XVIII
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DE CIÊNCIAS POLARES

Faro, 6-7 Novembro 2026

BUILDING POLAR COLLABORATIONS CREATING GLOBAL IMPACT

BOOK OF ABSTRACTS

Organização:

CCMAR Centro de Ciências do Mar Algarve

UAlg UNIVERSIDADE DO ALGARVE



Book of Abstracts

XVIII Portuguese Conference of Polar Sciences 2026

Editors: Inês Amaral, Pedro M. Guerreiro

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6 and 7 November 2026

Faro, Portugal

WELCOME

XVIII Portuguese Conference of Polar Sciences 2026

Dear colleagues and participants,

It is our pleasure to welcome you to the XVIII Portuguese Conference on Polar Sciences, taking place in Faro, Portugal, on 6–7 November 2026. Hosted by CCMAR, the conference brings together Portugal's polar research community and international partners to present recent scientific advances, discuss emerging challenges and develop new collaborations.

Changes in the Arctic and Antarctic have consequences far beyond the polar regions, affecting the global climate system, ocean circulation, sea level, ecosystems, biodiversity and biogeochemical cycles. Understanding these connected processes requires coordinated observations, interdisciplinary research, shared infrastructures and collaboration across national boundaries.

Under the perspective of "*Building Polar Collaboration, Creating Global Impact*", this meeting provides a forum to exchange research results, identify opportunities for collaboration and strengthen links between researchers, institutions and international programs. We also hope to encourage scientific networking and support the participation of early-career researchers in the Portuguese and international polar science communities.

We thank all authors, committee members, institutional partners, sponsors and everyone contributing to the conference. We wish you an inspiring and productive conference.

The Organizing Committee

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XVIII Portuguese Conference of Polar Sciences 2026

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XVIII Portuguese Conference of Polar Sciences 2026

The Organizing Committee gratefully acknowledges the support of the following organizations:

CPCP 2026 Final Programme

A	09:30–10:30	Ecosystems in Transition: Microbes, Vegetation and Environmental Change	Paula Matos
B	11:00–12:30	Life at the Limits: Biodiversity, Food Webs and Resilience	Catarina Magalhães
C	15:00–16:00	From Ice to Ocean: Cryosphere, Sediments and Chemical Cycles	João Canário
D	17:15–18:15	Polar Futures: Climate, Governance and Society	Catarina Frazão Santos

MORNING, November 6th

Start	End	O#	Session / activity	Abstract ID	Title / activity	Presenting author	Presenting author affiliation
08:00	**08:30**		**Transfer**		**Bus transfer to Gambelas**		
08:30	**09:00**		**Registration**		**Registration and welcome**	**Put posters in place**	
09:00	**09:30**		**Opening**		**Opening ceremony**	**Rector UAlg, Director of CCMAR, Propolar Coordinator, FCT representative**	
09:30	09:45	O1	**Session A**	38-1	SAME FJORD, DIFFERENT MICROBES: REWRITING PROKARYOTIC BIOGEOGRAPHY EVERY YEAR IN KONGSFJORDEN	Eva Lopes	CIIMAR - Interdisciplinary Centre of Marine and Environmental Research, University of Porto
09:45	10:00	O2	**Session A**	21-1	COMPARATIVE ANALYSIS OF PROKARYOTIC COMMUNITIES, HYDROGRAPHY, AND BIOGEOCHEMISTRY IN ATLANTIC VS NON- ATLANTIC INFLUENCED SVALBARD FJORDS	Joana Costa	CIIMAR - Interdisciplinary Centre of Marine and Environmental Research, University of Porto
10:00	10:15	O3	**Session A**	49-1	DIVERSITY OF CULTURABLE BACTERIA IN ANTARCTIC PENINSULA SNOW AND RAINFALL	Ksenija Vuckovic	CIIMAR - Interdisciplinary Centre of Marine and Environmental Research, University of Porto
10:15	10:30	O4	**Session A**	11-1	NOVEL METABOLICALLY FLEXIBLE MERCURY METHYLATORS DISCOVERED IN CANADIAN AND GREENLANDIC ARCTIC THERMOKARST LAKES	Nicola Gambardella	CIIMAR - Interdisciplinary Centre of Marine and Environmental Research, University of Porto
10:30	**11:00**		**Break**		**Coffee break**	**Networking**	**Put posters in place**
11:00	11:15	O5	**Session B**	7-1	FROM ROCKY SHORES TO POLAR LANDSCAPES: CCTBON AND THE FUTURE OF FINE-SCALE TEMPERATURE MONITORING	Rui Seabra	BIOPOLIS-CIBIO - Centro de Investigação em Biodiversidade e Recursos Genéticos, Universidade do Porto
11:15	11:30	O6	**Session B**	36-1	FROM NANO- TO MICROPHYTOPLANKTON: CHANGING SIZE STRUCTURE ACROSS ANTARCTIC PENINSULA WATERS	Afonso Ferreira	MARE – Marine and Environmental Sciences Centre / ARNET – Aquatic Research Network, Faculdade de Ciências, Universidade de Lisboa
11:30	11:45	O7	**Session B**	15-2	BEATS: BEAKS, GENES AND ARTIFICIAL INTELLIGENCE (AI) REVEAL HIDDEN DIVERSITY OF SOUTHERN OCEAN SQUID	Lucas Bastos	Centre for Functional Ecology – Science for People & the Planet (CFE), Associate Laboratory TERRA, Department of Life Sciences, University of Coimbra
11:45	12:00	O8	**Session B**	54-1	SHORT-TERM RESILIENCE WITH HIDDEN COSTS: PHYSIOLOGICAL AND MOLECULAR RESPONSES OF JUVENILE *NOTOTHENIA ROSSII* TO SIMULATED MARINE HEATWAVES	Maria Inês Amaral	CCMAR - Centro de Ciências do Mar,. Universidade do Algarve
12:00	12:15	O9	**Session B**	19-1	HAEMATOLOGICAL HEALTH INDICATORS OF SOUTHERN OCEAN SEABIRDS IN A CHANGING ENVIRONMENT	Sara Lopes-Santos	Centre for Functional Ecology – Science for People & the Planet (CFE), Associate Laboratory TERRA, Department of Life Sciences, University of Coimbra
12:15	12:30	O10	**Session B**	47-1	REGIONAL IMPACTS OF EXTREME WEATHER ON THE BREEDING SUCCESS OF ADÈLIE PENGUINS (*PYGOSCELIS ADELIAE*)	Oğuzhan Avşar	CIIMAR - Interdisciplinary Centre of Marine and Environmental Research, University of Porto
12:30	**14:00**		**Lunch**		**Lunch**	**At the Campus de Gambelas University Restaurant**	

