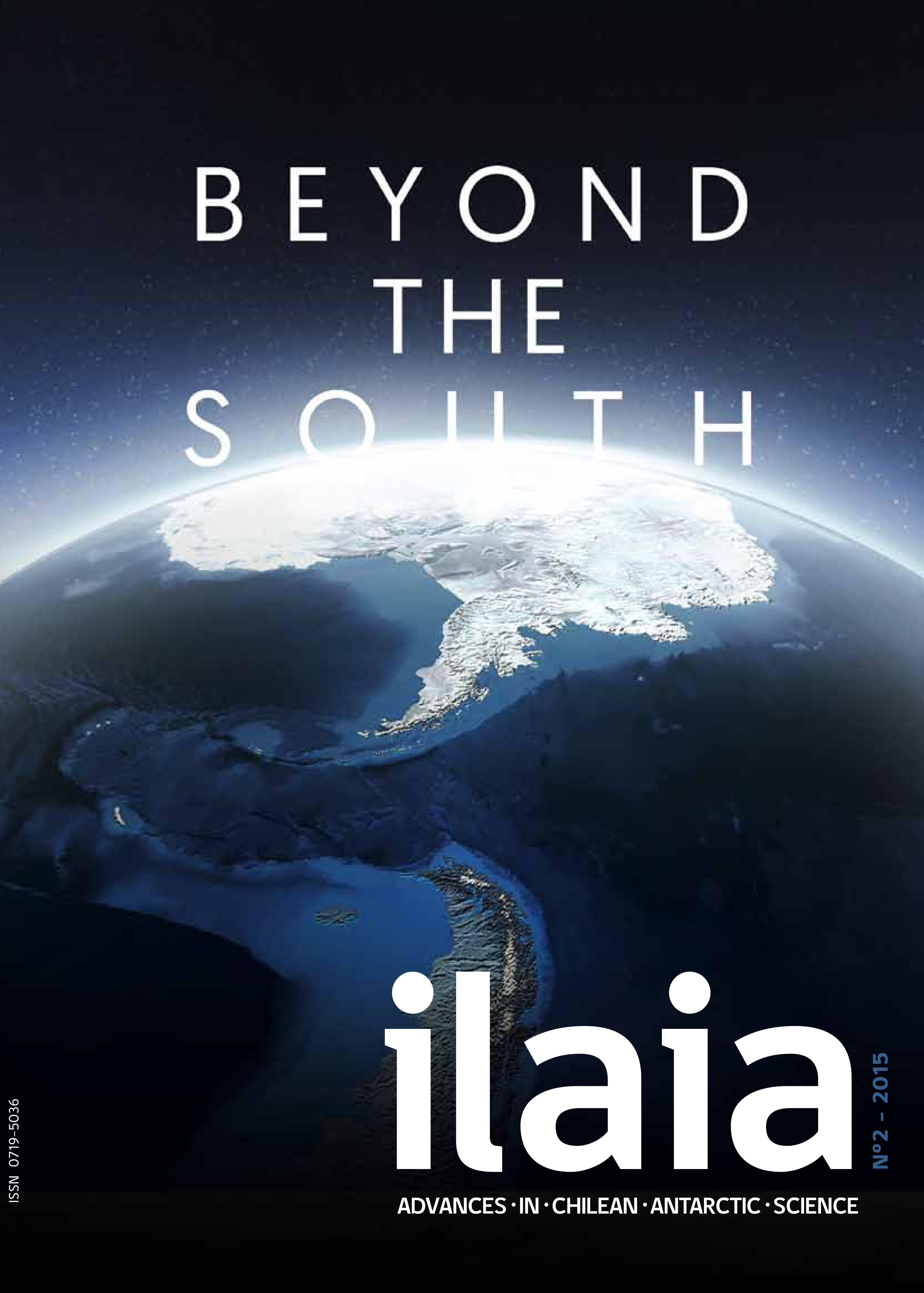

BEYOND THE SOUTH

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ADVANCES · IN · CHILEAN · ANTARCTIC · SCIENCE

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CONTENTS

EDITORIAL

It was a poet, the unforgettable Peruvian César Vallejo, who wrote “el viento cambia de aire” - an allusion to the “winds of change.” And this is precisely what I feel at times while walking along the streets of Punta Arenas. I sense that this wind that has been around us all our lives brings changes on the air as it fills its lungs with a polar spirit.

The fact is that with each passing day the Government of Chile and its scientific advisers increase their conviction that the White Continent is a window into a new world of knowledge and development as well as a lighthouse warning us of the dangers of a warming world. And similarly, every day Antarctica breathes its life into the historic streets of this southernmost city, the streets where De Gerlache, Arctowski, Charcot, Amundsen, Scott and Wilson, Shackleton, Pardo, Byrd, and others walked not so long ago. Today, the avenues of Punta Arenas are visited by hundreds of scientists from 20 countries en route to Ilaia, "beyond the south."

Our work in recent years has been focused on creating conditions to increase the potential for collaboration with Chile in the realms of polar science, logistics, education, and politics. Therefore, this year's Chilean Antarctic Science Program will include more than 80 projects, grouped into six lines of research, which in turn are associated with the new SCAR programs.

Along with providing greater resources for these projects to allow year-round work, the Chilean Antarctic Institute (INACH) is projecting investments in infrastructure and logistics along the Antarctic Peninsula, in Escudero (62° 12’ S), Yelcho Station (64° 52’ S), and Carvajal Stations (67° 46’ S) and selecting science projects for the Union Glacier site (79° 46’ S, 82° 54’ W). The first fruits of these efforts can be seen in two articles in this edition of Ilaia.

Every work platform and installation that Chile has made available to its scientists has also been made available for collaborative use by other countries, as we believe that such collaboration accelerates the growth of our own science. During the last Chilean Antarctic Expedition, the scientists and Antarctic programs of at least twelve countries (Germany, Brazil, Bulgaria, China, Republic of Korea, Spain, Poland, Portugal, Russia, United States, United Kingdom and Venezuela) worked with us. In addition, researchers from several other countries participated with our scientists at all the Chilean bases, as part of the international collaboration that we encourage.

We take great pride in reporting that implementation of a Chilean Government' Special Program for Development of the Remote Regions got underway in 2014, which included provisions for the construction of an International Antarctic Center that will make the Magallanes region a center of excellence for Antarctic research, outreach, and logistics. In this we see another example of the decisive actions that are moving Chile forward.

It is Antarctic air that we breathe here as well as in Washington DC, Incheon, Lisbon, Cambridge, Saint Petersburg, Madrid, Sofia, Warsaw, Shanghai, and so many cities in which the Frozen Continent provides an inspiration for the scientific community.

The winds of Antarctica are whispering in our ears. It is the air that unites us, and brings us closer together.

DR. JOSÉ RETAMALES ESPINOZA
Director
Chilean Antarctic Institute


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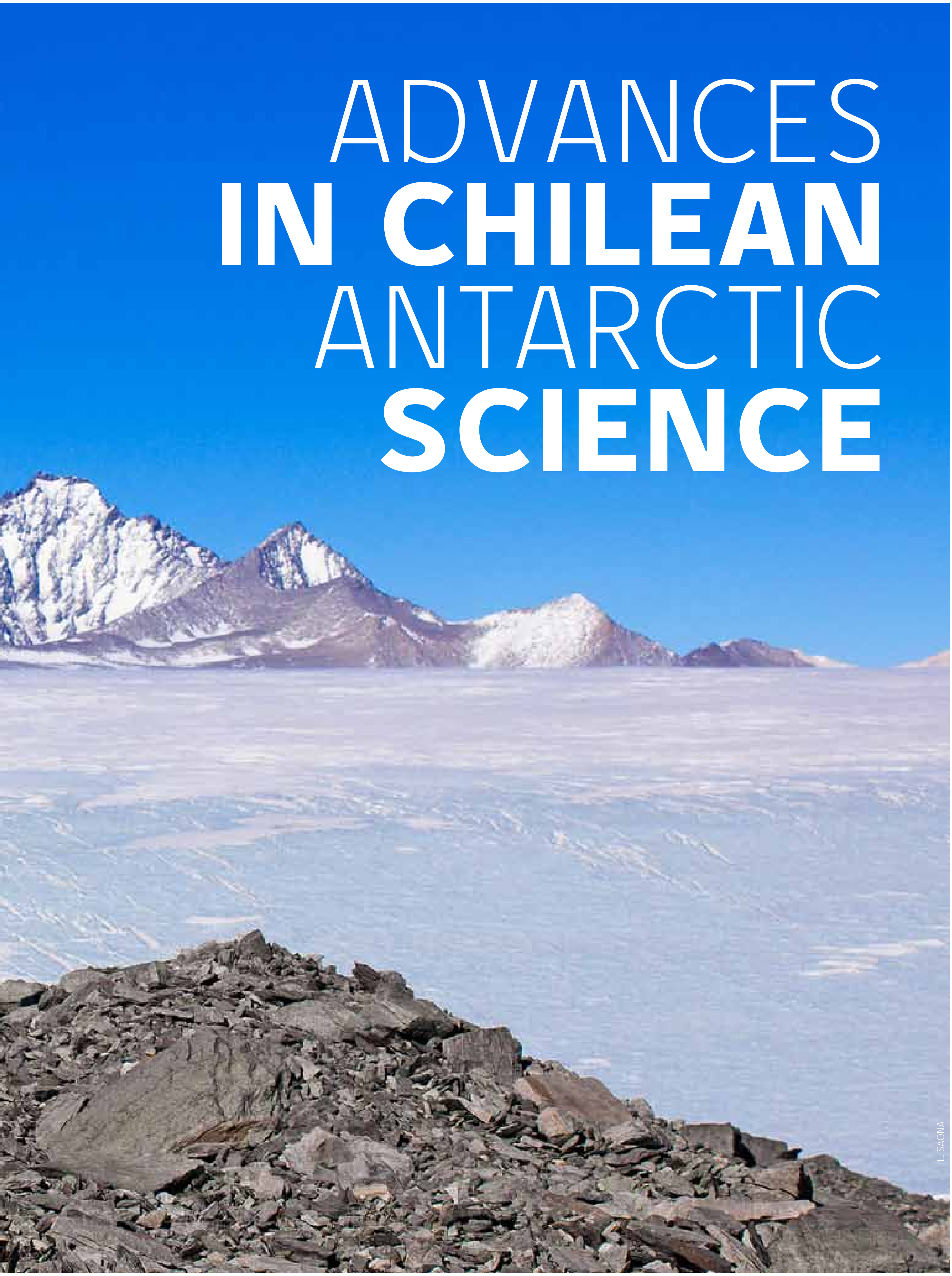
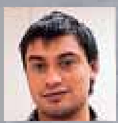
INACH

ADVANCES **IN CHILEAN** ANTARCTIC **SCIENCE**



DEEPER ANTARCTICA:
THE NEW CHALLENGE

Union Glacier is just 1080 kilometers from the South Pole, but at the end of 2014 it saw the arrival of the most varied group of Chilean scientists ever to reach that extreme point on the planet. For a month, fifteen researchers worked thirteen projects that focused on diversity and functionality of the microbiota there, along with studies of the optical properties of the Antarctic cryosphere and how it is affected by climate change, along with a search for photosynthetic bacteria and other organisms to understand their adaptation and ecological role. All told, eight Chilean scientific institutions participated in the expedition. This article describes some of the circumstances and results of that undertaking.

Jorge Gallardo C. and Pablo Espinoza
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When we talk about Antarctic exploration the image that immediately comes to mind is Ernest Shackleton's expedition, and the ship *Endurance*, lost after being crushed by ice in a frozen sea. We think of the crew's difficult journey towards Elephant Island, and the suffering of the small group that accompanied Shackleton in the perilous crossing to the South Georgias.

The collective memory recalls fewer details of the voyage of the cutter *Yelcho* under the command of boat-pilot Luis Pardo Villalón, who successfully rescued the crew of the *Endurance* on August 30, 1916. In those days, in our modern opinion, supremacy existed as a function of the presence and conquest of places not previously explored. Amundsen had already reached the South Pole and then Scott shortly afterward, the latter to perish on his return. Shackleton's undertaking had as its principal objective a trans-Antarctic expedition - to cross the continent by passing through the pole.

Today we continue to visit Antarctica, though our interests now are different, our means of transportation are faster and safer, and our bases that range from the South Shetland Islands to those within the Antarctic Circle now provide comforts unimaginable to the travelers at the beginning of the 20th century.

Today we undertake exploration in Antarctica with a new vision, one that focuses on science. We are now seeking evidence that will allow us to understand the flora and fauna there, and particularly their physiological adaptations and how those are written into their genetic code as well as clues to let us reconstruct the environment that must have existed in Antarctica before it separated from the continent of South America. We hope to determine how we might apply this knowledge to provide solutions for our immediate needs in areas such as agriculture, medicine, and industry.

L.SAONA

Without a doubt, Chile has taken an enormous step forward in extending its scientific research into the Antarctic Circle. This is a challenge that would be impossible without the cooperation of all the key players in Antarctic operations.

Chile reached a milestone in 2014 in the area of its biological research efforts. During one month, from the 20th of November through the 15th of December, there were 15 researchers at the Union Glacier (79º 46′ S / 82º 54′ W), including 13 from Chilean research organizations, and two from foreign universities. Their objective was conduct study projects to characterize living organisms there which have the ability to grow under such adverse conditions, with temperatures that can reach minus 50 degrees Celsius and the total absence of precipitation.

This expedition was assembled into two groups which remained for ten days ranging, exploring, and taking samples from several sites near the encampment. The first group was somewhat diverse with respect to its scientific disciplines, from glaciologists to biotechnologists. It included Patricio Flores (Fundación Biociencia), Salvador Barahona (University of Chile), Raúl Cordero (University of Santiago de Chile), Sarah Feron (University of Leuphana, Germany), and Francisco Fernandoy and Delia Rodríguez (both from the Andrés Bello University, in Concepción).

The second group consisted primarily of microbiologists, botanists, and biotechnologists, assembled by Reinaldo Vargas (Metropolitan University of Sciences and Education), Rodrigo Contreras (University of Santiago de Chile), Yuly López (University of Concepción), Carlos Areche (University of Chile), Luis Saona (Andrés Bello University, Santiago), Vicente Durán (Andrés Bello University, in Santiago) and Juan Carlos Aravena (University of Magallanes).

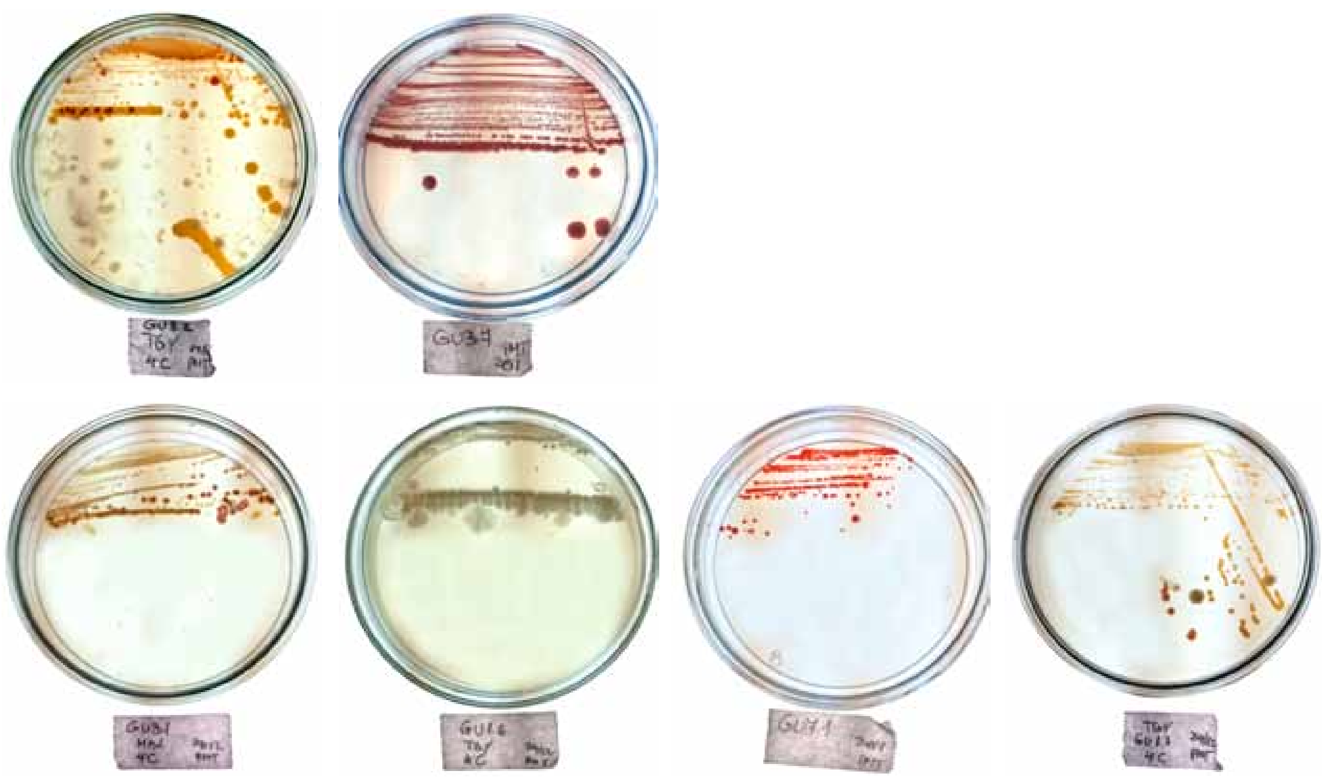
During the entire time, the INACH coordination team consisted of Jorge Gallardo (the chief scientist for the expedition) and Ricardo Jaña, together with the engineer Pablo Espinoza.

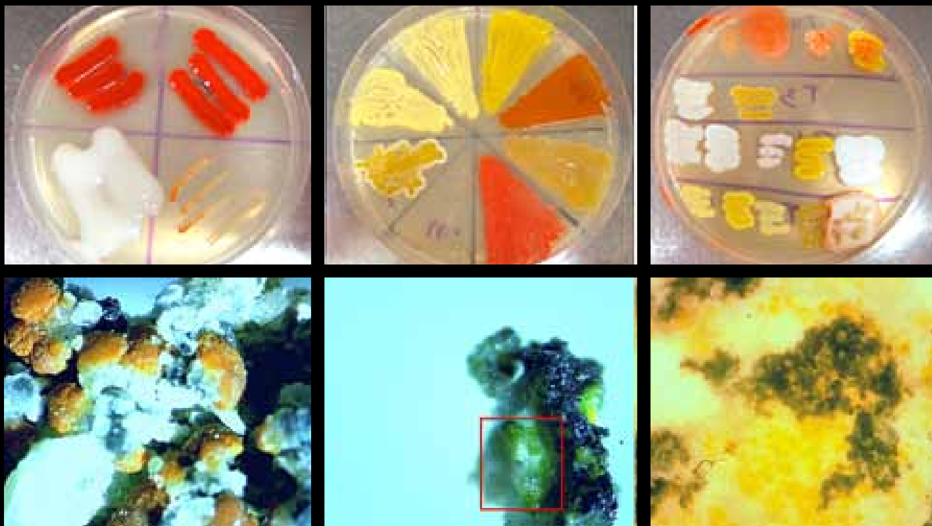
The researchers conducted a number of reconnaissance activities, as well as collecting samples and taking field measurements. For this the team received the air transport support of the Chilean Air Force and its two DeHavilland Twin Otter aircraft, whose crews shared in the mystery and excitement of scientific exploration. They took our team to places that would otherwise have been inaccessible, assisted in the acquisition of scientific equipment and helped in the planning during many months prior to our departure.

