetaceans in relation to environmental variables in the Southern Ocean will be investigated. At the same time, estimates of density and abundance of cetaceans in different areas of Antarctica will be carried out, depending on the available logistics. Finally, synergies will be generated with other international projects in order to contribute with population studies of cetacean species found in Antarctic waters through sampling (photo-identification and collection of biopsies) at points of opportunity. It is expected that the results generated throughout this project will contribute to the monitoring of the different populations of cetaceans, improving the understanding of the effects of climate change on cetacean communities in particular, and the Antarctic ecosystem in general. Finally, it is intended to contribute useful information for the prioritization of spatial conservation in Antarctica.

Multi-compartmental study of persistent organic pollutants in Fildes Peninsula, King George Island, Antarctica.

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Persistent organic pollutants are man-made toxic substances and, as their name implies, they are persistent because they are difficult to degrade. This characteristic makes them a group of pollutants of international interest due to the impact they have on the environment. Their persistence and toxicity added to the fact that they are transported globally mainly by atmospheric and maritime means that they are present in systems or regions that are very isolated geographically, such as Antarctica. In this context, this project proposes to study the transport and destination of several organic pollutants of international priority in the Antarctic continent. The objective of the proposal is to know and characterize the main persistent organic compounds and their concentrations in different environmental compartments (air, lagoon sediments, marine sediments, sea water and snow) and plastic residues that are originated and/or transported to Fildes Peninsula on King George Island in Antarctica. The aim is to establish current levels as a baseline for the

generation of a monitoring program to study the evolution of this type of pollutants in Antarctica.

New strategies for the control of the non-native diptera Trichocera (Saltrichocera) maculipennis Meigen, 1818 (Diptera: Trichoceridae) at the Antarctic bases of King George Island and its surroundings.

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In recent years the presence of non-native species has been recorded in Antarctica, *Trichocera maculipennis* being one of them. This insect belongs to the non-native Diptera Order of 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 natural Antarctic environment. However, in accordance with Antarctic policies it is necessary to make the greatest effort to eradicate or control the populations of non-native organisms in the area. In view of this situation, this project proposes providing useful information for the eradication and/or control of this invasive species in the Antarctic ecosystem. The objectives are: continuous monitoring of *T. maculipennis* in the BCAA; description of the life cycle of *Trichocera maculipennis* under controlled laboratory conditions for the BCAA; analyze the possible existence of morphological heteromorphisms in the populations of *Trichocera maculipennis* on King George Island, using geometric morphometry; estimate the genetic diversity of *Trichocera maculipennis* in the populations of King George Island.

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.

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.

ENVIRONMENTAL MONITORING

Penguins as sentinels of anthropic impact and climate change in the Antarctic ecosystem.

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Penguins are considered sentinels of the marine environment, since due to their status as top predator, they are capable of rapidly reflecting environmental changes in the marine environment. The rapid global warming observed in the Antarctic Peninsula region, the greater inter-annual variability in the concentration and extent of sea ice and the reduction in the abundance of Antarctic krill (Euphausia superba), have resulted in significant changes in population trends of penguins of the genus Pygoscelis.

Ardley Island, southeast of Peninsula Fildes, on King George Island, is a Specially Protected Antarctic Area (ZAEP No. 150) and one of the few areas in Antarctica where three species of penguins of this genus reproduce sympatrically. Particularly on this island, there has been a 90% decrease in the number of breeding pairs of Adelie and Barbijo penguins, while Papua has increased by almost 80% since the 1980s. On the other hand, Peninsula Fildes represents an important logistic centre for the South Shetland Islands and the Antarctic Peninsula, being the area with the highest density of scientific stations and refuges in Antarctica, and a high level of navigation activity in its surroundings. In this context, these penguin colonies can be used as sentinels to understand the effects of different sources of anthropogenic pressure, such as tourism or fishing and climate change, in an area heavily subjected to these pressures.

Monitoring and control of a non-native diptera in the BCAA and its zone of influence.

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Biological invasions are produced by non-native species and are one of the most important threats to biodiversity worldwide, threatening the survival of native species and responsible for major changes in ecosystem structure and functioning. In Antarctica, despite the isolation and harsh climatic conditions, the spread of non-native species also occurs. Particularly on King George Island, a species of non-native diptera (Trichocera maculipennis) originating in the northern hemisphere has spread to most bases, including the Artigas Antarctic Science Base. This activity aims to better understand the life cycle of the species for information on which are the critical sites and moments in which it is best to implement control measures to prevent its growth and dispersion. At the same time, work will be done to generate new control measures that are compatible with the environmental regulations that govern Antarctica.