AFTERNOON, November 6th

Start	End	O#	Session / activity	Abstract ID	Title / activity	Presenting author	Presenting author affiliation
14:00	**15:00**		**Panel**		**Polar collaboration for global impact — discussion panel**	**Maria Grigoratou-EPB, Diego Filun-Antarctica InSync, Warwick Vincent-Laval University Canada, Teresa Cabrita-PROPOLAR, Jose Xavier-LifeSciences WG SCAR**	
15:00	15:15	O11	**Session C**	31-1	CRYOGRID SIMULATION OF PAST AND FUTURE EVOLUTION OF PERMAFROST TEMPERATURES IN THE NORTHWESTERN ANTARCTIC PENINSULA	Joana Baptista	IGOT- Instituto de Geografia e Ordenamento do Território da Universidade de Lisboa
15:15	15:30	O12	**Session C**	18-1	FROM EXTERNAL LOADING TO INTERNAL CYCLING: THERMOKARST LAKE BIOGEOCHEMISTRY ALONG A PERMAFROST GRADIENT	Diogo Folhas Ferreira	CQE-Centro de Química Estrutural/IST - Instituto Superior Técnico - Universidade de Lisboa
15:30	15:45	O13	**Session C**	58-1	EXPLORING THE SETTLING BEHAVIOUR OF FINE-GRAINED MARINE SEDIMENT FROM THE ARCTIC REGION	Luís Portela	LNEC - Laboratório Nacional de Engenharia Civil
15:45	16:00	O14	**Session C**	8-1	WHAT CONTROLS MERCURY FLUXES ACROSS WATER/SEDIMENT INTERFACES IN VOLCANIC ENVIRONMENTS? THE CASE OF DECEPTION ISLAND	Catarina Louro	CQE-Centro de Química Estrutural/IST - Instituto Superior Técnico - Universidade de Lisboa
16:00	**17:15**		**Posters**		**Poster session, coffee and networking**	**Drinks, Chatting and Poster Interaction**	
17:15	17:30	O15	**Session D**	45-1	OBSERVED AND PROJECTED CHANGES IN MELTING-LAYER HEIGHT OVER THE ANTARCTIC PENINSULA: ROLE OF ATMOSPHERIC RIVERS AND IMPLICATIONS FOR RAINFALL	Irina Gorodetskaya	CIIMAR - Interdisciplinary Centre of Marine and Environmental Research, University of Porto
17:30	17:45	O16	**Session D**	50-1	ULTRA-HIGH-RESOLUTION MAPPING TO SUPPORT THE MANAGEMENT OF LANDING SITES ON THE ANTARCTIC PENINSULA: THE CASES OF CUVERVILLE ISLAND AND COLLINS BAY	Ana Rita Pereira	IGOT- Instituto de Geografia e Ordenamento do Território da Universidade de Lisboa
17:45	18:00	O17	**Session D**	12-1	ANTARCTIC TOURISM UNDER PRESSURE: STAKEHOLDER PERSPECTIVES ON CURRENT CHALLENGES AND FUTURE MANAGEMENT	David Abreu dos Santos	MARE – Marine and Environmental Sciences Centre / ARNET – Aquatic Research Network, Faculdade de Ciências, Universidade de Lisboa
18:00	18:15	O18	**Session D**	55-1	FROM ANTARCTIC SCIENCE TO THE CLASSROOM: THE COLOSSAL SQUID AS A CONTEXT FOR SCIENCE EDUCATION	Marta Espírito Santo	Agrupamento de Escolas Professor Ruy Luís Gomes, Almada
18:15	**18:45**		**Closing**		**Closing ceremony and awards**	**Adelino Canario and Teresa cabrita to present the awards**	
19:00	**20:00**		**Transfer**		**Bus transfer to Faro - last stop at conference dinner venue**		
20:00	**22:30**		**Dinner**		**Conference dinner**		