On the other hand, travel overland was supported by specialized personnel from the Chilean Army, who assisted us in the mountaineering training necessary to let us conduct our field work safely. And we cannot fail to mention the important support of the Chilean Navy, which kept our spirits high while organizing the base camp for our work and providing hearty food for us under difficult circumstances.

Scientific Impacts

Back in our laboratories with the samples and data gathered at the Union Glacier, we have been able to cultivate bacteria that show the ability to grow in media with very low levels of nutrients and under low temperatures (Figure 1), several yeasts which product pigments (Figure 2), a dozen lichens (Figure 3) - many of which not described and other finds that we are still analyzing.





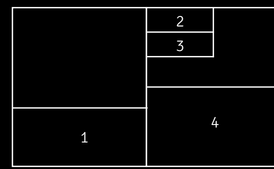


Figure 1. Bacteria isolated by Dr. Patricio Flores at the Fundación Biociencia laboratories.

Figure 2. Yeast isolated by Salvador Barahona (University of Chile) in Dr. Marcelo Baeza's laboratory.

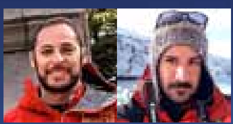
Figure 3. Lichens from Rossman Cove.

Figure 4. Group of researchers at Union Glacier. "Elephant head" sector. Yuly López, Carlos Areche, Luis Saona, Rodrigo Contreras, Juan Carlos Aravena, Reinaldo Vargas, Vicente Durán. Behind: Pablo Espinoza.

The possibilities are practically limitless for a country such as ours, with applications and solutions for industry that range from copper bioleaching (oxidation of minerals to obtain the valuable metal) or to provide added value through the use of bacteria that are capable of being incorporated into molecules with medicinal applications, or even biological solar energy production. Or proteins with unique adaptation which allows them to preserve biological material at very low temperature, a process called cryopreservation, which will have a tremendous impact not only in science and medicine but also in our economy. The understanding of how climate change affects atmospheric processes related to the Antarctic continent and the effects on global equilibrium, will allow us to make better decisions to mitigate the adverse impacts that global warming could have for our country. Even today, with all of our developments and comforts, we cannot forget the true sense of what it means to explore Antarctica. We are scientists, and there are probably many who think that our proper nature is to be at a desk or behind a microscope. But I have shared this adventure with researchers who would take these words as their own, as they were written by Luis Pardo Villalón to his father before leaving to rescue the crew of the *Endurance*:

"The task is great, but I am not afraid: I am a Chilean. There are two things that make me wish to face these dangers: to save the explorers, and to bring glory to Chile. I will be happy if I can accomplish what others have been unable to do. If I fail and die, you will have to take care of my wife Laura and my children, for they will be left with no support but yours. If I am successful, I will have done my humanitarian duty as a sailor and as a Chilean. When you read this letter, your son will be either dead or will have brought the shipwrecked men to Punta Arenas. I shall not return alone."

THE UNION GLACIER:
MICROORGANISMS AT THE FRONT DOOR OF THE SOUTH POLE



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Water is one of the essential elements of life since it is the medium for biological processes, for molecular transport, for regulation of pH, and for the stabilization of macromolecular structure. Availability of water can be limited as it passes between the liquid and solid (ice) and this can pose problems for biological processes and survival of organisms.

Many microorganisms that live effectively in cold environments (psychrophiles) experience frequent phases of low temperature and freezing. These organisms enhance their survival at temperatures below zero degrees Celsius by producing what are known as AFPs: Anti-Freeze Proteins.

AFPs have been described in scientific literature. However, very little is known about AFPs in bacteria. The harvesting of AFPs from Antarctic bacteria and studies about their means for adaptation to the Antarctic cold may provide insights into the complexity of the cellular mechanism for dealing with this type of stress. Likewise, psychrophillic microorganisms use all of their metabolic resources to optimize their survival under extreme low temperature conditions, and represent an inexhaustible supply of proteins with unique properties.

Figure 1. The scientific expedition on the Union Glacier. Here you see a group of scientists looking for samples to later isolate the microorganisms. They are assisted by Chilean military personnel who specialize in glacier travel and assure the safety of the team.

Water helps in the stabilization of macromolecular structures and provides the medium to allow biological reactions to take place, as well as for molecular transport and pH regulation. Limited access to water due to physical phase changes (from liquid water to ice crystals) may be prejudicial to the proper functioning and survival of organisms.

Many cold-adapted microorganisms, called psychrophiles, experience frequent phases of low temperature and freezing. These organisms enhance their survival at temperatures below zero degrees Celsius through several means, among them the production of materials known as AFPs: Anti-Freeze Proteins.

These AFPs were first encountered in ocean fish during the 1960s and their activity was described as a defense against freezing, effectively reducing the freezing point of the organism's blood or hemolymph, allowing fish and insects to survive at temperatures below zero degrees Celsius, conditions to which they are exposed in their natural environment.

AFPs have been isolated, identified, and described from several sources, including insects, fish, molds, diatoms, and bacteria, among others. However, little is known about the proteins that are responsible in bacterial activity for inhibition of recrystallization of water molecules. The activity that provides inhibition of recrystallization (IR) is the ability to prevent the formation of normal ice crystals, while allowing smaller crystals, possibly to protect the cell membranes from injury during freezing.

Recrystallization takes place rapidly at temperatures just below zero degrees Celsius, lowering the freezing point of a solution that contains ice without significantly influencing the fusion temperature of ice (thermal hysteresis).

These proteins are a point of industrial interest, since recrystallization inhibition during freezing and thawing, and the neutralizing of ice nucleation effects, have made these proteins promising natural modulators for the cold-storage of cells, tissue, and general food stocks.

This could represent an improvement in the preservation of food products and the maintenance of their physical properties during temperature fluctuations involved in freezing during storage or during transport. This is of vital importance for the texture of frozen food products, particularly those that are eaten while frozen (such as ice-cream and ice-juice items). The use of AFPs in these products could preserve the smooth and creamy texture of certain high-quality products. Likewise AFPs could be useful for foods that are eaten after thawing, such as meat and fish, since large inter-cellular ice crystals damage the product membranes, causing leakage, turning a frozen product into a lower quality item due to a reduction in its capacity to retain water and the loss of nutrients from tissue.

Some food items such as strawberries, raspberries, and tomatoes cannot be frozen without a loss of quality, due to damage to cell structures during freezing which results in changes to the product texture and flavor. Using AFPs at low temperatures could maintain cell integrity through maintaining the formation of only smaller and less damaging ice crystals during the freezing process.

There are studies surrounding the presence of microbial life in glacial ice. Several patterns of microbial populations have been found there, the result of varying climatic conditions down through history. For this reason, the continuous low temperatures of the polar regions present the highest probability of harboring psychrophillic bacteria colonies that possess AFPs.

A visit to the Union Glacier under the auspices of the 51st Chilean Antarctic Science Expedition has offered a unique opportunity to study psychrophillic microorganisms, since all the reasons that justify this search are magnified here (Figure 1). The temperatures here are the most extreme of any found on the Antarctic Peninsula, while accessibility and the risk of human contamination are limited. In fact, the difficulties of getting to this area have largely prevented microbiological studies to the point that there are no microorganisms isolated and described from this location. What is more, the extreme environmental conditions further complicate the existence of life here, even for the rather select group of extremophile microorganisms. As a result, new and adapted techniques will be needed for the study and isolation of these life forms.

Our arrival at the Union Glacier was an unforgettable experience, ranging from preparations for the trip, to training in roped-up techniques for walking safely on the glacier, and finally the landing itself of the Chilean Air Force C130 Hercules aircraft on the enormous blue ice runway.

Without a doubt, our first encounter with the glacier's environmental conditions was a hard lesson, dealing with powerful winds at the runway and the cold that was exacerbated by the wind-chill. Nevertheless, all of this passed into the background once we saw the majestic enormity of the ice and the huge mountains that at first seemed to be just a few meters from us. After seven hours of travel from Punta Arenas and another 30 minutes from the runway to the Union Glacier base, and arriving at two in the morning, it was not easy to fall asleep that first night, perhaps due to the round-the-clock sunlight and the excitement of the opportunity to be in the presence of one of the most beautiful and least explored parts of the Earth.

Every day was a different sort of adventure, walking roped-up in teams on the ice, practicing randonee skiing in order to advance more quickly when the distances were greater, and climbing mountains to satisfy our principal objectives. Although the weather conditions remained favorable to us most of the time and it never got dark, our "day" became quite long, taking advantage of the time for excursions. Still, the wind speed at times complicated the safe landings and takeoffs for the two Twin Otter aircraft that the Chilean Air Force used to move us on longer sections. Even so, thanks to the considerable experience of the pilots and the aircraft availability we were able to sample at locations some distance from our base, sometimes as far as 80 km away.

During the 15-day expedition on the Union Glacier, we were able to visit five different locations, with the most remote being 70 km from the base. At these places we collected sample of ice, dirt, and rocks, for a total of 26 samples that will assure the isolation of the greatest selection of psychrophillic microorganisms possible (Figure 2).

INACH has financed the project entitled "Isolated anti-freeze proteins from Antarctic psychrophillic microorganisms," which will produce studies of how the psychrophiles adapt to extreme environments, particularly those with limited moisture due to the low temperatures. Keeping in mind that this opportunity to travel to such a remote location is a rare privilege for Chilean science, we see ourselves obligated to not only continue to contribute through this project, but also to develop further lines of research by using the collected specimens.

For now, only a short time since the conclusion of this expedition, we are working at the Fundación Biociencia laboratories to isolate the psychrophillic microorganisms from the samples we collected at the Union Glacier.

In the samples we collected we have found several microorganisms that grow at low temperatures, with varying morphological characteristics, with the most significant of those being in the shape of a staff (Figure 3). There are also some with varying pigmentation, with some microorganisms in shades of red, yellow, and orange, while others have no apparent color at all. Growth time is rather long, calling for at least a month to allow their development to be observed on solid media, which presents a problem we need to overcome, to discover optimal cultivation conditions. We have also made an initial selection of these microorganisms based on their ability to survive freezing and thawing cycles, for the purpose of determining those which may produce AFPs for survival under the pressure exerted by the ice. We hope to continue this isolation and characterization work in search of AFPs and other compounds which may have industrial applications. Undoubtedly this will be a long process and it has only just begun, but the results are promising considering the advances made to date. It is hoped that in the coming months we will be able to isolate, characterize, and identify a larger number of these microorganisms for subsequent study of their adaptation mechanisms, including the AFPs. Then we hope to publish the results in international-level magazines in as short a time as possible.

Figure 2. Taking an ice sample from the glacier. The samples were taken using ice-screws inserted 20 cm into the glacier surface.

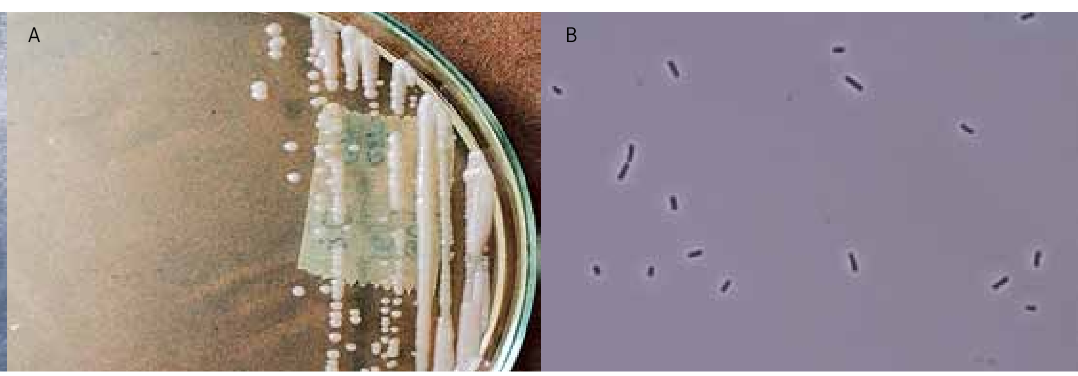

Figure 3. A culture of microorganisms. A) A Petri dish with a cream-colored colony corresponding to psychrophillic microorganisms. B) A phase-contrast optical microscope view of bacillary forms of this microorganism.

J. PLANA

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THE WINTER JOURNEY
OF THE HUMPBACK WHALE

Just where do the southern hemisphere's humpback whales go in the winter? In the summer, they feed in the icy waters of the Antarctic Peninsula as well as in the Straits of Magellan and the Gulf of Corcovado, but very little is known about where they go in winter, for their breeding v season. The answers may be found in the project called "Winter migrations of *Megaptera novaeangliae* that feed in Antarctic and Chilean continental waters, revealed through photo-identification analysis" – a project financed by the Chilean Antarctic Institute (INACH) that obtained previously unimaginable contributions to the knowledge of these majestic mammals.

Figure 1. Examples of humpback whales in waters of the west coast of the Antarctic Peninsula.

J. PLANA

Figure 2. Example of a humpback whale in the Straits of Magellan.

The humpback whale (*Megaptera novaeangliae*) is one of the species of large whales that has attracted considerable attention by researchers largely because it is one of the few species of whales with habitual presence in coastal waters, both during breeding and feeding, and for that reason it allows greater opportunities for study.

Nevertheless, humpback whale population units in the southern hemisphere (seven such breeding units are known) have received much less study than those in the northern hemisphere. For example, many important demographic parameters such as migratory movement patterns among the respective breeding and feeding areas, to name just one, are only conjectural for several southern hemisphere populations.

Migratory patterns for the humpback whale population group in the southeastern Pacific between high and low latitude locations were only recently developed, during the 1990s. At that time one whale was photographed in waters near the coast of the Antarctic Peninsula during the southern summer-autumn season. The same animal was photographed four months later off the coast of Colombia, confirming the speculation of the whalers of old about the relationships between certain individuals found in lower latitudes (in areas associated with reproduction) and those in higher latitudes (in feeding areas, including the Antarctic Peninsula).

Fourteen years later, in 2004, studies of these migratory patterns extended to the coast of Ecuador. Nevertheless, in recent years the spacial displacement of this humpback population took on greater complexity as it was learned that their breeding area reached as far as the coasts of Costa Rica in the north to as far south as Peru. Then the range of feeding areas grew to include the coasts of Chile, including the Straits of Magellan. More recently the Gulf of Corcovado has been added to the latter, becoming the only feeding area outside the limits of the Southern Ocean and the entirety of the southern hemisphere.

Understandably, it is essential to consider the winter migrations of the humpback whales in order to put together a new and more comprehensive structural model of their movements. In time this will help to define the boundaries for their management and conservation.

In spite of the present condition which acknowledges a large single area for humpback reproduction (from Peru to Costa Rica) and the movement of individuals to three discrete feeding areas (Golf of Corcovado, Straits of Magellan, Antarctic Peninsula) there is some earlier evidence suggesting the tendency of the Straits of Magellan group to migrate to further north, to Central America, while those that feed in the Antarctic Peninsula typically migrate to the waters of Ecuador and Colombia. The migrations of the humpbacks that feed in the Gulf of Corcovado is now under study.

An extensive international photo-identification research effort for humpback whales includes Brazil (with one institution), Chile (three), Peru (one), Ecuador (three), Colombia (two), Panama (two), and Costa Rica (two), along with contributions from third parties. The result includes catalogs of from dozens to hundreds of photos of individual humpbacks that have been sighted, with images of caudal fins, whose black and white coloration along with other secondary features serve as a sort of unique fingerprint which identifies each individual.

This effort has created the first photo-identification population for humpback whale populations in the southeastern Pacific, with

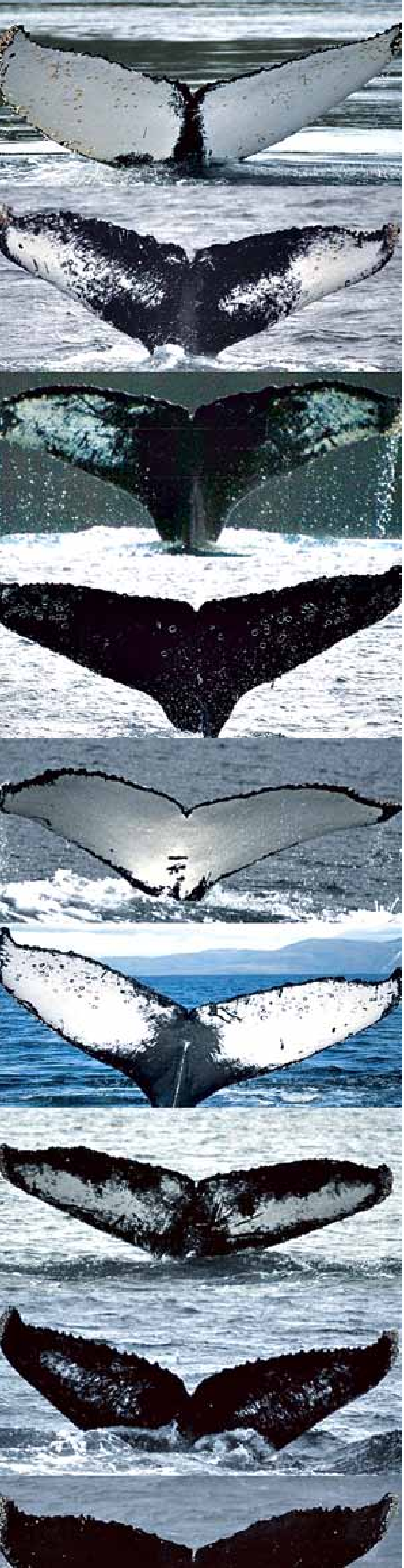


Figure 3. Color patterns on humpback whale caudal fin ventral surfaces.

the intent to identify winter migratory destinations and to postulate possible humpback migratory patterns for those whales that feed in either Antarctic or Chilean continental waters.

In the first phase of our work in this project ("Winter migrations of *Megaptera novaeangliae* that feed in Antarctic and Chilean continental waters, revealed through photo-identification analysis") (financed by the Chilean Antarctic Institute) there were more than 6000 caudal fin photographs assembled in 16 catalogs. Many of the images were enhanced with modified brightness and contrast for more effective use in identification.

For the process of comparing caudal fins photos (searching for the same individual in different locations) a computer based system was developed, using a single integrated image database where each caudal fin is identified by its color pattern along with other secondary features. The automated system speeds up the time needed to compare any given fin image with others in the database.

In the second part of the process there is a photographic comparison to quantify the number of migratory connections, which is to say how many individuals have been re-sighted in the feeding and breeding areas. We are also trying to determine if that are humpbacks associated with both the Gulf of Corcovado and the other two feeding areas, to see if there may be movement between these areas, to suggest the possibility that the northern Patagonian channels may be only a transit zone, for passing through briefly while traveling toward the more southerly locations.

Our results indicate that when comparing photo-identified humpbacks in the three feeding areas, there is an absence of common-animal sightings, suggesting that there is no movement or exchange of individuals between the three feeding zones, and thus likely that each such location should be considered a discrete feeding location.

The analysis of winter destinations shows 303 "recapture" events (or "re-sightings"- meaning that the humpbacks were photographed at least a second time) corresponding to 243 individuals. Beyond this, the humpbacks re-sighted around the Antarctic Peninsula and the Straits of Magellan have also been observed between the coasts in the north of Peru and those of Costa Rica, while the humpbacks from the Gulf of Corcovado, whose identified members are few, have presented only a few re-sightings and only in their most southerly breeding areas.

With respect to the humpback movement database, those whales that feed of the Antarctic Peninsula have so far shown a considerable tendency to winter around Machalilla (Ecuador), followed by the coast near Salinas, also in Ecuador, as well as central Colombian coasts. The winter locations along the north of Peru, the north of Colombia, Panama, and Costa Rica, all seem to involve a lower degree of use.

The humpbacks that feed in the Straits of Magellan show no known winter migration pattern to any specific locations. Nevertheless, accounts of re-sightings of certain individuals seem to suggest a tendency to winter over in more northerly areas, since those were

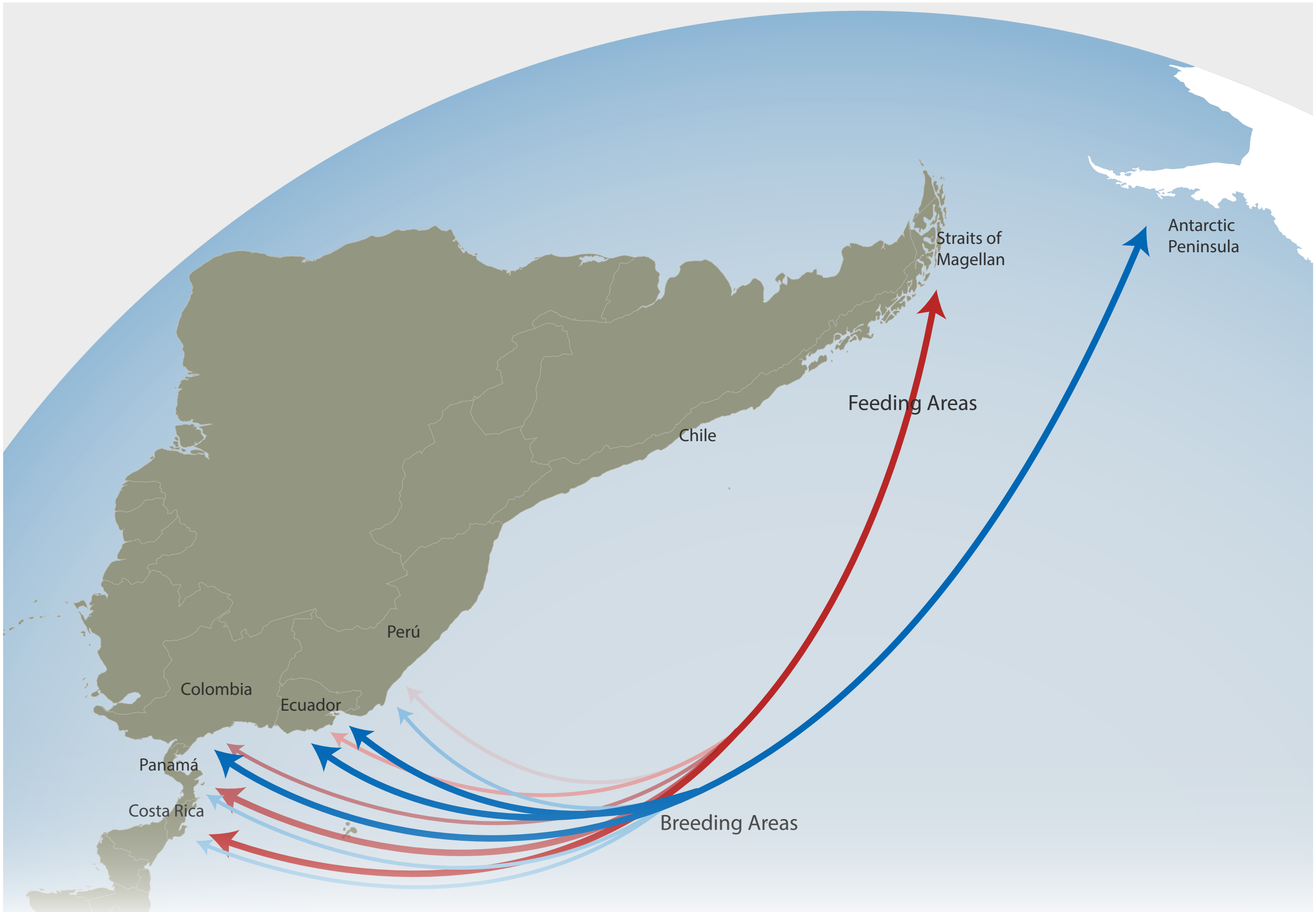


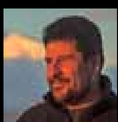
Figure 4. Table of migratory connections for the humpback whale.

photographed off the coasts of Ecuador and Colombia and then near Panama and/or Costa Rica.

Although this study is the first that attempts to integrate the large photographic database covering 14 locations where the humpbacks tend to congregate along the west coast of Central and South America, the number of individuals re-sighted is small, representing only 18.8 percent of the whales that have been photo-identified in feeding areas, or only 4 percent of the total number of humpback whales photo-identified in the southeastern Pacific region. Still, these figures are encouraging, since there is a clear indication that this humpback population unit is well on its way to post-whaling recuperation. This also suggests that the actual humpback population may be much larger than current estimates have indicated.

Thanks should be given to all the researchers who have contributed to the photo-identification catalog: Eduardo Secchi, Luciano Dalla Rosa, Anelio Aguayo-Lobo, Rodrigo Hucke-Gaete, Daniela Haro, Aldo Pacheco, Fernando Félix, Ben Haase, Cristina Castro, Judith Denkinger, Lilián Flórez-González, Martha Llano, Kristin Rasmussen, Héctor Guzmán, Frank Garita, Patricia Contador, and Jorge Plana.

STUDYING CLIMATE CHANGE THROUGH THE LIFE HISTORY OF THE ANTARCTIC MIDGE



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A couple of *Parochlus steinenii*.

Figure 1. Dr Tamara Contador.

Every polar season brings with it the beauty and mystery of how life in its various forms makes headway in these climatically extreme regions. It is commonly believed that this is the realm of nothing other than penguins and whales. But there is a great deal more among the eternal ice. Ecologist Tamara Contador, from the University of Magallanes, is following the life history of the only winged insect that is native to the White Continent, the Antarctic midge (*Parochlus steinenii*).

Insects make up the most diverse and abundant invertebrate animal group on the planet. They make up nearly two thirds of the known living things in the animal kingdom. They exist in every environment, including the most inhospitable places like Antarctica. Being ectothermic, their life cycle depends upon heat from the local environment and as a result they are very sensitive to climatic temperature change. Nearly any long-term variation in environmental conditions will affect them. For this reason they are considered key species as indicators of climate change.

Though it may seem remarkable, in the southern polar regions there are two species of insects: the Antarctic flightless midge (*Belgica antarctica*) which is wingless, endemic, and well described; and the Antarctic winged midge (*Parochlus steinenii*) which has been studied much less. The latter possesses wings and ranges from Bariloche (Argentina) to the South Shetland Islands.

Ecologist Dr. Tamara Contador, from the University of Magallanes (UMAG), is following the life history of *Parochlus steinenii*, sometimes called the "Antarctic fly," as it is the only native winged insect that inhabits the White Continent. Her project, "Addressing global warming scenarios in freshwater ecosystems using aquatic insects as model organisms in sub Antarctic and Antarctic regions" has received financing for three years through the FONDECYT startup program and the Chilean Antarctic Institute (INACH).

As coordinator for research and conservation at the Omora ethnobotanical park at Puerto Williams (Navarino Island, Chile), Dr. Contador is conducting a study comparing the sub-Antarctic fresh-water habitats (lakes and rivers on Navarino Island) with those in the northern Antarctic Peninsula area (King George Island). "What is special about this measurement is that we are using the Antarctic midge in these studies," she explained.

To understand the substance of this study, it is essential to acknowledge that birds and mammals are endothermic, which is to say that they regulate their own temperature internally. On the other hand, the majority of other animals are ectothermic, relying on ambient temperature to warm or cool them, as is the case with lizards and insects.

The Omora researcher's work is focused on two aspects of *Parochlus steinenii*. The first is to describe its life history, since very little is known about this tiny animal (which is only about 5 millimeters long). The second is to study its thermal tolerance, because "it is of interest to us as an indicator species for possible climate change scenarios and their effects on the ecosystems in South American Antarctic and sub-Antarctic fresh-water ecosystems."

Tamara is convinced that this insect could be a powerful instrument for indicating environmental change. Last summer was her first trip to the Antarctic Peninsula, as part of the 50th scientific expedition organized by INACH.

Figure 2. Dr Tamara Contador (left) during the field work in Deception Island.

"The behavior of *Parochlus steinenii* is quite amazing here. It differs from what we see in the individuals found on Navarino Island. What we have observed is that the adults form community groups for protection and reproduction. You see them like black stains on the rocks and they apparently gather together that way to protect themselves from the wind. There are hundreds of these insects together but they don't fly very much," related Tamara.

The researcher added that the larvae and pupae (the stage prior to becoming adults) are aquatic and live under rocks. The larvae live in the mud and hatch in thousands at a time. Meanwhile, the pupae float in the direction of the wind until they reach a shore. As Dr. Contador points out, "There are no long-range studies. Their life cycle and even what they eat are unknown, nor even what their critical temperature range is, or how many generations can be produced in a year. Not even their distribution within Antarctica is known. In the end, just very little is known. We hope to put together a multidisciplinary group to look into their food chain."

Preliminary results

Recent studies in entomology have provided some preliminary results which were shown at the 2014 open session of the Scientific Committee on Antarctic Research (SCAR) in Auckland, New Zealand.

What was revealed indicated the allowable temperature range for the larvae and adult forms of this species, which runs between -10 and +35 degrees Celsius. "This is certainly surprising," remarked Dr. Contador, "because this is a large temperature range. This could be a sign of adaptation. In what little literature on this that we could find, it was said that these insects could not tolerate the cold."

Being a part of SCAR has opened up the possibility of bringing about important cooperation amoung many researchers, such as in molecular studies with INACH scientists or with British colleagues to contribute to the understanding of adaptations by these species to polar climates, as well as in biogeographic (the distribution of living things on Earth) subjects.

Searching in Antarctica

In their first season in the field, the team consisting of Dr. Contador, a student named Simón Castillo (from the Pontifical Catholic University of Chile) and the photographer Gonzalo Arriagada, installed data-loggers (devices to record information) at the lakes and rivers where there are Antarctic midge communities, in attempts to learn the temperatures to which these insects are exposed during the year, and particularly during the winter.

Figure 3. Larvae of *Parochlus steinenii.*

Their goal was to build a database of information which would allow them to draw conclusions surrounding the variations in distribution in terms of latitude and altitude, involving environmental changes. For this reason they sailed for 10 days on the Chilean Navy ship *Aquiles* for the purpose of expanding knowledge of where in the South Shetland Islands this species may be distributed.

At Fildes Bay on King George Island, in the vicinity of Professor Julio Escudero Station, belonging to the Chilean national polar institute (INACH), the effort has been underway to describe the Antarctic midge in scientific literature, and to characterize its habitat, including the soil substrate, the temperature, the dissolved oxygen and pH of the water. "The idea is to understand the insects' preferences. The adults are very easy to find."

Meanwhile, for the work in the laboratory there was the task of collecting live pupae, larvae, and adults for the purpose of conducting thermal tolerance experiments on each sample organism. Dr. Contador indicated that the samples would be returned to the water alive. "What is their capacity for adaptation? We are being surprised by their heat tolerance," admitted the young researcher. "This year we are going to dig deeper into their cold tolerance."

Figure 4. Adult male of *Parochlus steinenii* hanging on ice.

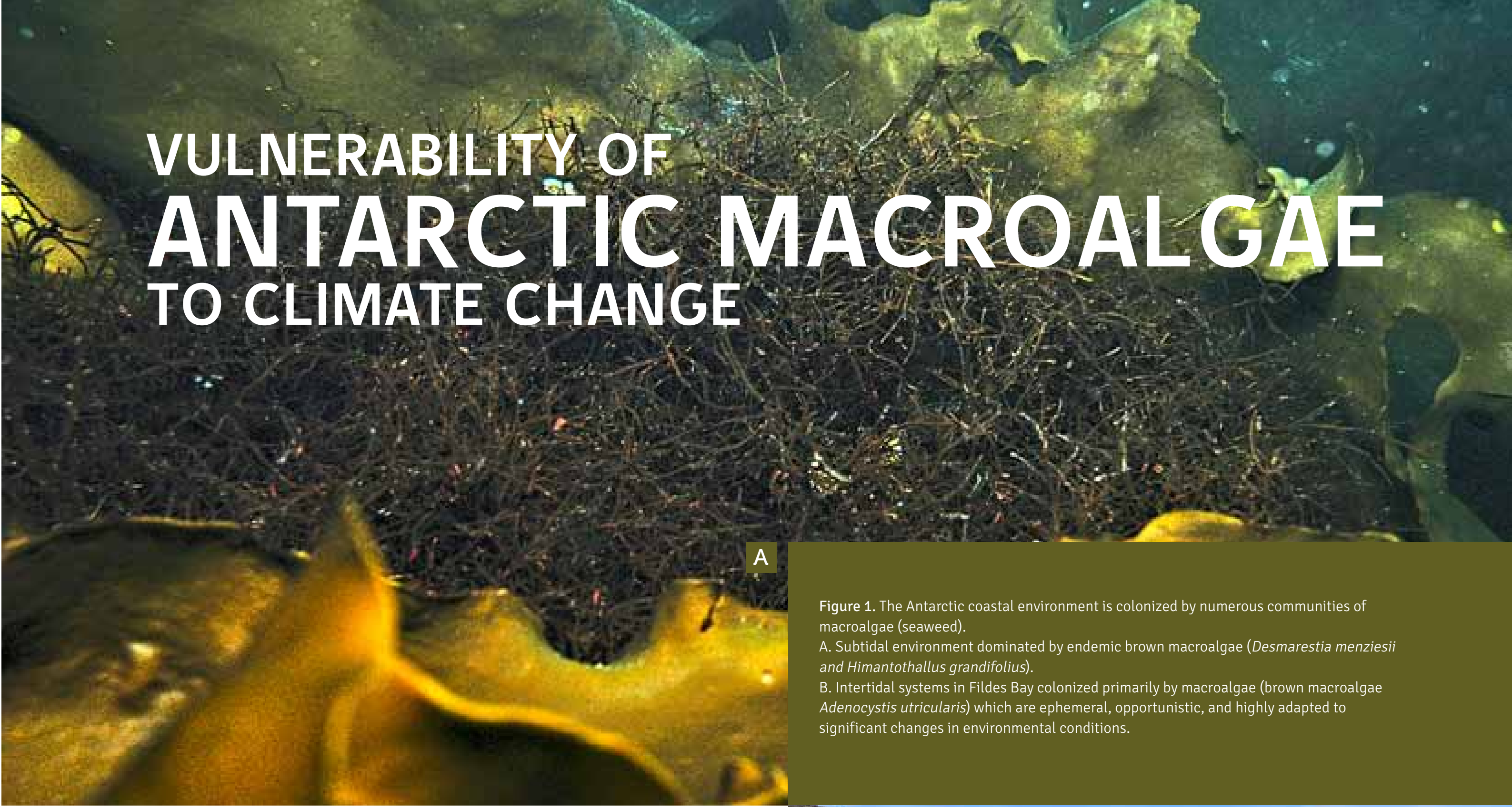
Publish what has been learned

This project includes an important component that relates to the dissemination and appreciation of scientific findings. Gonzalo Arriagada's images have been remarkable. They have been able to reveal the beauty of this micro-world. As he reported about this work during the meeting in Auckland, "Photography is a tool to promote conservation in Antarctic and sub-Antarctic ecosystems."

In Puerto Williams last April there was a science coffee-chat under the title, "Discovering the beauty of the Antarctic midge." It's hoped that workshops for the community might be developed along with a field guide on sub-Antarctic invertebrates called "Underwater inhabitants in rivers of the Cape Horn region." Then in 2016 there will be a photo-book to bring together the experience, habitat, and organisms that play a role in this research.

"I am fascinated by insects,"z reports Tamara Contador. "They are valuable in and of themselves. That they would be capable of surviving in Antarctica and to discover how they do it, is a question that for me would be super-interesting to answer. That means exploring and learning! I hope that after this work, that people can see the beauty in these insects."

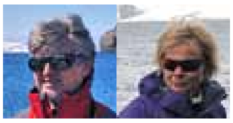
VULNERABILITY OF ANTARCTIC MACROALGAE TO CLIMATE CHANGE



A

Figure 1. The Antarctic coastal environment is colonized by numerous communities of macroalgae (seaweed).
A. Subtidal environment dominated by endemic brown macroalgae (*Desmarestia menziesii and Himantothallus grandifolius*).
B. Intertidal systems in Fildes Bay colonized primarily by macroalgae (brown macroalgae *Adenocystis utricularis*) which are ephemeral, opportunistic, and highly adapted to significant changes in environmental conditions.

B



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Macroalgae, commonly called "seaweeds," are the foundation of life in Antarctic coastal systems in because they provide the sea-floor substratum, refuge, and food for the benthic (bottom-dwelling) communities that live there. Concern for climate change has brought more studies that attempt to quantify and predict the effects of environmental modifications such as changes in ultraviolet radiation (UV) and temperature as they may impact the biology of these organisms as well as the food chains that depend on them. In the case of UV radiation, the responses of Antarctic macroalgae vary considerably according to depth and the photobiological adaptations that they display. In this article we discuss advances in one research effort by scientists from the Universidad Austral de Chile, with financial support provided by the Chilean National Science and Technology Research Agency (Comisión Nacional de Investigación Científica y Tecnológica, or CONICYT) and the Chilean Antarctic Institute (INACH).

There is a great abundance of marine macroalgae in Antarctic coastal zones and these form the base for bottom-dwelling communities and, in general, their biochemical processes. These organisms are very well adapted to extreme environmental conditions. At these high latitudes, for example, they may be exposed for several months to periods of very low light (in winter), followed by a period of high luminosity during the summer months.

This situation is exacerbated in the winter-spring season by the covering layer of marine ice, and then in the summer-fall period by high turbidity due to the sediments that result from movements of melting ice as well as the increases in phytoplankton.

Because of this, macroalgae have evolved to live with low levels of light in order to conduct their biological functions. For example, some species of genus *Corallina* can perform phytosynthesis at radiance levels as low as 10 μmol m-2 s-1, which allows them to live at extreme depths (as much as 50 meters).

On the other hand, due to the fact that Antarctica has been frozen for at least 14 million years, these macroalgae reveal very low thermal needs for photosynthesis, growth, and survival (between 0 and 10 degrees Celsius). In this sense, they differ in their degree of adaptation when compared to their counterparts in the Arctic, whose history of exposure to low temperatures goes back only about 5 million years.

There are also some types of Antarctic macroalgae that live in the intertidal zone that are exposed to even more extreme conditions. For example, during the summer when the coast in many areas is free of ice, these macroalgae colonize the rocky sections and withstand a range of temperatures that swings between -10 and +15 degrees Celsius during the tidal cycle.