INDEX

XVIII Portuguese Conference of Polar Sciences 2026

ORAL PRESENTATIONS

A | Ecosystems in Transition: Microbes, Vegetation and Environmental Change

O1. **SAME FJORD, DIFFERENT MICROBES: REWRITING PROKARYOTIC BIOGEOGRAPHY EVERY YEAR IN KONGSFJORDEN** *20*
Eva Lopes

O2. **COMPARATIVE ANALYSIS OF PROKARYOTIC COMMUNITIES, HYDROGRAPHY, AND BIOGEOCHEMISTRY IN ATLANTIC VS NON- ATLANTIC INFLUENCED SVALBARD FJORDS** *21*
Joana Costa

O3. **DIVERSITY OF CULTURABLE BACTERIA IN ANTARCTIC PENINSULA SNOW AND RAINFALL** *22*
Ksenija Vuckovic

O4. **NOVEL METABOLICALLY FLEXIBLE MERCURY METHYLATORS DISCOVERED IN CANADIAN AND GREENLANDIC ARCTIC THERMOKARST LAKES** *23*
Nicola Gambardella

B | Life at the Limits: Biodiversity, Food Webs and Resilience

O5. **FROM ROCKY SHORES TO POLAR LANDSCAPES: CCTBON AND THE FUTURE OF FINE-SCALE TEMPERATURE MONITORING** *25*
Rui Seabra

O6. **FROM NANO- TO MICROPHYTOPLANKTON: CHANGING SIZE STRUCTURE ACROSS ANTARCTIC PENINSULA WATERS** *26*
Afonso Ferreira

O7. **BEATS: BEAKS, GENES AND ARTIFICIAL INTELLIGENCE (AI) REVEAL HIDDEN DIVERSITY OF SOUTHERN OCEAN SQUID** *27*
Lucas Bastos

O8. SHORT-TERM RESILIENCE WITH HIDDEN COSTS: PHYSIOLOGICAL AND MOLECULAR RESPONSES OF JUVENILE *Notothenia rossii* TO SIMULATED MARINE HEATWAVES *28*
Inês Amaral

O9. HAEMATOLOGICAL HEALTH INDICATORS OF SOUTHERN OCEAN SEABIRDS IN A CHANGING ENVIRONMENT *29*
Sara Lopes-Santos/ Ivo Santos [P]

O10. REGIONAL IMPACTS OF EXTREME WEATHER ON THE BREEDING SUCCESS OF ADÈLIE PENGUINS (PYGOSCELIS ADELIAE) *30*
Oğuzhan Avşar

C | From Ice to Ocean: Cryosphere, Sediments and Chemical Cycles

O11. CRYOGRID SIMULATION OF PAST AND FUTURE EVOLUTION OF PERMAFROST TEMPERATURES IN THE NORTHWESTERN ANTARCTIC PENINSULA *32*
Joana Baptista

O12. FROM EXTERNAL LOADING TO INTERNAL CYCLING: THERMOKARST LAKE BIOGEOCHEMISTRY ALONG A PERMAFROST GRADIENT *33*
Diogo Folhas Ferreira