These seaweeds may be considered highly successful extremophiles and thus may offer important insights into the physiological mechanisms needed for not just surviving environmental change in the short term, but also long-term variations of the scale associated with climate change.

Within this context is the emphasis of the project entitled "Impacts of climate change on the physiology of Antarctic macroalgae: consequences related to primary inshore productivity within scenarios of increasing temperatures and UV radiation." This project is financed by CONICYT and INACH.

Solar radiation exposure: adaptation to low light versus photoprotection against UV

One of the environmental factors that has changed in recent times in Antarctica is the incidence of UV-B radiation. Due to the thinning of the ozone layer in this region, the incidence of radiation in wavelengths between 280 and 315 nm (UV-B) has increased during the spring. For macroalgae adapted to living in low light, this condition can be damaging to their biological functions, as has been documented during the past 20 years.

Several studies have reported the harmful effects that increases of radiation may have on the physiology and reproduction of these macroalgae, particularly in their early phases. When there is a high incidence of UV-B, there can be higher mortality of spores and gametes with subsequent reduction in the macroalgae populations, particularly in shallow water zones. In the case of adult macroalgae, this can result in non-lethal impacts such as reduction in rates of photosynthesis and primary production, with still-unknown effects on biochemical processes on Antarctic living systems.

The results of our research have indicated that: a) Antarctic macroalgae show low light requirements for photosynthesis throughout the range down to 30 meters of depth, which is to say that they show low acclimation potential in varying light conditions; b) when these organisms are subject to light corresponding to summer radiation levels of UV-B at 0.3 Wm-2 for short periods (2 to 4 hours) there is an observed response corresponding to depth, where the organisms closer to the surface show higher tolerance for UV radiation when compared to those macroalgae that live at depths greater than 10 meters; c) estimated vulnerability of DNA damage is relatively high in species from greater depths, which also show lower levels of UV-B damage repair; d) the antioxidation capacity of these macroalgae is high throughout the depth gradient and is not substantially affected by UV radiation; and e) the contents of photoprotective compounds (phenols) in brown macroalgae are high and strongly related to antioxidant activity.

In general, the metabolic responses of marine macroalgae that have evolved to withstand wide seasonal variations (environmental variability over a long time scale) in the environment work to facilitate these macroalgae to occupy wide depth ranges (variability on a spatial scale).

And if the temperature rises?

In addition to the potential effect of solar UV radiation there is now an increase in water temperature due to global warming. The recent report of the Intergovernmental Panel on Climate Change (IPCC 2013) indicates that the loss of Antarctic ice mass as a result of ocean temperature increases will continue for decades.

Several studies have indicated that the local effects of warming will be more severe in sectors of the Antarctic Peninsula and adjacent islands and thus this aspect will modify in one way or another the other factors such as UV radiation or ocean acidification that affect the physiology of these macroalgae.

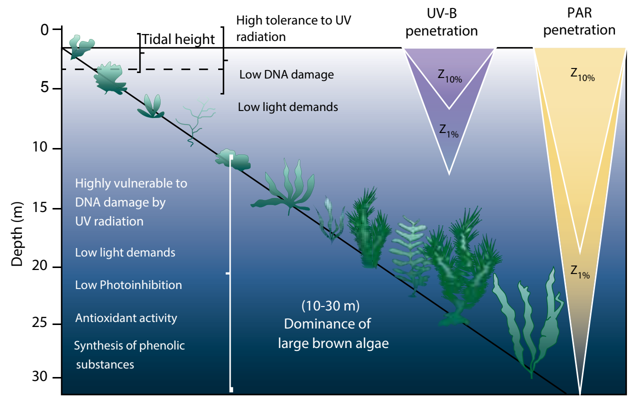
Changes in temperature also impact the rate of chemical reactions with particular effects on the thylakoid membranes. Thus, the study of photochemical processes in these structures, provides important information about the potential effects of temperature on, for example, the reduction in photosynthesis measured as the maximum quantum output of fluorescence (a process known as Fv/ Fm).

The results of 4-hour incubations with UV-B radiation at 0.3 W m-2 and visible light at 20 μmol m-2 s-1 under two temperature conditions show clearly that the reduction in fluorescence is greater in macroalgae that live below 10 meters under the surface (with reductions of 20 %) compared to macroalgae from the intertidal area (reductions of less than 10 %). Nevertheless, the increase in temperature has no effect on this response pattern under both sets of conditions.

The extended capacity of the Antarctic macroalgae to perform photosynthesis at temperatures higher than in their normal habitat has several possible explanations. For the intertidal macroalgae, this is a feature of their invasive and opportunistic nature, which allows them to grow, reproduce, and efficiently utilize resources such as light and nutrients, etc., during the short summer period. In the case of deeper dwelling species, although they live in a more stable environment in photobiological terms, these posses differing adaptations to deal with aspects such as low light, predation by herbivores, etc., and these adaptations also serve to modulate their thermal responses. For example, in the brown macroalgae the presence of high concentrations of phenols allows them to react to various environmental changes since these substances play several roles at a cellular level, whether as photoprotectors, antioxidants, or primary substances involved in cell wall formation.

The contents of these photoprotectors (phlorotannins) in brown macroalgae are related to the high antioxidant capacity of these species which are independent of the depth at which they grow. These results suggest that such compounds are foundational and important to guarantee anti-stress responses (from both biotic and abiotic factors) in wide ranges of their vertical (depth) distribution profile.

Deep-water macroalgae such as *Himantothallus grandifolius* or *Desmarestia menziesii* merit particular attention since they contain high levels of phlorotannins and antioxidant activity in response to UV radiation, which allows them to occupy shallower zones where the temperature is likely to be higher by several degrees.



Finally, the potential of these macroalgae to tolerate (at least for short periods) higher UV levels and temperatures provides indications of a significant genetic heritage, a reflection of a history of ancient Antarctic climate change and the fact that this characteristic has not been lost through their evolution toward living at lower temperatures. This suggests that Antarctic macroalgae possess the metabolic prerequisites for adaptation to modern climate change. And today, molecular studies together with ecological and climatic modeling will enable us to better address these questions.

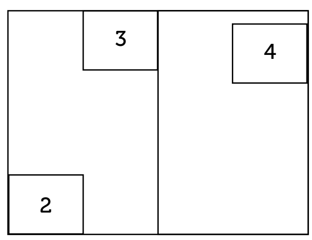


Figure 2. Dr. Iván Gómez (Universidad Austral de Chile) collecting intertidal macroalgae at Fildes Bay (King George Island).

Figure 3. The authors during field work at Fildes Bay, King George Island, in the South Shetland Islands archipelago.

Figure 4. Synopsis of the principal luminosity scenarios at an Antarctic litoral system dominated by macroalgae. The bathymetric distribution of the main macroalgae species are primarily determined by photobiological processes and the penetration of solar radiation. PAR= Photosynthetically Active Radiation; DNA= Deoxyribonucleic acid; Z1-10%= 1 or 10 % irradiance depth relative to surface.

R. KING/AAD

KRILL:
THE KEY PLAYER IN AN UNKNOWN WORLD

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It's a small crustacean that looks like a shrimp. It weighs about 2 grams and measures just 6 centimeters. But it's the cornerstone of the Antarctic ecosystem. If something were to happen to the krill, the effect would involve either a cascade or an avalanche of effects, impacting the entire food chain, from whales, seals, penguins and other species of marine birds, to squid and dozens of species of fin-fish. The meeting of work groups from the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), which took place in Punta Arenas, brought about the opportunity to hear the opinions of distinguished international experts on one of the key species of the Antarctic ecosystem.

Antarctic Krill (*Euphausia superba*).

Last June there were two working groups from the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) that met in Punta Arenas. These included the sections on (1) Statistics, Assessment, and Modelling, and (2), Ecosystem Monitoring and Management). The discussion covered the current situation surrounding krill, which poses still many more questions to answer.

According to Dr. Javier Arata (INACH), one of the meeting organizers and vice president of the CCAMLR scientific committee, "krill is not only food for Antarctic animals: since 1973 krill has been harvested commercially in Antarctica and since 2011 Chile has actively participated in krill fishing." With an annual capture of almost 215,000 tons, krill fishing is increasing every year and raising questions about industry as well as the outlook for this species.

Dr. Javier Arata (INACH).

Dr. So Kawaguchi (Australian Antarctic Division) is an internationally recognized expert in krill biology as well as chief of the only laboratory that operates a live-krill aquarium all year round. For Dr. Kawaguchi, "the most important thing about krill is its enormous biomass, almost equivalent to the weight of all the human beings on the planet, and this mass is found in the Southern Ocean."

Although there are several species of krill, the only one of commercial interest is the Antarctic krill (*Euphausia superba*), due to its size, since it is larger than the other species. The Antarctic krill has a circumpolar distribution and lives in both the open ocean and on the continental shelf, where it is accessible by predators and commercial fishing.

One of the most important questions surrounding krill is about its population size. Dr. Volker Siegel (an expert in krill demographics at the Johann Heinrich von Thünen Institute in Germany), indicated that studies are "mesoscale surveys" or rather, "scientific surveys in certain areas in such a way as to allow us to estimate the biomass for these areas, such as the Antarctic Peninsula, the South Orkney Islands, or the South Georgia Islands. Nevertheless, we have very little information about many large areas." What is in fact possible is extrapolation of information based on regional surveys, which have determined a quantity of 380 million tons of krill biomass in the entire Antarctic ecosystem.

Studies conducted by Siegel and his team have focused on the Atlantic sector of the Antarctic Peninsula "because we have found that about 70 percent of the total krill population live in the South Atlantic sector. In other words, three quarters of the total krill population is living in one quarter of the area in which they can live."

This significant concentration of krill is possible thanks to the high productivity of the waters of this sector, with an enormous availability of phytoplankton and better living conditions for the krill. "They probably grow more quickly than in other areas further south, and at the same time their reproduction and the larvae survival rate are better than in areas covered with ice," reported Siegel.

Living under the ice

One other aspect that challenges polar researchers is achieving a full understanding of the krill life-cycle, and in particular its ability to live under the sea ice, along with its behavior during the long polar winter.

Dr. So Kawaguchi (Australian Antarctic Division).

Dr. Jan van Franeker works at the Institute for Marine Resources and Ecosystem Studies (IMARES, Holland) and has developed techniques to sample krill under the ice, demonstrating the importance of the contribution of krill biomass to the sustainability of significant bird and whale populations during the winter.

The krill life cycle begins when these animals gather in summer, "in tight swarms, seeking areas where there is an abundance of phytoplankton in order to feed and reproduce. Generally speaking, it is believed that krill eggs, once released, sink to deeper water and then when they hatch the larvae begin their migration back to the surface. This is when the juvenile krill must find food and refuge in order to survive their first winter," reports Franeker. Krill live about five years.

During the year, krill undertake a vertical migration within the water column, which had resulted in the belief that their numbers decreased in winter, when in fact what was happening was a migration toward deeper water. "In summer the krill live near the surface, between zero and 150 meters of depth; in winter they move to deeper water. We have very little winter data but it seems that the main distribution in depth is between 200 and 400 meters. The krill are concentrated in shallow water and usually the scientific sampling has been done in depths of less than 200 meters, and for that reason our data seems to indicate fewer krill in winter than in summer," says Dr. Volker Siegel.

In winter the juvenile krill desperately need food to allow them to survive and reach maturity in summer. "This is very interesting: the adult krill population appears to move toward the bottom of the

water column, but the very young krill," - says Siegel - "are to be found directly beneath the ice where the larvae and the juveniles consume the algae."

Krill –– and its predators

The main predators of krill are whales, penguins, and seals, together with fish and other birds, although the degree of impact depends upon the sector in which they live. In the Antarctic Peninsula and nearby islands (with large coastal areas) the most common predators are penguins (Adelie and chinstrap penguins), crab-eater seals, and Antarctic fur seals. On the other hand, in the open sea, far from land-based animals, the predominant predators are whales: the blue whale (subspecies *Balaenoptera musculus intermedia*, also called the "true blue" whale or Antarctic blue whale), the fin whale (*B. physalus*), the humpback whale (*Megaptera novaeangliae*), and the Antarctic Minke whale (*B. bonaerensis*).

Dr. Luis Pastene has lived in Japan since 1985 and is currently the director of the University of Tokyo Institute of Cetacean Research, Survey and Research Division. Pastene explains that "Antarctic krill are the main food source for the great whales what migrate to Antarctica during the austral summer. They depend on krill for their nutrition and thus, their growth as individuals and as a population."

The daily krill consumption of a whale is between 300 and 400 kilograms, at least for the fin whale, also known as the common rorqual. There are some species that consume less, such as the Antarctic Minke whale, and others for which there are no estimates (as in the case of the humpback whale).

After having suffered from over-hunting during the 20th century, whale populations have recovered, each at its own rate and according to the effects of previous hunting. The most dramatic case is that of the humpback whale which had fallen to just 2 percent of its original population size. "Happily, most of the species and populations have recovered or are in the process of recovery. For example, the population of western Australian humpback whales shows about 28,000 individuals (a number similar to that prior to their commercial hunting) and their rate of growth is 9.7 percent annually. Data from the same population obtained in their feeding area suggests 29,067 individuals and an annual rate of growth at 13.6 percent," says Pastene.

According to this University of Concepción (Chile) biologist, this recuperation is due to "conservation measures imposed by the International Whaling Commission. Between 35 and 50 years have passed since the end of commercial whaling, during which time their populations have recovered at varying rates of growth."

Penguins are another krill predator. Dr. María Mercedes Santos is director of the Ecosystem Monitoring Program (for penguins) at the Argentine Antarctic Institute, and studies penguins in genus *Pygoscelis* (Chinstrap, Gentoo, and Adelie penguins),

1 Dr. Volker Siegel (Johann Heinrich von Thünen Institute, Germany).

2 Dr. Jan van Franeker (Institute for Marine Resources and Ecosystem Studies, IMARES, Netherlands).

3 Dr. Luis Pastene (Institute of Cetacean Research, University of Tokyo).

4 Dr. María Mercedes Santos (Argentine Antarctic Institute).

three species that feed on krill and particularly in the area where she works: the Atlantic Ocean sector north of the Antarctic Peninsula, the South Shetland Islands, and the Orkneys. Dr. Santos has observed a decline in the Adelie penguin populations in the areas mentioned above. "What we have not been able to establish is whether it is specifically due to a reduced availability of krill; there are other local factors such as snow levels or storms, which also affect the survival of the chicks. There is no one single factor that is causing the drop in these populations and that is what we are discussing," noted Mercedes.

Dr. Santos indicated that there is even one population that has fallen by 70 percent since 1995, on King George Island (also called "May 25th Island"). There is a completely different situation for the Gentoo penguins, whose populations are growing. The reason could be that the Adelie penguins, which depend so much more on the ice, now see their ice environment being altered, since the Antarctic Peninsula region is being strongly affected by global warming. But the Gentoo penguin numbers are growing in both numbers and range, particularly toward the south. "This is a species that, in general, avoids the ice, it is more of a sub-Antarctic animal, and thus these changes are an indicator that something is happening, that a sub-Antarctic species is expanding its range toward the south on the Antarctic Peninsula," reported the Argentine researcher.

How much krill is out there? How much can be harvested?

The management of krill needs to be tied to an understanding of the size of its populations and the time required to replenish the krill that has been harvested. For scientists this is another complicated aspect of this "little polar giant." Jan van Franeker indicated that there had been calculations of krill consumption by flying birds, penguins, seals, and whales, but when these are compared to estimated amount of available krill, just the birds would eat all the krill, and then some. A similar effect was observed with calculations for krill consumption by whales.

The Dutch ecologist admits that there is "pressure to achieve higher levels of krill harvesting and we actually do not know how reliable our models are for doing this. We must be very, very careful."

One bit of news came out of the symposium in Punta Arenas by the groups belonging to the CCAMLR, from a meeting by the companies that harvest krill (Association of Responsible Krill Harvesting Companies - ARK). According to Javier Arata, "these companies look to CCAMLR for good decisions surrounding the harvesting of krill, which they see as a resource they hope will last for a long time and for that reason they wish to support the research, for an understanding of the actual numbers and distribution of krill and how much can be extracted before damaging the ecosystem."

Krill is a living resource well adapted to the extreme polar environment. If it is a given that this environment is changing, then efforts must be directed to understanding how these changes may affect the krill. Dr. Kawaguchi summarized it in this way: "... we also must understand the behavior of the fishing companies and how they operate. In that way we can achieve an understanding from two viewpoints: from the fishermen and from the krill itself."

Humpback whales feeding on krill in the Antarctic Peninsula region.

J. PLANA

TRACK CHANGES:
ONE DAY AT THE ARTURO PRAT ANTARCTIC STATION, HALF A CENTURY LATER

In this chronicle, Dr Francisco Hervé (winner of the Chilean national geology prize) tells of his return to Prat Station, fifty years after doing field work there for his thesis. During the intervening years, Professor Hervé has undertaken one of the most distinguished academic careers related to Antarctica, with frequent notable contributions of knowledge relating to the geological history of the Antarctic Peninsula and its connections with Patagonia. At the same time, the landscapes that Dr. Hervé knew half a century ago have undergone some quite visible transformations. Here, he relates his observations on those changes.

Dr. Francisco Hervé
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The hallway opened before me, after passing through the door at Arturo Prat Station on Greenwich Island, Antarctica. It was a long and narrow corridor, constructed of materials that showed their considerable age, but with nothing really unusual about them. But it was special to me. As I walked on I became absorbed in this space, as it took me back fifty years to the time when I spent a summer here, doing the field studies for my thesis in geology.

I recognized the kitchen there on the left, a bedroom on the right, and at the end of the hallway, there was the living room off to the left. That is where Roberto and I slept, spreading out our sleeping bags on the carpet after the staff had left that room to retire to their sleeping quarters.

At the end of the hallway there is a door to the dining room, living room, and bedroom for the station commander. Perhaps I did not take into proper account the current station commander, who came out to receive us, when I asked about the guest logs from 1964. He showed me some of them and with some excitement I looked over the signatures of the station chief from those days, a one Navy commander Pedro Sallato and his executive officer, lieutenant commander Javier Gantes. These were gentlemen I remember well, though afterwards I never saw them again.

But there was no trace of me, nor any of Roberto Araya, my co-worker. I had the strange sensation of being very much alone with my memories, since Roberto and Pedro have since passed away, and I don't know what became of Javier. The signatures in the book, however, were unmistakable. What I remembered was good and true and in no way a matter of my imagination. The absence of our own signatures there was consistent with the realities of our own experience.


We had sailed from Punta Arenas aboard the transport ship *Aquiles*, a handsome vessel belonging to the Chilean Navy, much bigger than the *Piloto Pardo*, on which we had begun our journey from the same pier in 1964.

During the past decade I had made many splendid sailing trips toward Puerto Williams in small boats, and likewise I enjoyed the tranquility and rhythm one enjoys aboard the *Aquiles*. The glaciers along the Beagle Channel seemed that same as what I remembered from my first trip, though we had no warning that nowadays there are large streams of water flowing off the glacier faces.

My time aboard the *Aquiles*, with my wife Cristina, still retains a certain mysterious dimension. I still do not know exactly how that trip was arranged or who took it upon themselves to make it happen. I imagine that it was the Chilean Antarctic Institute (INACH), due to what happened in La Serena in September of 2013, where I had been invited to give a talk in the Latin American Antarctic Science Meeting.