O13. EXPLORING THE SETTLING BEHAVIOUR OF FINE-GRAINED MARINE SEDIMENT FROM THE ARCTIC REGION *34*
Luís Portela

O14. WHAT CONTROLS MERCURY FLUXES ACROSS WATER/SEDIMENT INTERFACES IN VOLCANIC ENVIRONMENTS? THE CASE OF DECEPTION ISLAND *35*
Catarina Louro

D | Polar Futures: Climate, Governance and Society

O15. OBSERVED AND PROJECTED CHANGES IN MELTING-LAYER HEIGHT OVER THE ANTARCTIC PENINSULA: ROLE OF ATMOSPHERIC RIVERS AND IMPLICATIONS FOR RAINFALL *37*
Irina Gorodetskaya

O16. ULTRA-HIGH-RESOLUTION MAPPING TO SUPPORT THE MANAGEMENT OF LANDING SITES ON THE ANTARCTIC PENINSULA: THE CASES OF CUVERVILLE ISLAND AND COLLINS BAY *38*
Ana Rita Pereira

O17. **ANTARCTIC TOURISM UNDER PRESSURE: STAKEHOLDER PERSPECTIVES ON CURRENT CHALLENGES AND FUTURE MANAGEMENT** *39*
David Abreu dos Santos

O18. **FROM ANTARCTIC SCIENCE TO THE CLASSROOM: THE COLOSSAL SQUID AS A CONTEXT FOR SCIENCE EDUCATION** *40*
Marta Espírito Santo

POSTER SESSION

A | Ecosystems in Transition: Microbes, Vegetation and Environmental Change

P1. **PROKARYOTIC FINGERPRINTS OF A CHANGING OCEAN IN THE PACIFIC ARCTIC REGION** *43*
Ana Rita Domingos

P2. **EXPLORING MICROBIOME DIVERSITY IN THE ARCTIC OCEAN ICE PLATFORM** *44*
Diana Sousa

P3. **RETHINKING EDNA METABARCODING TAXONOMIC ANNOTATION: A PROBABILISTIC FRAMEWORK APPLIED TO ARCTIC VERTEBRATE DATA** *45*
Luís Afonso

P4. **IMPROVING NITRIFICATION MODELING IN THE ARCTIC OCEAN THROUGH INTEGRATION OF MICROBIOME DATA** *46*
Leonor Castro

P5. **PLANT SPECIES AND MERCURY AND ARSENIC RELEASE COLLECTIVELY SHAPE THE STRUCTURE OF PROKARYOTIC COMMUNITIES IN ARCTIC SOILS (SISIMIUT, GREENLAND)** *47*
Rodrigo Costa

P6. **COLD-ADAPTED MICROORGANISMS INFORM HABITABILITY ON FROZEN AND ICE-COVERED EXOPLANETS** *48*
Afonso Mota

P7. **CONTROLS ON ANTARCTIC VEGETATION: WHERE DOES MICROSCALE END AND MESOCLIMATE BEGIN?** 49
Paula Matos

P8. **FROM CLIMATE TO MICROSCALE: ANTARCTICA'S FIRST VEGETATION SPECIES DISTRIBUTION MODELS** *50*
Marina Bowen

P9. **LICHEN ISOTOPIC SIGNATURES AS A POTENTIAL ECOLOGICAL INDICATOR FOR CLIMATE SHIFTS IN THE ANTARCTIC PENINSULA**.....*51*
Pedro Areias

P10. **OBSERVER ERROR IN IMAGE-BASED ESTIMATES OF ANTARCTIC VEGETATION ABUNDANCE ACROSS ENVIRONMENTAL GRADIENTS?**..... *52*
Tiago Madureira

B | Life at the Limits: Biodiversity, Food Webs and Resilience

P11. **PHYTOPLANKTON BLOOMS IN THE NORTHERN ANTARCTIC PENINSULA: INSIGHTS FROM IN-SITU AND SATELLITE OBSERVATIONS**.....*54*
Pedro Moniz

P12. **POPULATION GENOMICS OF POLAR OCEANS SQUID**.....*55*
Lucas Bastos

P13. **LONG-TERM MONITORING ANTARCTIC MARINE FOODWEBS: INSIGHTS FROM COMPARATIVE STUDIES OF CEPHALOPODS** *56*
José C. Xavier

P14. **MODELLING THE INFLUENCE OF TOURISM AND FISHERIES ON THE PRESENT-DAY AND FUTURE HABITAT SUITABILITY OF THE HUMPBACK WHALE (*Megaptera novaeangliae*) IN THE SOUTHERN OCEAN** *57*
Francisco Borges

P15. **FROM ZOOPLANKTON COMMUNITIES TO MICROPLASTICS: EXPLORING SPATIAL PATTERNS ALONG THE ANTARCTIC PENINSULA**.....*58*
Milene A. Guerreiro

P16. **TEMPERATURE AND SIZE MODULATION OF OXYGEN CONSUMPTION AND METABOLIC THRESHOLDS IN THE ANTARCTIC SPINY PLUNDERFISH *Harpagifer antarcticus***.....*59*
Inês Amaral

P17. **DECOUPLING PHENOTYPE AND GENOTYPE: AGLOMERULISM IN ANTARCTIC NOTOTHENIOIDS**.....*60*
José Teixeira

P18. **TOWARDS A BASELINE ASSESSMENT OF CONTAMINANT BURDENS AND BIOMARKER RESPONSES IN MYCTOPHID FISH FROM THE SCOTIA SEA** *61*
Joana Fragão

P19. **ASSESSMENT OF EMERGENT POLLUTANTS IN ARCTIC PRIMARY PRODUCERS**....*62*
Maria Teresa Cabrita

P20. **ACUTE TOXICITY OF ESCITALOPRAM TO THE ANTARCTIC COPEPOD *Boeckella poppei***.....*63*
Miguel Jorge Lourenço Domingos

P21. **ANTARCTIC COASTAL WASTE LEACHATE REDUCES SURVIVAL OF *Boeckella poppei*** *64*
Inês Oliveira

P22. **STANDARDIZATION OF ACUTE TOXICITY TESTS FOR TWO ANTARCTIC FRESHWATER INVERTEBRATES** *65*
Caio Cesar Ribeiro

C | From Ice to Ocean: Cryosphere, Sediments and Chemical Cycles

P23. **ASSESSING RISK ASSOCIATED TO PERMAFROST DEGRADATION IN THE ANTARCTIC PENINSULA: GENERAL FRAMEWORK** *67*
Mariana Cândido

P24. **DETECTING GROUND SURFACE DISPLACEMENT IN THE ICE-FREE AREAS OF THE NORTHWEST ANTARTIC PENINSULA USING INSAR** *68*
Cátia Pereira

P25. **HYDROGRAPHIC AND BIOGEOCHEMICAL HETEROGENEITY IN GLACIER INFLUENCED MAXWELL BAY** *69*
Jacqueline Joosten

P26. **ARSENIC SPECIATION AND DYNAMICS IN ARCTIC PERMAFROST THAW ENVIRONMENTS** *70*
Vasco Vaz Cardoso

P27. **SCREENING TRACE METALS ACROSS ANTARCTIC ICE FRESHWATER AND COASTAL HABITATS** *71*
Carolina Duarte

P28. **SEA STATE ESTIMATION BY THE POLAR SHIP ADM. MAXIMIANO'S ATTITUDE DURING THE 43RD BRAZILIAN OPERANTAR** *72*
André Lanfer Marquez

D | Polar Futures: Climate, Governance and Society

P29. **CLIMATE CHANGE, OCEAN, ARCTIC AND SECURITY NEXUS** *74*
Céline Rodrigues

P30. **INSIGHTS FROM TWO YEARS OF PROJECT PLANT: CLIMATE-SMART PLANNING AND GOVERNANCE IN THE SOUTHERN OCEAN** *75*
Catarina Frazão Santos

P31. BLUE JUSTICE IN THE SOUTHERN OCEAN: UNRAVELLING THE ANTARCTIC TREATY SYSTEM DISCOURSE TO INFORM EQUITABLE OCEAN GOVERNANCE..... *76*
Beatriz Cabral/ Catarina Pereira Santos [P]

P32. BIODIVERSITY PATTERNS IN THE SOUTHERN OCEAN GOVERNANCE DISCOURSE *77*
Catarina Pereira Santos

P33. HOW DO WE SPEAK ABOUT POLAR SCIENCE COMMUNICATION?..... *78*
Joana M. da Silva

P34. FROM POLES TO PEOPLE: HOW ASSOCIATION OF POLAR EARLY CAREER SCIENTISTS (APECS) PORTUGAL COMMUNICATES WITH SOCIETY *79*
Mariana Steyer Molinari

INTERNATIONAL GUESTS

Online participation in the discussion panel



Warwick F. Vincent

Dr. Warwick F. Vincent is professor emeritus in the Department of Biology at Laval University in Quebec City, Canada, and is former director of the Centre for Northern Studies (CEN), an interuniversity center for northern research and training. Originally from New Zealand, he began his polar science career in Antarctica, working on the limnology and microbial ecology of lakes, rivers and ice shelf ecosystems in the McMurdo Sound region. Warwick then continued these interests when he moved to Laval University, and over the last 35 years has worked with students, collaborators and Indigenous communities to study Arctic ecology, including in the “Last Ice Area” along the northern coast of Canada and Greenland. He is a Fellow of the Royal Society of Canada and a founding member of ArcticNet, and has served on many advisory committees for Arctic and Antarctic research, outreach and conservation. He has a longstanding commitment to supporting early-career researchers and to international collaboration in polar science.