It was there that I realized that I would like to return to Antarctica fifty years after my first visit, to compare certain morphological aspects of the area around Prat Station that just might have changed after all those years. And so I must offer my most sincere thanks to both INACH and Chilean Navy for making this trip possible.

The crossing of Drake's Passage, that most fearful stretch of water for a ship headed to Antarctica, was probably the most tranquil of all the times I had traveled there. I cannot remember another trip when the sea was so blue and without distinct waves, with so few sea-birds slicing the air near the ship, with nary an iceberg until we had the South Shetland Islands already in sight.

Likewise I was blessed with a very comfortable bunk, in contrast to the cots in the passageways of the patrol boat Lientur, on which we had slept on another occasion. Our stay at Fildes Bay this time found us among five ships, ranging from elegant cruise vessels to the little boats of the South American navies, and such a number would have been inconceivable fifty years ago.

I wanted to save my going ashore for Arturo Prat Station. And so we watched from the ship while all the movements were taking place to and from land. For our next trip back to Fildes Bay we were invited to visit the Russian Orthodox church, one of the most conspicuous structures on this comparatively populated corner of the Antarctic Peninsula.

We then sailed toward O'Higgins Station, were I remember quite well the 1964 disembarking of the German professor Hubert Miller. This was undoubtedly a harbinger of the installation some decades later of the enormous white satellite antenna for the German research programs, during which time professor Miller played the role of the extremely influential coordinator of the German Antarctic programs and as his country's representative in the Scientific Committee on Antarctic Research (SCAR).

The trip into O'Higgins Station was always uncomfortable due to the stinking residue of the penguins which had invaded the area around the base, and this material stuck to the boots and trousers

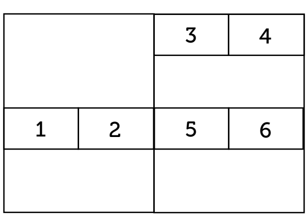


Figure 1. Face of the Cooperativa Vitalicia glacier, on the coast of Ensenada Rojas (January 1964).

Figure 2. The same Ensenada Rojas in January 2014, with the face of the glacier completely gone. In its place are low coastal beach ridges. The beach line is probably not the same as in 1964.

Figure 3. Roberto Araya and the journalist from La Prensa Austral, mister Vivanco, at the face of the ice front located behind Caletón Iquique, near Arturo Prat Station (January 1964).

Figure 4. George Watson, curator of the Museum of Natural Sciences at Washington, D.C. (USA) and the geologist Roberto Araya, on the coast of Bascopé Peninsula, with Picacho López in the background. In January 1964 it was not possible to walk to the highest point on this mountain without walking on a substantial section of ice.

Figure 5. Arturo Prat Station in November, 1988, showing significant ice on Picacho López.

Figure 6. Glacial moraine at the base of Picacho López, where it can be seen that it is now possible to climb to the highest part of the peak on rock that is free of ice (February 2004). The ice probably reached this place in 1964.

of everyone who went ashore.

The itinerary of the *Aquiles* took us to places I had once known well, either during my first journey fifty years ago or on the eleven subsequent trips: Deception Island, Byers Peninsula, and Hurd Peninsula where at the latter the Bulgarian scientists went ashore to the Spanish base. Then our captain set our course toward Arturo Prat Station. We reached Chile Bay on the 26th of January, 2014, just past noon, fifty years after my having been at this station for nearly three months.

On the 26th of January, 1964, according to my field journals, we were working on surveys of the vicinity of Prat Station, investigating the reasons for the existence of certain raised marine geomorphological features that characterize that area.

We went ashore at the pier that is located at Caletón Iquique, where I previously described my entering the station. I also walked around the exterior in an attempt to compare my memories with the old photographs.

Figure 7. In February 2004 Picacho López was connected by rock all the way to its base. In the center of this photo, the Cooperativa Vitalicia glacier is seen in a grayish color, behind Caletón Iquique and Arturo Prat Station.

Figure 8. Picacho López in 2004.

Cristina and I went out to observe the morphology of the surroundings near the station, on a sunny and almost without wind, something rare in this part of the world.

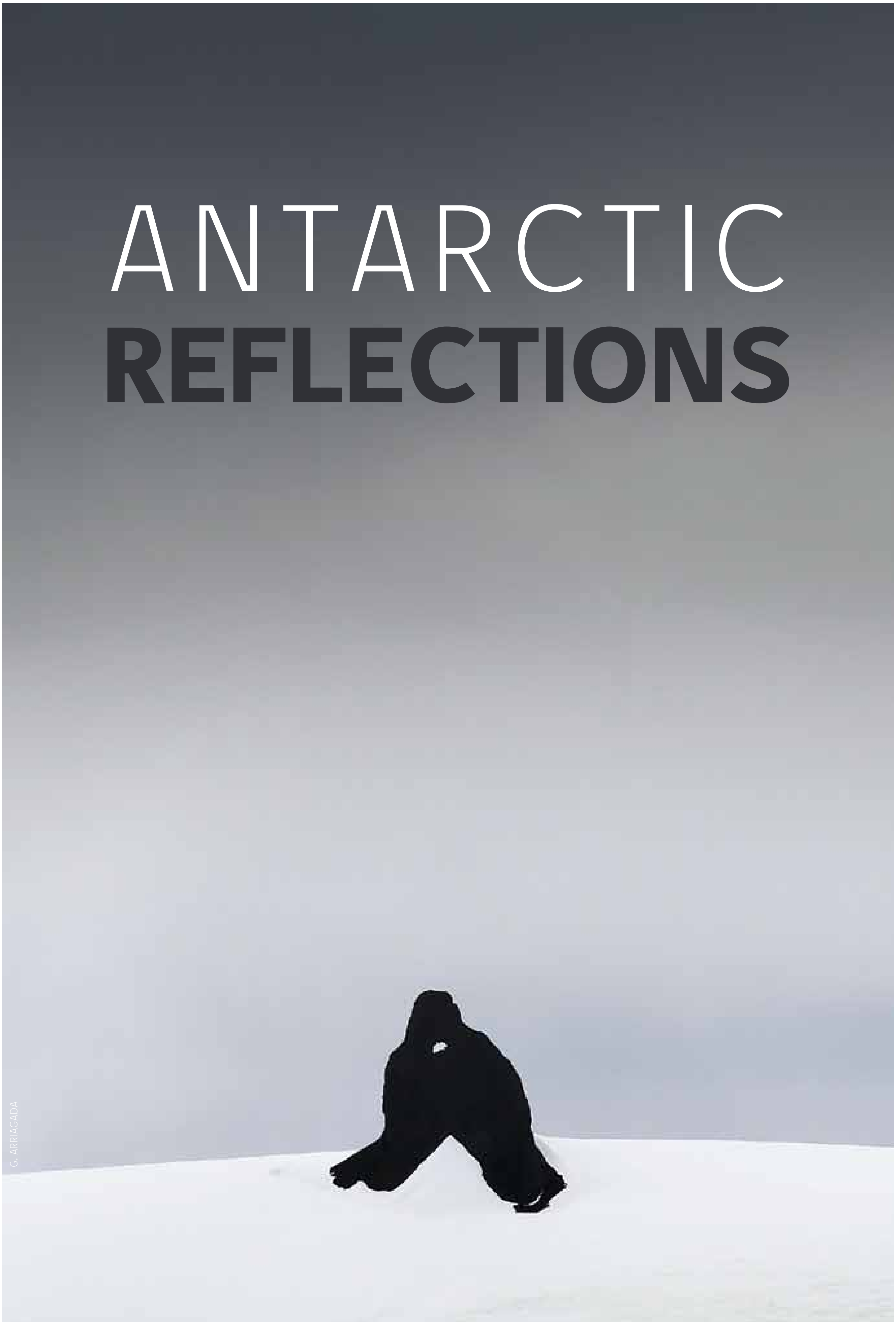
It was possible to ascertain what I had already suspected when observing the shoreline from the ship: along Ensenada Rojas in 1964 you could see the cliff face of the Cooperativa Vitalicia glacier. Now there is no glacier there at all, just some little piles of gravel along the beach. The face of the glacier that once covered more than 500 meters along this coast, with a height of nearly 15 meters, where huge fragments broke off and fell every day, simply no longer exists. And the same thing has occurred, as we saw later, at the face of the glacier behind Caletón Iquique, where that glacier has also disappeared. Similarly, today you can observe Picacho López, to the northeast of the station. Years ago it was surrounded by ice. Today you can climb it and never leave the rocks, the apparent result of the march of deglaciation.

With this, my principal objective for traveling to Antarctica was now satisfied, to show that in fifty years the glaciers around Prat Station have diminished dramatically in volume. The geomorphological features that were studied during this opportunity bring us to the conclusion that there has been a relative uplifting of the level of the islands with respect to sea level, a phenomenon probably caused by lower ice volume. The retreat of the ice is betrayed by the glacial gouging in the exposed rock. The thickness of the ice seems to have been reduced by about 100 meters. It would be very interesting to determine when this process of deglaciation began, to understand its magnitude and whether there is evidence of recent acceleration in the retreat of the glaciers that could be linked to global warming during the last century.

That night there was a party aboard the *Aquiles*. I took this to be due to the situation I described and not because Malaysian diplomats were returning to their country. All in all, my journey turned out to be the most pleasant of the many I have undertaken to Antarctica, and this was due to the ship, the weather, and for the fine companionship that we enjoyed throughout this time.

There was one positive and indeed spectacular change, and that is today one can see large numbers of whales around the ship, both while underway and when in port, something that would not have occurred fifty years ago. When human beings apply their intelligence and will towards a common good, great advances are inevitable.

ANTARCTIC **REFLECTIONS**



G. ARRIAGADA

LATITUDE 80 SOUTH, LONGITUDE 80 WEST:
THE RIGHT PLACE. THE RIGHT TIME

P. ESPINOZA

A little more than four decades after the 70th anniversary of the beginning of Chile's activity in the Antarctic territory (1902-1972), I called a conference entitled "What shall we do in Antarctica?" Then I summarized the documents that dealt with Chile's jurisdictional claim to the American (Western Hemispheric) quadrant of Antarctica and addressed our actions and concerns developed during a seven-year period which analyzed and treated those concerns from several perspectives.

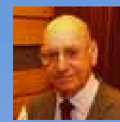
The preparation of this assessment took into account the Chilean presence in Antarctica as a highly commendable exercise in scientific activity, which time has proven to be the only truly valid justification for any presumed rights in the White Continent. It must be remembered that this had been taking place in an "area that was limited in continental terms (the Antarctic Peninsula), through which the continent was first discovered, and which brought about scientific and geographical recognition. Though it may be that, objectively, the Chilean scientific effort is of some interest, it is not particularly important in terms of geographic science or for humanity in general, as it might have been, had the Chilean effort instead covered relatively unknown areas." Basically our conclusion was that we should propose "further penetration to the south" for the purpose of gradually achieving successful progress in scientific activities in the polar plateau region that is within the confines of the jurisdiction claimed by Chile.

Forty years have passed since then, during which time there has been a rich and varied legacy of many types of activities within the immensity that is Antarctica. The principal and most relevant participants have been the major scientific and technological powers in the world, headed up by the United States but also involving Russia, Germany, Great Britain, Japan, and China, among others. The advancements have been nothing less than amazing and the international community has periodically captured the limelight through scientific publications and the dissemination of information, including scientific meetings, seminars, symposia, and documentary films.

At this time we would like to highlight the merit of this admirable international effort, in promoting the growth of knowledge related to Antarctica and its vast marine environment, in which Chile has gone from a marginal and irrelevant role to one that is truly remarkable although still comparatively minor within a global context. This effort is in no way less valiant or less deserving of recognition when taking into account Chile's national potential, its capacities, and its potential for active participation.

Indeed, while considering the focus of our earlier proposal, and the events of our own history during the recent past, we must recognize that after a period of some uncertainty and hesitation, the Chilean Antarctic policy developed since the final decade of the twentieth century has become more focused and ambitious, if such a term can be used, to propose the goal of deep penetration into the Frozen Continent, into the high polar plateau, for the purpose of establishing a permanent station, one that is strategically located within the geographical context of our territorial and jurisdictional aspirations. Moreover, this base must be constructed in such a way as to become a distinguished center of the most significant levels of scientific activity, dedicated to the creation of advanced study and research programs.

Mateo Martinic
Chilean National Prize for History (2000) and
Prize Bicentennial (2006)



Thanks to a coherent vision sustained by successive national governments, and the consistent and efficient coordination and planning provided by the Chilean Antarctic Institute, along with the unfailing assistance of the Chilean Air Force, an historic geopolitical and scientific objective was eventually defined: to construct a settlement which involves a national presence upon the remote reaches of the icy continent itself. In this way Chile would make a statement certain to be respected, one that would affirm its sovereignty, providing for nothing less than serious international recognition of the considerable contributions this country has made in advancing Antarctic scientific knowledge, as well as its peaceful, cooperative, and constructive efforts that benefit the community that shares these interests in Antarctica, and indeed serves the entirety of all humanity.

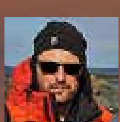
One paradigmatic milestone was achieved recently, in the seasonal (Antarctic summer) opening of the Chilean Air Force's Lieutenant Parodi Station, located in the Patriot Hills area, which was kept operational between 1998 and 2008 for Chilean and foreign university researchers under the coordination of the Chilean Antarctic Institute. Based upon the experience of this productive and determined effort, the government ordered the creation of a new permanent station in this polar territory, in the immediate vicinity of the Union Glacier, a site considered more advantageous and convenient for the advanced objectives under consideration. This rather historic measure has already begun to materialize, starting with the Antarctic summer season activities for the years 2013-2014. There, on the Antarctic plateau, at a site whose approximate coordinates are 80 degrees south latitude and 80 degrees west longitude, located 1,200 kilometers south of President Frei Station and 3,000 kilometers from Punta Arenas - and just over 1,100 kilometers from the South Pole - a new center for advanced scientific work will arise and mark Chile's presence in this strategic area where its territorial claim is unchallenged, in a place where its next phase of important scientific work will be undertaken.

We are enormously pleased with this decision which, without a doubt, will soon be viewed as one of the most important moments in Chilean Antarctic history, made possible thanks to the wealth of our experience and scientific work under the most demanding physical conditions, giving rise to a new tradition that provides a competitive environment and honors for Chilean scientists and, most certainly, members of the Chilean Army and Navy, and in particular the Chilean Air Force, which has supplied the critically important logistical support essential for meeting the demanding goals associated with national interests.

And so, the "march toward the south," which we proposed when it seemed to be only a utopian vision, has become a measurable and encouraging reality that allows us to anticipate new and intriguing discoveries from our Antarctic researchers and scholars within the cooperative international sphere of work in which Chile participates. It is our considered belief that nothing can or will be better able to justify our efforts and interests in Antarctica than the conscientious, constructive, and valuable work undertaken to further our sovereign claims through the advancement of scientific knowledge.

ANTICIPATING ANTARCTICA IN THE 21ST CENTURY:
A VIEW FROM THE SOCIAL SCIENCES

This short paper takes the form of a speculative essay to present some general reflections concerning the importance of opening up a broader discussion in relation to the challenges facing the future of the Antarctic region. To a certain degree the geophysical and life sciences play an anticipatory role in predicting, prefiguring and preempting probable future global change dynamics. In this essay I argue that the social sciences can also play a key role in anticipating possible futures in relation to the Antarctic. In dialogue with the life and geophysical sciences, social and cultural research may open up modes of thinking about probable, possible and preferred Antarctic futures. It can offer a broader approach for better understanding what is at stake in the ways we imagine the future of Antarctica to be, giving a more nuanced picture of how different knowledge practices present contested futures for the Antarctic. In the case of Chile, a nation operating in Antarctica within a framework that is increasingly globalized and interconnected, anticipating Antarctica deep into the 21st century is a nation-wide challenge. It therefore demands a rethinking of existing political frameworks leading to a new cultural economy grounded on emerging forms of Antarctic identity that may ultimately position the Magallanes region as a center for world-class scientific work and Punta Arenas as an Antarctic city.



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E. BARTICEVIC

Anticipating the complexity of Antarctica from the social sciences

As it is widely acknowledged, Antarctica has sparked our collective human imagination since long before it was actually discovered at the beginning of the 19th century. Today it continues to fire our imagination, nearly two centuries later. As the world becomes increasingly uncertain and complex, it is all the more important to be able to foresee probable future scenarios in the Antarctic region. No country can afford to underestimate the importance of a long-range view where science, politics and civil society come together on a scale that transcends national interests and instead extends horizontally from the local to the global.

The Portuguese sociologist Boaventura de Sousa Santos once stated: "we live in times of tough questions and weak answers." By this he meant that it's by asking tough questions that at the end we can address matters of concern; matters that may ultimately shape the foundations and horizons of possibilities within which we may choose to act. For Santos the weak responses are those that fail to attenuate difficulties and only serve to increase them.

Imagining and anticipating the future of Antarctica is one of those tough questions. It raises a challenge for science practices as much as for policy-making. It sets opportunities as well as obstacles for international cooperation. There is no time for trial and error anymore. Antarctica is no place for weak answers. Antarctica is at a turning point.

Thinking today about the Antarctica of tomorrow is an exercise in prospecting. In the specific case of Chile it demands a rethinking of how we build a country-image faced with a diversity of challenges from energy sustainability to climate change. More importantly, this is an invitation to project ourselves as a society toward a future that is increasingly difficult to pre-empt, and one that may well surpass all of our expectations.

It would be an error to assume that the Antarctica of the future is merely a simple projection of its past. In order to act consistently and take ethical responsibility for the future of the continent and the Southern Ocean, both states and non-state actors must have reasonable expectations for the future. This is a crucial matter because only a very small number of those decisions made today will really have only a localized impact. On the contrary, the vast majority of today's decisions and actions will impact global systems, in such areas as climate change, ocean acidification, international relations, and our emerging understanding of the cultural values of Antarctica.

The increasing complexity of human activities in Antarctica warrants the inclusion of critical and reflective work which the humanities and social sciences do best. Innovative insights from these disciplines are also needed regarding the future role that Chile will have to play in relation to the Antarctic, and how the country will meet the challenges that lie ahead in coming decades. The great challenges in Antarctica related to global change are occurring on several fronts. In addition to renewed friction over overlapping territorial claims there is now the specter of geopolitical changes, with the emergence of polar Asian states with Antarctic pretensions, including China, Korea, and India. Since its inception in 1959, the Antarctic Treaty System had provided a regulatory framework that was statist and based on scientific endeavor. For the past 50 years, the rubric that has come to best define the Antarctic is that of "a continent devoted to peace and science." Historically, that had worked, so long as there were a limited number of participants and a limited set of activities. The situation by the middle of the century might be quite different. If we look ahead another thirty years, what would be the motto that defines the Antarctic in the 2040s? Predicting the range of probable futures for Antarctica, such as the melting of the West Antarctic Ice Shelf, is already a difficult task in itself, and particularly so if we consider the advancements in scientific knowledge and in the institutions that facilitate interpretations of this knowledge. Many of the climate change projections that climate scientists have modeled for the coming decades in the Antarctic can be as troubling as the future scenarios that emerge from a critical reflection by social and cultural researchers. In both cases the common denominator is the fragility of Antarctic ecosystems within the context of a new geological era: the Anthropocene, where human activities become a geophysical force capable of modifying the Earth's atmosphere and geology. The most striking aspect of this is the scale of the matter as these most profound and irreversible changes are taking place on a planetary level. Antarctica is of course not exempted from this as the continent and ocean have gradually and relentlessly turned into an "anthropogenic landscape".