Maria Grigoratou

Dr. Maria Grigoratou is Executive Secretary of the European Polar Board and Head of the European Polar Coordination Office, based at Umeå University in Sweden. A biological oceanographer, she holds a PhD in Marine Ecology and Ecosystem Modelling from the University of Bristol, UK, and has specialized in plankton ecology and the responses of marine ecosystems to environmental change. Her research has combined field observations, laboratory studies and ecosystem modelling. Before joining the European Polar Board, she was a postdoctoral researcher at the Gulf of Maine Research Institute in the USA and a scientist and EU coordinator for the G7 Future of the Seas and Ocean Initiative at Mercator Ocean International in France. She is also a lead author for the IPBES monitoring assessment. Her current work focuses on science diplomacy, research coordination and strengthening international collaboration across the polar research community.



Diego Andrés Filún Hernández

Dr. Diego Andrés Filún Hernández works in international scientific cooperation at the Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, in Bremerhaven, Germany. He coordinates scientific activities for Antarctica InSync, an international initiative bringing together researchers and polar programs to improve understanding of Antarctica and the Southern Ocean. The initiative seeks to synchronize observations across ice, ocean, atmosphere, land and ecosystems, connecting different disciplines and research infrastructures. Its preparatory phase began in 2024, with coordinated field campaigns planned for 2027 to 2030. Diego helps advance cooperation between research institutions and national Antarctic programs to support joint scientific planning and observations. Through his work on Antarctica InSync, he contributes to international collaboration in polar science and to a stronger understanding of environmental and climate change in the Antarctic region.

XVIII Portuguese Conference of Polar Sciences 2026

ABSTRACTS

Book of Abstracts | 6–7 November 2026

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A

Ecosystems in Transition

Microbes, Vegetation and Environmental Changes



SAME FJORD, DIFFERENT MICROBES: REWRITING PROKARYOTIC BIOGEOGRAPHY EVERY YEAR IN KONGSFJORDEN

Eva Lopes[1,2], Miguel Semedo[2], Allison Bailey[3], Philipp Assmy[3], Catarina Magalhães[1,2]

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3. Norwegian Polar Institute, Framsenteret, 9296 Tromsø, Norway

ABSTRACT

Atlantification is rewriting the physics of Svalbard's fjords, but the microbes that underpin their food webs remain largely unaccounted for in this transformation. We present nine years (2016–2024) of the late-summer transect of the Norwegian Polar Institute's seasonal pelagic monitoring in Kongsfjorden, sampling from the glacier-influenced inner basin to the Atlantic-influenced outer fjord at surface and bottom depths. Combining hydrography, nutrients, chlorophyll-a, and 16S rRNA gene metabarcoding, we assessed diversity, taxonomic composition, co-occurrence networks, and genus-level distance-decay relationships across the Atlantic–glacial gradient. Prokaryotic communities reorganized repeatedly under contrasting water-mass influence, alternating between Atlantic-dominated, Arctic-dominated, and transitional years. Alpha diversity was persistently higher at the Atlantic-influenced outer fjord but collapsed in inner-fjord surface waters. Bottom-water diversity declined more gradually. Composition shifted among Bacteroidota- and Rhodobacteraceae-dominated assemblages, with year-specific dominance of genera such as Polaribacter, Formosa, and Sulfitobacter. Co-occurrence networks revealed strong water column depth structuring: surface networks showed lower connectivity and predominantly positive associations, whereas bottom networks were more complex and enriched in negative associations, with nitrifying taxa highlighted as focal taxa. Genus-level distance-decay relationships were sporadic rather than persistent: abundance declined significantly with increasing distance only for a few genera, mostly within Proteobacteria and Bacteroidota, and almost exclusively in the Atlantic-dominated year, remaining undetected in the Arctic-dominated year. These results show that microbial diversity and spatial structure are governed by interannual hydrographic variability rather than geographic distance alone, and that single-year snapshots can misrepresent microbial biogeography. Continued multi-year monitoring is essential to disentangle transient spatial signatures from lasting prokaryotic responses to Atlantification.

COMPARATIVE ANALYSIS OF PROKARYOTIC COMMUNITIES, HYDROGRAPHY, AND BIOGEOCHEMISTRY IN ATLANTIC VS NON-ATLANTIC-INFLUENCED SVALBARD FJORDS

Joana Costa[1], Francisco Pascoal[1], Mafalda S. Baptista[1], Haakon Hop[3], Philipp Assmy[3], Anette Wold[3], Catarina Magalhães[1,2] and Pedro Duarte[3]*

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ABSTRACT

Fjords in Svalbard are undergoing significant changes due to climate warming. Those along the west coast of Spitsbergen are particularly affected by the increasing influence of “warm” Atlantic Water (AW), a process known as Atlantification. We compared Kongsfjorden, a relatively “warm” fjord on the west coast, with Rijpfjorden, a typical cold Arctic fjord on the north coast of Nordaustlandet, combining physical and biogeochemical data with 16S rRNA gene amplicon and shotgun metagenomic sequencing. We hypothesize that differences in fjords’ water masses and prokaryotic communities provide insight into the effects of Atlantification as it expands eastwards along the shelf north of Svalbard.

We found that warm AW dominated in Kongsfjorden, whereas Rijpfjorden was dominated by cold Arctic Water and Winter Cooled Water. Our results suggest that the Atlantic-influenced Kongsfjorden is a nutrient sink, whereas Rijpfjorden showed similar behavior only in 2016, a particularly warm year; otherwise, no clear sink/source role could be identified. Analysis of 16S rRNA gene sequences revealed that Proteobacteria had higher relative abundances in Kongsfjorden, while Bacteroidota dominated in Rijpfjorden. Ammonium- and nitrite-oxidizing prokaryotes were most prevalent in deeper water masses of both fjords. The archaeal taxa of the ammonia-oxidizing community, mainly *Nitrosopumilus* and *Nitrosopelagicus*, were consistently more dominant than ammonium- and nitrite-oxidizing bacteria. Denitrification and nitrogen fixation genes differed between the fjords, with Kongsfjorden having a higher coverage of diazotroph genes.

Kongsfjorden and Rijpfjorden displayed distinct hydrographic conditions, with Kongsfjorden being under a stronger influence of Atlantification. Our results suggest that warmer water masses are linked to higher nutrient uptake. The clear association between microbial communities and water masses offers insight into changes driven by Atlantification.

DIVERSITY OF CULTURABLE BACTERIA IN ANTARCTIC PENINSULA SNOW AND RAINFALL

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ABSTRACT

The Antarctic Peninsula has been experiencing a pronounced warming trend over the past six decades, accompanied by significant increases in temperature and precipitation. Extreme weather events drive anomalous heat and moisture transport from mid-latitudes and strongly influence surface melt and precipitation over Antarctica. These processes are coupled with long-range transport of aerosols, including bioaerosols involved in cloud condensation and ice nucleation. Despite their known role in atmospheric processes, in Antarctica, microbial aerosols and precipitation bacteria remain poorly characterized.

This study investigates the culturable microbial diversity in rainfall, snowfall, and fresh surface snow, collected on King George Island during the austral summers of 2022 and 2023. A total of 74 isolates were obtained using four different culture media and two incubation temperatures. Phylogenetic analysis based on 16S rRNA gene sequencing revealed representatives from four bacterial phyla: Pseudomonadota, Bacillota, Actinomycetota, and Bacteroidota. Taxa were distributed across sample types and years, suggesting that precipitation phase may influence diversity. We examined air mass back trajectories to assess how microbial composition is linked to their potential source regions, highlighting contributions from the Southern and Pacific oceans.

Our results highlight precipitation as a vector of deposition of viable microorganisms into Antarctic ecosystems and expand current knowledge of culturable bacterial diversity in polar precipitation. By linking microbiological composition to rainfall and snowfall contributions, such as the identification of potentially ice-nucleating strains in rainfall, this work contributes to understanding the potential role of microorganisms in Antarctic atmospheric and cryospheric processes under a rapidly changing climate.

Keywords: Precipitation, culturable diversity, air-mass sources, climate change

NOVEL METABOLICALLY FLEXIBLE MERCURY METHYLATORS DISCOVERED IN CANADIAN AND GREENLANDIC ARCTIC THERMOKARST LAKES

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ABSTRACT

Arctic landscapes are rapidly changing due to permafrost thaw caused by the rising in temperature. Permafrost soil is estimated to store 793 ± 461 Gg of mercury (Hg), a pollutant of global interest of which its organic form, methylmercury (MeHg), is a potent neurotoxin that bioaccumulate and biomagnify in the environment. Permafrost thaw causes the release of the stored Hg in novelly formed water bodies including thermokarst lakes. Thermokarst lakes cover important portions of the Arctic with an anoxic hypolimnion acting as anaerobic bioreactors for most of the year. As Hg methylators, prokaryotes able to transform Hg into MeHg, thrive in low-oxygen conditions, thermokarst lakes are suspected to be MeHg hotspots.