One of the key challenges identified in the 2014 SCAR Antarctic and Southern Ocean Science Horizon Scan was the need to disentangle natural and human impacts. For the Antarctic community that formulated the six scientific priorities for the next two decades, the need to forecast the impacts of human activities on the region is a key prerequisite for effective Antarctic governance and regulation. However, we must also acknowledge the intertwining of natural and social processes contained within the figure "the future of Antarctica." It is increasingly difficult to conceive of the Antarctic as outside of human influence and the challenges that human activities - directly or indirectly – have on the continent and the Southern Ocean. I am not only talking about those persistent challenges (such as territorial claims, or the escalating conflict between anti-whaling groups and the Japanese whaling program) or challenges from increased tourism and the growing interest in Antarctic bio-resources and other commercial activities such as fishing. I am also refering to, for instance, the impact of non-native invasive species in the Antarctic ecosystem, or how some countries have begun to develop strategies for cultural diplomacy to forge new Antarctic imaginaries linked to national, regional and local identities. In other words, the social sciences provide conceptual and methodological tools to understand in a more comprehensive and holistic manner how natural and cultural, human and non-human, discursive and material factors intertwine in our present and future relationship with Antarctica. Several social studies of perceptions and opinions carried out in different parts of the world show that, in general, people value Antarctica, and there is a strong desire to protect its environment and unique biodiversity.

Not long ago the Australian environmental historian Tom Griffiths wrote that Antarctica *"is not only a region of elemental majesty; it is also a global archive, a window on outer space and a scientific laboratory. It is not only a wondrous world of ice; it is also a political frontier, a social microcosm and a humbling human experiment."* Hence, anticipating the future of Antarctica is not only a scientific or a political challenge. It is also an effort involving how we, as a global society, as a species, value the Antarctic and how these values are tied to specific actions within normative frameworks that become part of the development of policies that are designed to address those challenges already perceptible on the horizon.

In Antarctica one can observe the beginnings of a deeper and long-reaching transformation. It is more or less accepted that by the middle of this century, rapid population growth and industrial expansion will have led to severing impacts on the availability of food, water, and energy for a planet of 9 billion people. Amidst a crisis that evolutionary biologists call the sixth mass extinction the footprint of humanity will require the equivalent of two entire planets to sustain in the long term. With carbon dioxide levels exceeding 400 parts per million scientific models predict that a tipping point will have been reached, and that irreversible environmental degradation could follow. This evidence that we are exceeding key planetary boundaries is most clear in the Polar Regions.

Within this context, and in the midst of these pronounced changes, Chile, as an Antarctic country, now faces enormous challenges that go beyond its strategic interests. This is seen in Chile's occupation of the region and its position as a gateway to Antarctica. These challenges also require us to act outside of our purely economic interests in natural resources, tourism, or providing services for international scientific efforts, which increase every year, as access to the Antarctic Peninsula through Punta Arenas grows in significance. From a personal standpoint, I believe that the big challenge here is to build a normative vision, to create a workable ethical framework for international cooperation and environmental protection for Antarctica. At the same time there should be a mechanism for Chile to develop a national self-image reflecting the values associated with the Antarctic, while transforming the Magallanes region and the city of Punta Arenas into a scientific and cultural center that is inherently tied to the work to be done in the Antarctic region.

Punta Arenas: Antarctic City

It's a beautiful warm morning in Punta Arenas on November 6, 2047. The city is celebrating the annual Antarctica Innovation Festival and a large number of national and international visitors are gathering outside the Interactive Antarctic Museum in Punta Arenas and waiting online for the immersive virtual experience. Many are curious to see the latest scientific visualizations of Antarctica that showcase the latest developments in robotics, quantum computing, and 3D printing. The Antarctic culture of Punta Arenas is in the air.

Some are there to celebrate the centenary of the 1947 expedition. But unlike 100 years ago these events will not be a reaffirmation of sovereignty. They will be a celebration of a new form of Antarctic citizenship. This idea of "Antarctic citizenship" refers to the idea that each of us is an integral part of a broader ecosystem, that our future depends on our acting collectively, responsibly, and positively towards Antarctica in ways that set aside the interests of one nation or another. This "Antarctic citizenship" is closer to the concept of "stewardship" and “custodianship” and differs from a status granted by a national government, which for Antarctica would be absurd. At that moment in 2047 Antarctic citizenship has come to mean a new kind of identification and political identity towards the southern continent. Citizenship is something that is constructed and performed; it is not only a status that is granted or denied by a State. Thus, by mid-century an "Antarctic citizen" is not a person who has been born in Antarctica, or who will necessarily have live there long enough, but instead one who undertakes political participation in Antarctic-related matters of concern on a daily basis from which he or she constructs a sense of belonging and identification.

By 2047 several climate change projections modeled in the first decade of the century have more or less occurred as predicted, including the relentless fracture of the West Antarctic Ice Shelf. Faced with the global reality of greater scarcity of resources, interest in Antarctic bio-resources has become more significant than ever. The signatory parties of the Antarctic Treaty have opened the Protocol on Environmental Protection for the Antarctic Treaty System for review. The results of these negotiations are uncertain.

We are not talking of an absurd science fiction scenario here. We are venturing into possible and preferred futures. In just over thirty years time, Chile’s position – like any other country with stakes in Antarctica - will have to be based significantly more than on short term national interests - whether political, strategic, or commercial. Many events may happen between now and then. Thirty years ago the world was somewhat different from what it is today. The Soviet Union was still five years away from Perestroika. There was no Internet. Several countries were discussing a new Convention on the Regulation of Antarctic Mineral Resource Activities, which as is widely known never entered into force.

If the future is being built today there is an opportunity on the horizon for a country like Chile to be more than a gateway to the Antarctic. One challenge ahead is how we might think of Punta Arenas as one of a new type of global "Antarctic cities." Therefore we need serious foresight to develop the required parameters to define what is an "Antarctic city". What does "Punta Arenas -Antarctic City" really mean in practical terms? How can the image of an Antarctic city be created as part of a national priority but transcending national interests at the same time towards greater good on a global scale? What sort of actors and what kind of activities and practices must be considered when designing a new Antarctic cultural economy?

Without a doubt, satisfactory answers to these tough questions are beyond the scope of this short position statement. But I would like to bring up two fundamental elements that support the value and significance of Punta Arenas as an example of an "Antarctic city." We must of course recognize that these advantages of the Magallanes region do not exist independently of other important characteristics (current economic development of the region, connectivity, investment, etc.)

The first aspect has to do with empowering Punta Arenas as a world-class scientific node. For this, we understand that the development of scientific capacity depends upon more than just the availability of adequate infrastructure and investment. It is also the product of good working relationships between professionals in the fields of science, industry, government, and the greater community. Having a world-class scientific node assumes that the field of scientific research is closely tied to a broader civic community. By the middle of this century it will be impossible to think of only a single institution coordinating activities in Antarctica. There will need to be a cluster of institutions working together, including universities, local government agencies, non-governmental organizations (NGOs), along with the integration of civil society in some manner. This condition can only be achieved through the establishment of shared values, strong alliances including public/private networks and private investment in the development of human capital and innovation, along with academic research. In this way Punta Arenas will be able to establish itself as an attractive international scientific node for other Latin American countries wishing to participate in Antarctic scientific work.

The second aspect is related to the need to begin creating policies to promote Antarctic cultural economy and Antarctic cultural identity as part of increasing the Magallanes Region's relationship to the national and regional strategies for Antarctica. According to a recent study the city of Punta Arenas is below average in 3 of the 4 categories analyzed: to live, to work, and to study. There is only one category, "place to visit", in which Punta Arenas is rated above average.

However, there is no doubt that incentives in the areas of lower taxes, reduced customs rates, and free-port privileges, do increase the competitiveness of the Magallanes Region, making its current role as "gateway to Antarctica" already very important. Likewise the region offers well-developed logistics and operational services, along with capable seaports, airports, telecommunications infrastructure, and other services based in and around Punta Arenas.

However, the absence of cultural capital tends to diminish opportunities for development opportunities. It's not enough to merely strengthen existing skills. There must be a regional strategy to promote a cultural economy for the urban centers in the region, including encouragement for sustainable tourism, as well as promotion and regulation of the special interests that link Patagonia and Antarctica.

Developing an Antarctic culture and identity cannot be imposed or designed from the top-down. We must move beyond the campaigns for dissemination of information on Antarctic activities at a national level. It's not enough to incorporate Antarctic themes in education curricula, or providing incentives and support for academic studies, artistic work and cultural field programs that focus on the southern polar region. Today, economic and cultural processes are more interrelated than ever. From a cultural economy perspective, there must be a better understanding of the economic dimensions of the cultural practices and products in Punta Arenas that are related to Antarctica, as we have seen in cities like Christchurch or Hobart, where the Antarctic connection has added to the economy and culture of these cities.

How is Antarctica a catalyst for economic and social development for Punta Arenas and the Magallanes region? This requires conceptualizing an Antarctic cultural economy for Punta Arenas that is supported by public policies and citizen participation. This in turn implies the need for a communications strategy that creates a "branding" of the Antarctica Magallanes region, with Punta Arenas as its central feature, as the focus of scientific, cultural and educational development. This ultimately moves from the concept of Punta Arenas as a gateway to Punta Arenas as an "Antarctic city." In this way we can begin to think that the notion of a 'gateway city' is today predominantly treated locally and globally as a limited functional one. Punta Arenas must also think of itself in relation to other Antarctic cities, like Hobart, Christchurch or Ushuaia. As new modes of global cities these Antarctic cities are melding globalist aspirations with national interests, in paradoxical combinations of cosmopolitan and nationalist commitment. The core question to be addressed concerns the possibility (beginning to be expressed by the cities themselves) of reimagining the current largely functional role as one of custodianship within a local, regional and globalizing network of broader economic, ecological, political and cultural relations.

Conclusions

One defining quality of our current moment in the world is the disposition to thinking and living in anticipation of the future. Some would argue that we appear to be increasingly living in a regime of anticipation in which likelihoods and probabilistic outcomes often prevail. This intensification of modes of knowing those emerging worlds that the future brings about is marking a peculiar mode of anticipation, one that urges social actors - and the biophysical sciences above all – to get hold of the as-yet-not. For the purposes of this essay, this appraisal of the 'not yet' is traversed by a fundamental, game-changing question: As Australian environmental historian Libby Robbin puts it: "how can we live in a world where there is no nature without people". The underlying significance of this matter is that what we do next has fateful consequences for human and non-human life on Earth. We no longer have the option to step out of civilization with the recourse of coming back to it at a later time once the crisis is over. Antarctica ceased long time ago to be that enemy or force to be vanquished. As US scholar Elena Glasberg has noted, "the ice itself is under threat. It is no longer the enemy or the implacable outside force to be conquered. Nor is it an uncomplicated pure wilderness. It is no longer exactly a blank backdrop for imperial posturing. Rather, the ice is fragile, melting, ever shifting—in need of rescue". In this sense, Antarctica and the Southern Ocean will continue to be a unique natural laboratory for scientific discovery. But we must also acknowledge that the Antarctic is also a laboratory of ideas that invites us to think about the future of humanity on this planet. It is a tough question that asks how, as a species, we might learn to live in extreme environments posed by the Anthropocene.

In this essay I have tried to invite a reflection around Antarctica's future, and the consequences that come with acting in the present on the basis of how to explore "the future" within an Antarctic context. We must consider what consequences might arise from acting in the present on this future basis, and identify the participants who are included (and excluded) in this future. Antarctica offers us a plausible model of how 21st century humanity might continue to colonize and inhabit new extreme environments, including future exploration of other planets. International cooperation and dialogue can certainly benefit from improved understanding of the existence of many possible futures for the Antarctic, futures which can be articulated, mobilized, legitimized and implemented in very different ways.

In a world where we are seeing a renewed intensification of national-interest rivalries (particularly over resource management) and severe qualification of the negotiation of global protocols, the shift from 'gateway cities' to 'custodial cities' is a complicated one. Social research can show on what basis and in what ways this might be achievable for sub-Antarctic and polar regions in a way that provides an important exemplary illustration of what is possible for other eco-zones. In the case of Chile, the Chilean Antarctic Institute (INACH) would need to play a major role in all this. In a multidimensional world, a relatively small country like Chile could only benefit from increasing its international partnerships, and by working collaboratively with other countries and nongovernmental players to establish fair and just international standards and global procedures that are firmly based on solid democratic traditions.

THE INTERNATIONAL ANTARCTIC CENTER: HUNTING DOWN A DREAM

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In June of 2014, the Government of Chile presented a "Special Plan for the Remote Regions" which addressed the nation's southernmost territory, the Magallanes and Chilean Antarctic Region. This plan included specific consideration for polar and subpolar scientific work, along with provisions for the design and construction of an International Antarctic Center. The dream that has been kept alive for many long years is about to become a reality. The Magallanes regional government is leading the development of proposals and technical specifications for bidding for its design.

The History of a Dream

Among the functions of the human brain, and something that distinguishes our species from most of the other animals, is our unique ability to perceive and use time as a dimension of the known universe. We possess an understanding of the past, present and future as components of what is commonly called history. Thanks to this cognitive function, we can not only predict critical everyday situations such as accidents or potentially risky behavior, but we are also able to project ourselves into a future in which we want to move about and live.

For several years now, we at the Chilean Antarctic Institute (INACH) have collectively employed this ability to gradually construct an expectation, a desire, a dream: to build a place where Antarctic science can be experienced and enjoyed from the standpoints of wonder, learning, and dialogue.

As of 2006, we had already begun to put together the background requirements, using both national and international consultants, who helped to develop a museum project, which was the original concept at the time.

From the first minute we started to think about this project we believed it would be a significant contribution to not only to the Magallanes region, but for the nation and the entire world. An Antarctic center in Punta Arenas, where thousands of tourists would visit every year, and where the 20 countries of the Antarctic Treaty System that use the city as a gateway, would see a space dedicated to exchange and cooperation. A center open to the world, designed for the interactions of a wide variety of users.

This process counted on such resources as the highly esteemed opinions of Jorge Wagensberg and Hernán Crespo, developers of Barcelona's CosmoCaixa, as well as assistance from our national experts who brought this concept to maturity and helped lay the groundwork to demonstrate the feasibility of the project. The initial efforts also included a number of visits to several museums and interactive centers associated with scientific, technological, and polar subjects in Europe, Asia, Oceania, and America.

This project, unfortunately, had to be postponed several times in recent years due to the funding demands to respond to the natural disasters that are so common in Chile. But in the end, the flame of hope was kept very much alive.

On June 17, 2014, in Punta Arenas, the President of Chile, Michelle Bachelet, presented the scope for a "Special Plan for the Remote Regions" for the Magallanes and Chilean Antarctica territory, revolving around the objective scientific progress in Antarctica as an area of major focus. During her speech, the president said, "This is a plan that seeks to improve the quality of life of each of the inhabitants of the southernmost regions of Chile. With this we are taking responsibility for one of the major inequities of our country: territorial inequality."

For the Magallanes region, this plan involves a total cost of 309 billion CLP (about US$515 million). The program establishes six priorities: transforming the Magallanes territory into a world-class scientific region; strengthening connectivity for the largest territory in the nation; improving social development for the inhabitants; investing in the development of energy for the future; building upon the Patagonian pioneer heritage; and promoting work and entrepreneurship through the creation of new tools to enhance the economic, social and cultural development of the community.

The area of "a world-class scientific region" includes the design and construction of an International Antarctic Center, with an investment of nearly 36 billion CLP (about US$60 million). The dream has begun to materialize.

An Antarctic Center: Why?

The development of a nation's Antarctic science is a complex and strategic process, which must include the creation of superior human resources, financing relevant projects through open competitions, and the dissemination of knowledge in professional journals. But that is not enough.

If we perceive knowledge as a resource that enables the sociocultural and economic development of a country, then sharing the benefits of scientific activity with the general public becomes an ethical imperative, particularly when 90 percent of the funding for the scientific programs involve public resources, to which every citizen has contributed through their taxes.

For over a decade, international bodies such as the Organization of Ibero-American States (OEI, for its Spanish acronym) and UNESCO have recommended that countries promote what they call "scientific literacy" among their citizens. This concept attempts to that show the role of literacy as a key element for social development during the twentieth century is no longer enough. Citizens must also develop the ability to interpret 21st-century scientific information, to prepare them to confront the daily decisions of a society heavily dependent upon technology. It might be said that this is the emergence of a "scientific culture".

In Chile, there is still less than satisfactory perception, understanding, and public appreciation of science and technology. What is needed are initiatives to address these shortcomings. Analyses involving comparative studies of our country, within the context of the Organization for Economic Cooperation and Development (OECD), have frequently indicated that if we do not increase public investment in science, technology and innovation, and if we fail to promote a scientific culture, then we run the risk of significantly lower levels of future national development.

One signal that can be a key feature in this quest is the construction of the International Antarctic Center. This project is intended to assemble a scientific center for international cooperation along with a place for the dissemination of Antarctic knowledge, whose specific mission is to develop a national scientific culture that is based primarily upon the research conducted on the White Continent and in Patagonia.

This dream is no mere coincidence or matter of chance. It is based largely on the current Chilean Antarctic scientific work being conducted, which is nearly seven times greater than what it was 10 years ago. For the 2015-2016 season, INACH will support more than 80 research projects. A total of twenty countries will use Punta Arenas as their gateway to the White Continent.

The new International Antarctic Center should create the opportunities for community participation and dialogue, to allow citizens to achieve the ability to interpret polar scientific information. We have a special opportunity, unique in all the world, to be able to learn (and grasp) the knowledge generated in the Antarctic territory, and in doing so to improve our quality of life, to create new centers of economic development, and to contribute to building a “cultured” society.

Progress

Last year the Magallanes regional government took steps to begin the implementation of the International Antarctic Center, and charged INACH and the University of Magallanes with the work of preparing proposals and technical specifications for the conceptual phase of the Center's design. In this time, the greatest challenges include ensuring feasibility and sustainability of the Center and reconciling the complex relationships between the architectural work and its contents, to ensure the functionality that will enable it to meet its objectives.

We have already begun working the first phase, with the development of a timeline with key project milestones, taking into account funding and production aspects of investment and production for the spaces and facilities for the functions of science, logistics, and outreach. As a part of this we've talked to a number of national Antarctic scientists and science communications specialists around the country, providing relevant information that has allowed, among other achievements, the building of narratives ("storytelling") to be used in the interpretive-interactive area of the center, for the purpose of connecting the Center with the community and various national and international target audiences.

Strategic scientific areas have been defined for the Center to further develop. Additional equipment will allow the formation of collaborative working groups that foster national and international cooperation. We are hoping to strengthen working alliances through networking with partners in both science and media, since we have already noted a great deal of interest in the Center by the international community.

We still have a long way to go. Meeting the obligations of each phase of such a large and complex project will call for expertise and dedication. We must ensure the quality of the proposal from the very beginning, employing the talents and commitments that our community will provide to reach these objectives. Today the International Antarctic Center is no longer just a dream shared by a few. This is a dream for the entire Magallanes region, where we continue to contemplate a country that is increasingly Antarctic.

CHILEAN ANTARCTIC **SCIENCE PROGRAM**


T. DUPRADOU

Line I.

The State of the Antarctic Ecosystem

I.4 Biodiversity of Southern Ocean seaweed

I.7 Microevolution of penguins

I.8 Parasite fauna in Antarctic fishes

I.9 Photobionts of genus *Caloplaca*

I.10 Evolutionary adaptions of *Nacella*

I.11 Viral and bacterial diversity in seawater and Antarctic fish species

I.12 A biophysical study of ichthyoplankton

I.13 Evolutionary history of the Antarctic pearlwort

I.15 New fungal species from Antarctic marine sponges

I.16 Plant cover and microorganisms

I.17 Microsphere - Microbial Life in Antarctic Cryosphere

I.1 Macroalgal Adaptive Radiation

I.2 Paleogeographic patterns v/s climate change

I.3 Diversification of the spiny plunderfish *Harpagifer*

I.5 Phylogeography and evolutionary history of *Neobuccinum eatoni*

I.6 Biogeographic patterns and processes in mollusks

I.14 Metagenomics of microbial communities

Line II.

Antarctic Thresholds: Ecosystem Resilience and Adaptation

II.12 Climate adaptation in marine species

II.15 *Campylobacter* in Antarctica

II.18 Historic and recent colonizers

II.19 Characterization of *Deschampsia antarctica*

II.20 Active layer of frozen soils

II.3 Invertebrates responses to thermal stress conditions

II.4 Moss carpets and native plants

II.5 Responses of the Antarctic mosses to global warming

II.6 Response of soil enzymatic and microbial activity

II.7 Freezing tolerance of Antarctic vascular plants

II.9 Photosyntetic responses to warming

II.10 Addressing global warming scenarios in freshwater ecosystems

II.11 Endophytic fungi in *Deschampsia antarctica*

II.13 Freshwater flow and primary productivity

II.14 Bio-optical modelling of Antarctic sea-ice algal growth

II.16 Biological hot spots along the Antarctic Peninsula continental shelf

II.17 Warming, CO2 and leaf respiration

II.1 Impact of global change on the physiology of Antarctic seaweeds

II.2 Antarctic Plant Ecophysiology

II.8 Antarctic microbial community in response to deglaciation

Line III.

Antarctic Climate Change

III.2 Chemical fingerprint of Antarctic aerosols and snow in Laclavère Plateau

III.5 Glaciers dynamic

III.1 Climate reconstruction at the northern Antarctic Peninsula

III.3 Glacier response to climate change in Chile

III.4 Influence of the solar activity on the polar enviroment

Overview

CHILEAN ANTARCTIC SCIENCE

Line IV.
Physical and Earth Sciences

- IV.4 Thermal evolution of the Antarctic Peninsula
- IV.7 Geochronology in Peninsula Fildes
- IV.8 George VI Ice shelf tributary glacier types
- IV.1 Magnetospheric dynamics
- IV.2 Ozone and solar radiation
- IV.3 Reflectivity of Antarctica
- IV.5 Seismic facies variability and sedimentation
- IV.6 Ozone and atmosphere-ocean system

Line V.
Antarctic Microbiology and Molecular Biology

- V.4 Microorganisms able to synthesize nanoparticles
- V.5 Microbial consortiums with high acidogenic and methanogenic activity
- V.6 Potential of Antarctic actinobacteria
- V.7 Gram+ bacteria associated with Antarctic macroalgae
- V.8 Yeasts and Antarctic terrestrial habitats
- V.9 Polyphenols isolated from Antarctic lichens
- V.10 Antifreeze proteins
- V.13 Study of cold-active enzymes
- V.14 Bacterial diversity in soils
- V.24 Metabolites in Antarctic yeast
- V.25 Thermophilic antartic lipases
- V.15 Mercury resistance mechanisms in bacteria
- V.16 Biochemical mechanisms in moss
- V.17 Reduction of tellurite and copper in bacteria
- V.18 Production of metabolites in microalgae
- V.19 Depsides and depsidones from Antarctic lichens
- V.20 Lichens and biofilm formation
- V.21 Cytotoxic activity in Antarctic and Subantarctic actinobacteria
- V.22 Antibacterial compounds from Antarctic lichens
- V.26 Psychrophilic bacteria isolated from *Deschampsia*
- V.27 Antimicrobial activity of *Pseudomonas*
- V.28 Nanostructures from tellurite-resistant bacteria
- V.29 Tellurite resistance in bacteria
- V.30 Production of fluorescent nanoparticles from bacteria
- V.1 New antineoplasic molecule from *Deschampsia*
- V.23 Equinochromes in sea urchins
- V.2 Antibacterial activity of lichens
- V.3 Enzyme with beta-galactosidase activity
- V.11 Metagenomic of microbial communities associated to Antarctic marine invertebrates
- V.12 Role of Antarctic root-endophytes in Lettuce crops

Line VI.
Antarctic Environment

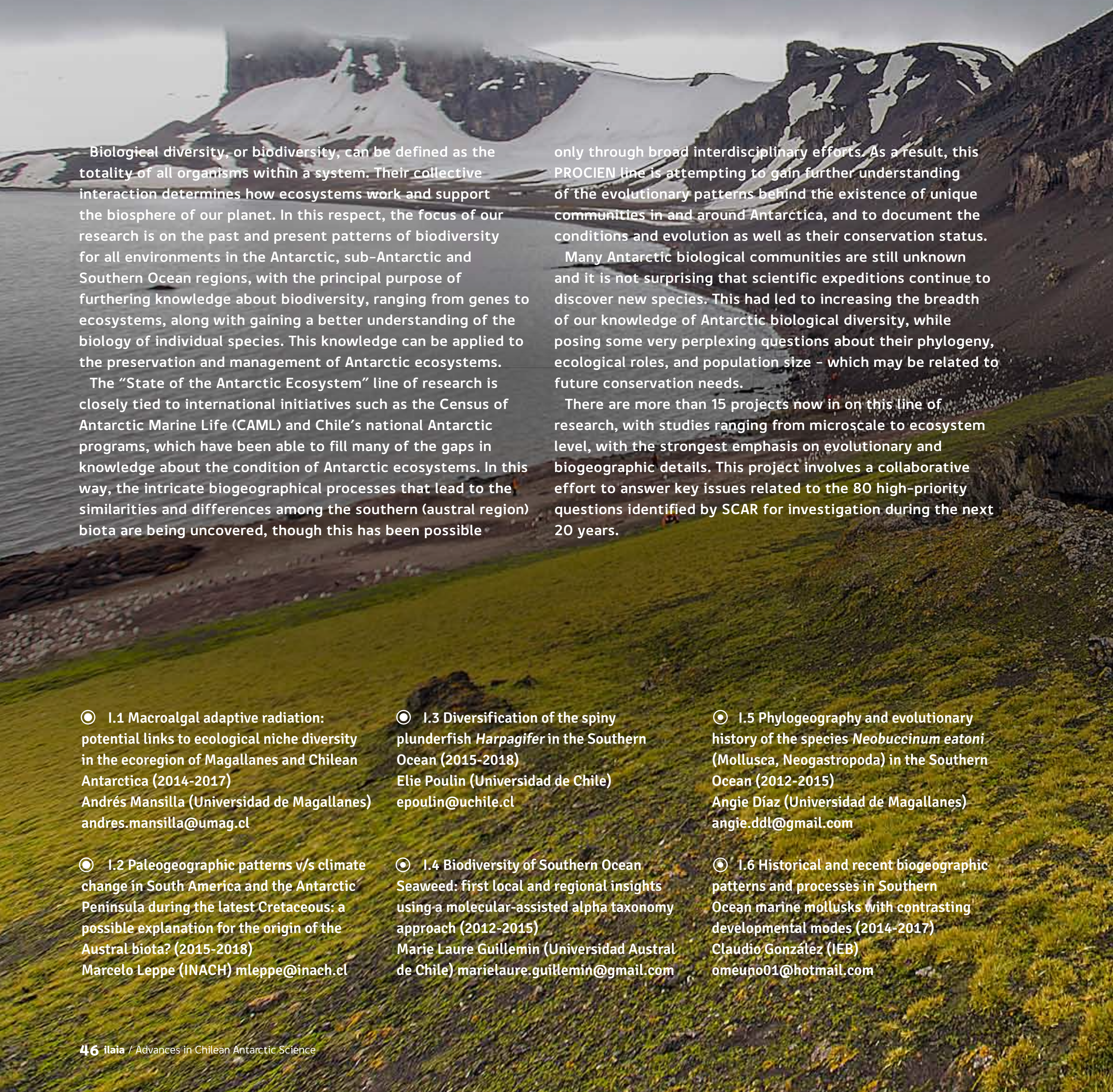
- VI.2 Persistent Organic Pollutants (POPs) in the aquatic food web
- VI.3 Impacts of Antarctic bases on the aquatic ecosystems
- VI.4 Resistance genes from waste waters
- VI.6 Heavy metals and persistent organic pollutants on Antarctic fauna
- VI.7 Non-native plant species
- VI.5 Environmental Antarctic Monitoring Center
- VI.8 Melting Claims
- VI.1 Paint schemes to protect structural steel constructions

FINANCING SOURCES

- INACH FIELD PROJECTS
- INACH LAB PROJECTS
- INACH THESIS SUPPORT
- INACH SPECIAL PROJECTS
- PIA INACH
- CORFO-INNOVACHILE
- FONDECYT-INACH
- FONDEF-INACH
- INTERNATIONAL COLLABORATION

Line I: THE STATE OF THE ANTARCTIC ECOSYSTEM

Associated with the Scientific Committee on Antarctic Research (SCAR) program, "State of the Antarctic Ecosystem (AntEco)."



Biological diversity, or biodiversity, can be defined as the totality of all organisms within a system. Their collective interaction determines how ecosystems work and support the biosphere of our planet. In this respect, the focus of our research is on the past and present patterns of biodiversity for all environments in the Antarctic, sub-Antarctic and Southern Ocean regions, with the principal purpose of furthering knowledge about biodiversity, ranging from genes to ecosystems, along with gaining a better understanding of the biology of individual species. This knowledge can be applied to the preservation and management of Antarctic ecosystems.

The "State of the Antarctic Ecosystem" line of research is closely tied to international initiatives such as the Census of Antarctic Marine Life (CAML) and Chile's national Antarctic programs, which have been able to fill many of the gaps in knowledge about the condition of Antarctic ecosystems. In this way, the intricate biogeographical processes that lead to the similarities and differences among the southern (austral region) biota are being uncovered, though this has been possible only through broad interdisciplinary efforts. As a result, this PROCIEN line is attempting to gain further understanding of the evolutionary patterns behind the existence of unique communities in and around Antarctica, and to document the conditions and evolution as well as their conservation status.

Many Antarctic biological communities are still unknown and it is not surprising that scientific expeditions continue to discover new species. This had led to increasing the breadth of our knowledge of Antarctic biological diversity, while posing some very perplexing questions about their phylogeny, ecological roles, and population size - which may be related to future conservation needs.

There are more than 15 projects now in on this line of research, with studies ranging from microscale to ecosystem level, with the strongest emphasis on evolutionary and biogeographic details. This project involves a collaborative effort to answer key issues related to the 80 high-priority questions identified by SCAR for investigation during the next 20 years.

I.1 Macroalgal adaptive radiation: potential links to ecological niche diversity in the ecoregion of Magallanes and Chilean Antarctica (2014-2017)
Andrés Mansilla (Universidad de Magallanes)
andres.mansilla@umag.cl

I.2 Paleogeographic patterns v/s climate change in South America and the Antarctic Peninsula during the latest Cretaceous: a possible explanation for the origin of the Austral biota? (2015-2018)
Marcelo Leppe (INACH) mleppe@inach.cl

I.3 Diversification of the spiny plunderfish *Harpagifer* in the Southern Ocean (2015-2018)
Elie Poulin (Universidad de Chile)
epoulin@uchile.cl

I.4 Biodiversity of Southern Ocean Seaweed: first local and regional insights using a molecular-assisted alpha taxonomy approach (2012-2015)
Marie Laure Guillemin (Universidad Austral de Chile) marielaure.guillemin@gmail.com

I.5 Phylogeography and evolutionary history of the species *Neobuccinum eatoni* (Mollusca, Neogastropoda) in the Southern Ocean (2012-2015)
Angie Díaz (Universidad de Magallanes)
angie.ddl@gmail.com

I.6 Historical and recent biogeographic patterns and processes in Southern Ocean marine mollusks with contrasting developmental modes (2014-2017)
Claudio González (IEB)
omeuno01@hotmail.com

I.7 Microevolution of penguins in Antarctica: genomic-wide SNP analysis to understand adaptation (2014-2017)
Juliana Vianna (Pontificia Universidad Católica de Chile) jvianna@uc.cl

I.8 A missing Component of Biodiversity: Evaluation the Biodiversity on parasite fauna in Antarctic Fishes (2014-2017)
Isabel Valdivia (Universidad Austral de Chile) isabel.valdiviarojas@gmail.com

I.9 Photobiont selectivity and specificity in the genus *Caloplaca* (lichenized Ascomycota): comparisons between southern Chile and Antarctic communities (2014-2017)
Reinaldo Vargas (Universidad Metropolitana de Ciencias de la Educación) reinaldovargas@gmail.com

I.10 Evolutionary adaptions of voltage dependent potassium channels from an Antarctic organism (2012-2015)
Patricio Rojas (Universidad de Santiago de Chile) patricio.rojas.m@usach.cl

I.11 Study of viral and bacterial diversity in seawater and Antarctic fish species: Finding of natural reservoir of salmonid pathogen (2013-2016)
Marcelo Cortez (Universidad de Santiago de Chile) marcelo.cortez@usach.cl

I.12 Does dietary overlap, feeding selectivity and growth change in Antarctic ichthyoplankton at different time scales? A biophysical study in Chile Bay, Greenwich Island, South Shetland Islands during austral summer season (2013-2016)
Mauricio Landaeta (Universidad de Valparaíso) landaeta.mauricio@gmail.com

I.13 Evolutionary history of the Antarctic pearlwort *SWW* (Caryophyllaceae): Population genetics, phylogeographic patterns, and adaptive differentiation (2014-2017)
Cristian Torres (Universidad del Bío Bío) crtorres@ubiobio.cl

I.14 The metagenomes and metatranscriptomes of microbial communities at the Arctic and Antarctic Ocean surfaces: which metabolic processes and principal actors drive these ecosystems and how will climate change modify them? (2013-2016)
Beatriz Fernández (Universidad de Chile) biotica@gmail.com

I.15 Identification of new fungal species from Antarctic marine sponges (2014-2016)
Inmaculada Vaca (Universidad de Chile) inmavaca@uchile.cl

I.16 Effects of plant cover on methanogenic activity and diversity of soil microorganisms in Antarctic soils (2014-2015)
Alejandro Atenas (Universidad de Concepción) aleatenas@udec.cl

I.17 Microsphere-microbial life in Antarctic cryosphere: climate change and bioprospecting (2014-2015)
Marcelo González et al. (INACH-USP) mgonzalez@inach.cl

J. BARBOSA

Funding over USD 850.000.
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Funding between USD 105.000 and 210.000.
Funding under USD 105.000.

T. DUPRADOU

Line II:
ANTARCTIC THRESHOLDS: ECOSYSTEM RESILIENCE AND ADAPTATION

Associated with the "Antarctic Thresholds: Ecosystem Resilience and Adaptation (AnT-ERA)" program, from the Scientific Committee on Antarctic Research (SCAR).

Stress factors in Antarctic ecosystems result from a number of aspects, including seasonal and inter-annual variability, long-term climate change, conditions involving low temperature, high levels of ultraviolet radiation, and scarcity of water. To these natural conditions we also acknowledge the stress factors related to human activities.

The unusual conditions found at various locations in Antarctica have shown differing levels of change. While some areas of the White Continent itself may not show evidence of this, the Antarctic Peninsula region has become one of the areas that has suffered the greatest temperature increases in the past fifty years. In the coming years we should expect to see cascading biological responses, ranging from a molecular level to alterations of entire communities, and involving key organisms in the Antarctic ecosystem.

The AnT-ERA program is intended to describe how Antarctic organisms have adapted to current conditions, and how they might respond in the future. It also hopes to identify which species will likely be winners and which will be losers under these new scenarios, and how this will affect the functioning of the communities and ecosystems.

This represents an opportunity for measuring and quantifying the effects of a warming climate, for impacts ranging from factors affecting individual species to the ecosystem, and helps in the understanding of current patterns and processes as well as for the detection of changes in the future.

This concept employs several projects, using a number of different approaches, to address the research questions, whether these deal with Antarctic plants, algae, invertebrates, mosses, or bacteria as the principal subjects in the studies. Antarctic algae, for example, have revealed their resistance to the effects of changing conditions in the Southern Ocean, demonstrating that they have the metabolic prerequisites to adapt to such change. Likewise, Antarctic macroalgae would be resistant to short-term UV stress at current temperatures and under probable increases predicted within the context of climate change.

◉ II.1 Impact of global change on the physiology of Antarctic seaweeds: Consequences for coastal processes in scenarios of temperature shifts and enhanced radiation (2012-2015)
Iván Gómez (Universidad Austral de Chile)
igomezo@uach.cl

◉ II.2 Antarctic Plant Ecophysiology: Unraveling the biological consequences of climate change on plant populations of the Maritime Antarctic (2012-2015)
León Bravo (Universidad de La Frontera)
leon.bravo@ufrontera.cl

◉ II.3 Coping with warming of Southern Ocean: invertebrate's responses to thermal stress conditions (2013-2016)
Marcelo González (INACH)
mgonzalez@inach.cl

◉ II.4 Assessing the importance of moss carpets for the establishment of native plants in the Antarctic under a global change scenario (2012-2015)
Angélica Casanova (Universidad de Concepción) angecasanova@gmail.com

◉ II.5 Metabolomic responses of the Antarctic mosses *Sanionia uncinata* and *Polytrichum alpinum* to global warming (2014-2017)
Gustavo Zúñiga (Universidad de Santiago de Chile) gustavo.zuniga@usach.cl

◉ II.6 Response of soil enzymatic and microbial activity to global temperature increase in cold ecosystems of Patagonia and Antarctica (2014-2017)
Angela Machuca (Universidad de Concepción)
angmachu@udec.cl

◉ II.7 How would experimental warming affect freezing tolerance of Antarctic vascular plants? (2015-2018)
León Bravo (Universidad de La Frontera)
leon.bravo@ufrontera.cl

◉ II.8 Shifts in marine Antarctic microbial community structure and function in response to deglaciation and sea ice meeting accelerated by climate change (2014-2017)
Beatriz Díez (Pontificia Universidad Católica de Chile) bdiez@bio.puc.cl

◉ II.9 Photosintetic responses to warming as consequence of the climate change in populations of Antarctic plants from different latitudes in the Maritime Antarctic (2013-2016)
Patricia Sáez (Universidad de Concepción)
patrisaezd@gmail.com

◉ II.10 Addressing global warming scenarios in freshwater ecosystems using aquatic insects as model organisms in sub-Antarctic and Antarctic regions (2013-2016)
Tamara Contador (Universidad de Magallanes) tamara.contador@yahoo.com

◉ II.11 Effect of endophytic fungi on the ecophysiological performance and biochemical responses of *Deschampsia antarctica* under the current scenario and in one of simulated global climate change (2013-2016)
Rómulo Oses (CEAZA) romulo.oses@ceaza.cl

◉ II.12 Applying evolutionary principles to infer climate adaptation in marine species: using a genomic approach (2014-2017)
Juan Gaitán (Universidad Austral de Chile)
juadiegaitan@gmail.com

◉ II.13 Influence of freshwater flow on primary productivity, biogenic silica content and nutrients in South Patagonia and the Antarctic Peninsula (2012-2015)
Claudia Aracena (Universidad Austral de Chile) claudiaaracenap@gmail.com

◉ II.14 Bio-optical modelling of Antarctic sea-ice algal growth (2012-2015)
Ernesto Molina (Pontificia Universidad Católica de Chile) emolina@bio.puc.cl

◉ II.15 *Campylobacter* in Antarctica: diversity, origin and effects on wildlife (2014-2017)
Daniel González (Universidad de Concepción)
danigonz@udec.cl

◉ II.16 Physical controls of biological hot spots along the Antarctic Peninsula continental shelf: future status and current climate trends (2014-2017)
Andrea Piñones (CEAZA)
andrea.pinones@yale.edu

◉ II.17 Effect of warming and increased CO2 concentration on thermal acclimation of leaf respiration of Antarctic plants (2014-2017)
Carolina Sanhueza (Universidad de Concepción) csanhuez@gmail.com

⊙ II.18 Historic and recent colonizers: genetic and phenotypic variability and phylogenetic relationships of *Colobanthus quitensis* and *Juncus bufonius* in the context of regional changes in Antarctica (2013-2015)
Marely Cuba (Universidad de Concepción)
mcuba@udec.cl

⊙ II.19 Characterization anatomical, physiological and molecular in *Deschampsia antarctica* DEV., under salt stress (2013-2015)
Daisy Tapia (Universidad de Concepción)
d.tapia02@ufromail.cl

⊙ II.20 Study of the active layer of frozen soils within the area of Düse Bay, Antarctic Peninsula (2014-2015)
Sebastián Ruiz (Universidad de Magallanes)
sruizp@outlook.com

◉ Funding over USD 850.000.
◉ Funding between USD 210.000 and 850.000.
◉ Funding between USD 105.000 and 210.000.
⊙ Funding under USD 105.000.

Line III:
ANTARCTIC CLIMATE CHANGE

Associated with the "Antarctic Climate Change in the 21st Century," and "Past Antarctic Ice Sheet Dynamics" programs, from the Scientific Committee on Antarctic Research (SCAR).

In dealing with the threat posed by climate change, it is clear that a large number of our society's challenges and opportunities will flow from two sources: the study of phenomena in Antarctica, and the impacts of global telecommunications.

The growing concern over climate change in recent years reinforces the urgent need to find answers to many key questions affecting Antarctica, so that the coming impacts can be assessed, along with a better understanding of the causes that bring these changes about.

At the same time, as a result of this search for answers relating to Antarctica, a steadily growing multidisciplinary approach has been developed, stimulating the advancement of science and at the same time, aiding in the formation of advanced human capital.

Within this context two SCAR scientific programs work toward these objectives:

1. Antarctic Climate Change in the 21st Century (AntClim21), an effort attempting to provide better regional predictions relating to key elements of the Antarctic atmosphere, the Southern Ocean, and the cryosphere over the next 20 to 200 years. The program also expects to provide improved understanding of the responses of physical systems and the biological factors derived from natural and anthropogenic forcing.

2. Past Antarctic Ice Sheet Dynamics (PAIS), a program which is responsible for greater knowledge and understanding of the sensitivity of the ice sheets on East and West Antarctica and the Antarctic Peninsula, against a wide range of changing climatic and oceanic conditions. These include modeling the "greenhouse" climate of the past, which was warmer than the present environment, along with earlier periods of warming and ice retreat during the terminal phases of the most recent ice ages.

Several of the PROCIEN projects in this line of research reflect the efforts to enhance understanding of these processes and mechanisms of change, and to assess the associated trends. One approach attempts to reconstruct past climate conditions using recent high-resolution glacial and geochemical records obtained for the Laclavere ice plateau and surrounding areas near the Union Glacier. This type of research involves enormous logistical challenges to provide for working in those extreme and remote environments. These projects involve the use of cutting-edge technologies to assist in solving key questions regarding the past, present and changing future in Antarctic climate parameters.

III.1 Recent high-resolution climate reconstruction at the northern Antarctic Peninsula: glacio-geochemical investigations at Plateau Laclavere ice cap (2012-2015)
Francisco Fernandoy (Universidad Nacional Andrés Bello) francisco.fernandoy@unab.cl

III.2 Chemical fingerprint characterization of Antarctic aerosols and snow in Laclavère Plateau: Assessment of their impact on glacier retreat and its relationship with global warming (2013-2016)
Francisco Cereceda (Universidad Técnica Federico Santa María)
Francisco.cereceda@usm.cl

III.3 Understanding glacier response to climate change in Chile (2013-2016)
Shelley MacDonell (CEAZA)
shelley.macdonell@gmail.com

III.4 Influence of the solar activity on the polar environment (2014-2017)
Alessandro Damiani (Universidad de Santiago de Chile)
alessandro.damiani@usach.cl

III.5 Glaciers dynamic on the Antarctic Peninsula and the Southern Patagonian Ice Field and estimating variations in mass loss for the oceans (2014-2015)
Ricardo Jaña (INACH-FURG) rjana@inach.cl

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Funding between USD 105.000 and 210.000.
Funding under USD 105.000.


E. BARTICEVIC

Line IV:

PHYSICAL AND EARTH SCIENCES

Associated with the "Antarctic Astronomy and Astrophysics" and "Solid Earth Responses and Influences on Cryosphere Evolution" programs, by the Scientific Committee on Antarctic Research (SCAR).

More than anything else, it is the physical environment that has determined the nature of the existence of life in Antarctica, and has shaped its landscape. Understanding of the physical conditions is a major component in an appreciation of the present, as well as the future of the White Continent.

This research line integrates the branches of Antarctic science to create a holistic study of the continent and its surrounding ocean, as key parts of our planet down through history. This line is tied to the research conducted by two SCAR Standing Scientific Groups: GeoSciences, and Physical Sciences. In addition, it is also linked to two of the SCAR Scientific Research Programs: Antarctic Astronomy and Astrophysics (AAA), and Solid Earth Response and influence on Cryospheric Evolution (SERCE) .

At a physical level, the processes occurring at the interfaces between the ice, the oceans, the land and the atmosphere -- all these are essential to provide us with the ability to describe and predict responses to climate change.

There are still uncertainties that call for continuing research to enhance our understanding of the dynamics of the Antarctic ice shelf, as well as the processes and changes involved in sea ice and ocean current circulation. There are still unresolved questions about atmospheric dynamics and chemistry, and the role of upper-atmospheric ozone as it affects the Antarctic climate.

We must also keep in mind that the elements of physical sciences research in Antarctica are based on the unique properties of the White Continent. Some of these special characteristics also support its use as a platform for astronomical observation and studies of the relationships between earth and the sun.

The 2015 PROCIEN projects covering this theme include two that we believe are particularly noteworthy. One is the study and interpretation of recent sedimentary processes to detect varying rates of sedimentation along the coast of the Antarctic Peninsula. The other is a new approach to study the influence of solar activity on the Antarctic environment, which compares satellite data estimates with new models of atmospheric chemistry in an effort to assess climate forcing.

◉ **IV.1 Turbulence in space plasmas and its impact on the magnetospheric dynamics and space weather (2011-2015)**
Marina Stepanova (Universidad de Santiago de Chile) marina.stepanova@usach.cl

◉ **IV.2 Multichannel espectroradiometer to monitor ozone and solar radiation in Antarctica (2014-2015)**
Raul Cordero (Universidad de Santiago de Chile) raul.cordero@usach.cl

◉ **IV.3 Reflectivity of Antarctica (2015-2018)**
Raúl Cordero (Universidad de Santiago de Chile) raul.cordero@usach.cl

◉ **IV.4 Thermal evolution of the Antarctic Peninsula and the South Shetland Islands by thermochronology: implications to climate change (2014-2017)**
Francisco Hervé (Universidad de Chile) fherve@ing.uchile.cl

◉ **IV.5 Seismic facies variability and sedimentation processes in small bays and fjords of the Danco Coast, Antarctic Peninsula (2012-2015)**
Cristián Rodrigo (Universidad Nacional Andrés Bello) cristian.rodrigo@unab.cl

◉ **IV.6 Ozone variability influence on the coupled atmosphere-ocean system (2014-2017)**
Pedro Llanillo (Universidad de Santiago de Chile) pedroquechua@hotmail.com

⊙ **IV.7 Geochronology of secondary mineral assemblages in Peninsula Fildes, King George Island: implications on the origin of these paragenesis (2014-2015)**
Daniela Matus (Universidad Nacional Andrés Bello) d.matuswalsen@uandresbello.edu

⊙ **IV.8 Clustering of George VI Ice shelf tributary glacier types (2014-2015)**
Guido Staub (Universidad de Concepción) gstaub@udec.cl

◉ Funding over USD 850.000.	◉ Funding between USD 210.000 and 850.000.
◉ Funding between USD 105.000 and 210.000.	⊙ Funding under USD 105.000.

J. BARBOSA

Line V:
ANTARCTIC MICROBIOLOGY AND MOLECULAR BIOLOGY

Progress in molecular studies in Antarctica is coordinated with the national guidelines that are aimed at responding to specific needs through applied research. In recent decades, the Antarctic continent has become the focus for researchers who are interested in not only the study of adaptations of organisms to extreme Antarctic conditions, but are looking into possible applications.

After more than ten years of study, the stomachs of krill have provided insights and characterization of the first known enzymes that degrade proteins at low temperature. Many of the projects in this PROCIEN address the search for applications.

These include the characterization of antibacterial molecules produced by Antarctic bacteria, biotechnological applications of fluorescent nano-composites produced by bacteria, and even antineoplasic compounds from an Antarctic plant that could help fight cancer.

Yeasts, which are important in industrial processes such as bread making, can also be a source of new antioxidants. In the coming years, Chile should be able to not only increase the number of Antarctic scientific publications but also the number of related patents.

N. PISARENKO

◉ V.1 New antineoplasic molecule from *Deschampsia antarctica* Desv. (2012-2015)
Manuel Gidekel (Uxmal)
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◉ V.2 Antibacterial activity of Antarctic lichens against multiresistant pathogenic bacteria (2012-2015)
Gerardo González (Universidad de Concepción) ggonzal@udec.cl

◉ V.3 Enzyme of Antarctic origin with beta-galactosidase activity, highly efficient at low temperature to delactose milk (2014-2016)
Renato Chávez (Universidad de Santiago de Chile) renato.chavez@usach.cl

◉ V.4 Isolation of Antarctic microorganisms able to synthesize highly fluorescent semiconductor nanoparticles (Quantum Dots) for biotechnological applications (2011-2015)
José Pérez (Universidad Nacional Andrés Bello) jperezd@gmail.com

◉ V.5 Selection and identification of microbial consortiums with high acidogenic and methanogenic activity from Antarctic sediments, for application to psychrophilic wastewater anaerobic digestion under temperate to cold climates (2013-2016)
Léa Cabrol (Pontificia Universidad Católica de Valparaíso) lea.cabrol@gmail.com

◉ V.6 Actinobacteria diversity in Antarctic ecosystems and assessment of the biotechnological potential of their secondary metabolites (2012-2015)
Leticia Barrientos (Universidad de La Frontera) lbarrientos@ufro.cl

◉ V.7 Phylogenetic diversity and bioactive potential of gram-positive bacteria associated with marine macroalgae from Antarctica (2013-2016)
Sergio Leiva (Universidad Austral de Chile)
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◉ V.8 Studies of diversity, adaptations and applied potential of yeasts colonizing Antarctic terrestrial habitats (2013-2016)
Marcelo Baeza (Universidad de Chile)
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◉ V.9 Polyphenols isolated from Antarctic Lichens as inhibitors of tau aggregation (2013-2016)
Carlos Areche (Universidad de Chile)
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◉ V.10 Antifreeze proteins purified from psychrophilic Antarctic microorganisms (2013-2016)
Patricio Muñoz (Fundación Biociencia)
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◉ V.11 Functional metagenomic of whole microbial communities associated to Antarctic marine invertebrates: diversity and bioactive compounds synthetic capabilities (2012-2015)
Nicole Trefault (Universidad Mayor)
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◉ V.12 Evaluating the role of Antarctic root-endophytes on the ecophysiological performance, environmental tolerance and yield in Lettuce crops (2014-2017)
Marco Molina (CEAZA)
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⊙ V.13 A xylanase from an Antarctic filamentous fungus as model for the study of cold-active enzymes (2014-2016)
Renato Chávez (Universidad de Santiago de Chile)
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⊙ V.14 Bacterial diversity in soils of different animal settlements from Cape Shirreff, Antarctica (2014-2016)
Julieta Orlando (Universidad de Chile)
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⊙ V.15 Role of mercury resistance mechanisms in tellurite cross-resistance in psychrotolerant bacteria isolated from Antarctic Chilean territory (2014-2016)
Fernanda Rodríguez (Universidad de Santiago de Chile) fernandarodriguez27@gmail.com

⊙ **V.16 Biochemical mechanisms of desiccation tolerance in the Antarctic moss *Sanionia uncinata* (2014-2016)**
Marisol Pizarro (Universidad de Santiago de Chile) marisol.pizarro@gmail.com

⊙ **V.17 Study of the extracelular reduction of tellurite and copper in bacteria isolated from the Chilean Antarctic territory (2014-2016)**
Mauricio Valdivia (Universidad de Santiago de Chile) maur.valdivia@gmail.com

⊙ **V.18 Nutraceutical metabolites and photosynthesis activity in Antarctic snow microalgae: Effects of temperature and radiation (2014-2016)**
Claudio Rivas
(Universidad Austral de Chile)
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⊙ **V.19 Depsides and depsidones from Antarctic lichens: Antioxidant activity and their possible effect as tau aggregation inhibitor (2014-2015)**
Francisco Salgado (Universidad de Chile)
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⊙ **V.20 Effect of lichen compounds on biofilm formation and quorum sensing type I system of *Vibrio anguillarum* (2014-2015)**
Claudia Torres (Universidad de Concepción)
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⊙ **V.21 Evaluation of the cytotoxic activity of extracts isolated from Antarctic and Subantarctic actinobacteria, *Candida* sp., and from human cancer cell lines (2014-2015)**
David Astudillo (Universidad de Valparaíso)
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⊙ **V.22 Antibacterial effect of derivated compounds from Antarctic lichens against *Acinetobacter baumannii* (2014-2015)**
Xabier Villanueva (Universidad de Concepción)
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⊙ **V.23 Isolation and comparison of equinocromos in tropical, *Lytechinus variegatus* (Lamarck, 1816), and Antarctic, *Sterechinus neumayeri* (Meissner, 1900) urchins, and their potential pharmacological and therapeutic applications (2014-2015)**
Marcelo González et al. (INACH-USP)
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⊙ **V.24 Analysis and enhancement of the production of metabolites of biotechnological interest in Antarctic *Xanthophyllomyces dendrorhous* yeast strains (2012-2015)**
Jennifer Alcaíno (Universidad de Chile)
jalcainog@u.uchile.cl

⊙ **V.25 Enantioselectivity of thermophilic Antarctic lipases in nonaqueous systems (2012-2015)**
Jenny Blamey (Fundación Biociencia)
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⊙ **V.26 Characterization of psychrophilic bacteria isolated from *Deschampsia antarctica* phyllosphere and their potential protective effect against frost injury to plants (2013-2015)**
Fernanda Cid (Universidad de La Frontera)
fernanda.cid.alda@gmail.com

⊙ **V.27 Characterization, heterologous expression and improving antimicrobial activity of bacteriocins produced by Antarctic *Pseudomonas* (2013-2015)**
María Soledad Pavlov (Pontificia Universidad Católica de Valparaíso)
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⊙ **V.28 Synthesis of tellurium-based nanostructures by tellurite-resistant bacteria isolated from the Chilean Antarctic Territory (2013-2015)**
Benoit Pugin (Universidad de Santiago de Chile) benpugin@hotmail.com

⊙ **V.29 Identification and characterization of a new mechanism/strategy for tellurite resistance in tellurite-resistant bacteria isolated from Chilean Antarctic Territory (2013-2015)**
Claudia Muñoz (Universidad de Santiago de Chile) c.munoz.villagran@gmail.com

⊙ **V.30 Isolation of Antarctic bacteria resistant to Cd+2 and TeO3-2 producers of fluorescent nanoparticles to be used on bioremediation (2014-2015)**
Daniel Plaza (Universidad de Chile)
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Line VI: ANTARCTIC ENVIRONMENT

The Antarctic continent is characterized by an environment that features broad and complex interrelationships with the rest of the planet. Antarctica influences and is in turn influenced by what happens elsewhere on the earth.

Antarctica as an "island" continent? It is simply not so. Its cold ocean currents interact with much of the maritime environment of the rest of the world. The Humboldt current affects weather conditions throughout Chile. Furthermore, particles from distant volcanoes, trash from all the continents, and pollen and spores of various plant species, all find their way to Antarctica, transported by wind and currents from distant parts of the world, including South America, Africa, Asia, and Australia.

Antarctica's pristine environment, having very little human intervention, makes it susceptible to harm from increasing human activity. The search for more friendly anthropogenic interaction with this region calls for the development of new technologies adapted to the extreme polar conditions as well as a comprehensive political and regulatory framework for environmental monitoring that is kept up to date.

PROCIEN supports several initiatives in this line of research. Some projects are studying the impact of the Antarctic bases and stations on the freshwater bodies of the Fildes Peninsula, in order to obtain accurate data related to the effects of human occupation on the freshwater ecosystems in Antarctica. This research line also includes assessment of the effectiveness of the Antarctic Treaty, which has regulated activities on the White Continent since it came into force in 1961.

VI.1 Protocol to select paint schemes to protect structural steel against atmospheric corrosion in areas of Chile with high environmental corrosivity (2013-2016)
Rosa Vera (Pontificia Universidad Católica de Valparaíso) rvera@ucv.cl

VI.2 Biomagnification and potential effects of Persistent Organic Pollutants (POPs) in the aquatic food web of the Antarctic Peninsula and Patagonia (2012-2015)
Gustavo Chiang (Universidad de Concepción) gustavochiang@gmail.com

VI.3 An assessment of the impacts of Antarctic bases on the aquatic ecosystems of the Fildes Peninsula (2014-2017)
Roberto Urrutia (Universidad de Concepción) rurrutia@udec.cl

VI.4 Fildes Peninsula Resistome: Is there any contribution of antimicrobial resistance genes from waste waters? (2012-2015)
Helia Bello (Universidad de Concepción) hbello@udec.cl

VI.5 Environmental Antarctic Monitoring Center (2012-2015)
Claudio Gómez (Universidad de Magallanes) claudio.gomez@umag.cl

VI.6 Assessment of heavy metals and persistent organic pollutants on Antarctic fauna from several locations of the Antarctic Peninsula (2014-2016)
José Celis (Universidad de Concepción) jcelis@udec.cl

V.I7 Diaspores record and other botanical structures of non-native plant species in areas of high human activity in King George Island, Antarctic Peninsula (2014-2015)
Eduardo Fuentes (Universidad de Concepción) eduafuentes@udec.cl

VI.8 Melting Claims: Antarctica as a challenge for theories of territorial and resource rights, and as a conceptual locus for rethinking the normative grounds of sovereignty claims over natural resources (2015-2017)
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"Ilaia" is a Yamana word that means "beyond the South."

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