In this study, we investigated the diversity and metabolic capacities of microbial Hg methylators in thermokarst lakes from Greenland and Canada using a genome-centric metagenomic approach from lake sediments. We reconstructed and manually curated 20 high-quality metagenome-assembled genomes (MAGs) representing the most abundant Hg methylators. Phylogenomic and average nucleotide identity analyses revealed that 16 of these MAGs likely represent novel species, highlighting the substantial unexplored microbial diversity associated with Hg cycling in Arctic environments. Metabolic reconstruction revealed versatile microorganism with a broad range of capacities, including potential aerobic respiration, nitrogen fixation, arsenic methylation and antibiotic resistance. These findings expand current knowledge of the diversity and functional potential of Arctic Hg methylators, providing new insights into the microbial processes governing MeHg production in this area. Furthermore, the genomic resources generated in this study establish a foundation for future genome-guided cultivation efforts of these important microorganisms.

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B

Life at the Limits

Biodiversity, Food Webs and Resilience



FROM ROCKY SHORES TO POLAR LANDSCAPES: CCTBON AND THE FUTURE OF FINE-SCALE TEMPERATURE MONITORING

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ABSTRACT

Temperature is a major abiotic stressor, shaping species distributions worldwide. Its ecological relevance is particularly acute in intertidal ecosystems, where organisms experience alternating marine and atmospheric conditions and where small-scale topography generates highly heterogeneous thermal landscapes. Yet, despite the importance of temperature in structuring rocky shore biodiversity, global knowledge of intertidal thermal conditions remains limited, largely due to the technical and logistical challenges of sustaining long-term monitoring across large stretches of coastline.

CCTBON, the Coupled Coastal Temperature and Biodiversity Observation Network, was developed to overcome these limitations. The network relies on rugged temperature loggers embedded directly into rocky shore substrates. Deployed this way, loggers can record up to 15 years of hourly temperature data without needing any maintenance. CCTBON currently includes more than 3200 loggers deployed at more than 260 rocky shores worldwide – the largest network of its type. With sites from Pole to Pole, it is generating an unprecedented dataset of in situ intertidal temperatures.

For Antarctic and Subantarctic rocky shores, where fine-scale thermal data remain especially scarce, CCTBON offers a unique opportunity to link physical microclimates with biodiversity patterns and to facilitate comparisons across bioclimatic regions. The network already includes six sites in the region, with more sites to be added in January/February 2027. Beyond rocky shores, CCTBON can serve as a blueprint for comparable long-term monitoring networks across polar environments, including glacier margins, polar lakes and streams, bird nesting sites, and other temperature-sensitive landscapes.

FROM NANO- TO MICROPHYTOPLANKTON: CHANGING SIZE STRUCTURE ACROSS ANTARCTIC PENINSULA WATERS

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ABSTRACT

Phytoplankton size strongly influences marine food webs and carbon export, yet the size structure of Antarctic phytoplankton communities remains poorly constrained. This is particularly relevant for diatoms, major contributors to Antarctic productivity that are commonly associated with large phytoplankton size classes. Here, we combined pigment-based community observations with size-fractionated HPLC measurements and independent Imaging FlowCytobot (IFCB) observations to investigate how phytoplankton size structure changes across Antarctic Peninsula waters.

Diatoms emerged as the major biomass-forming group: although they dominated only about one quarter of pigment samples (27.3%), they accounted for more than half of total phytoplankton biomass (52%). However, this biomass was not restricted to large cells. Nanophytoplankton dominated most low- to moderate-biomass communities, with substantial diatom-associated biomass occurring within the nano-size fraction. As biomass and diatom dominance increased, communities progressively shifted towards microphytoplankton, which became dominant during intense blooms. Independent IFCB observations supported this ecological transition, showing an increasing contribution of large-cell biovolume under high-biomass, diatom-rich conditions.

These results show that Antarctic diatoms cannot be assigned to a single, fixed size class. Instead, their size allocation changes with community state, from nano-sized contributions across many communities to microphytoplankton dominance during blooms. This variability challenges global pigment-based size-class models that closely associate diatoms with microphytoplankton, and highlights the need for regionally validated approaches to describe Antarctic phytoplankton structure and its biogeochemical role.

BEATS: BEAKS, GENES AND ARTIFICIAL INTELLIGENCE (AI) REVEAL HIDDEN DIVERSITY OF SOUTHERN OCEAN SQUID

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ABSTRACT

Cephalopods play key roles in Southern Ocean food webs, linking primary consumers to top predators, including toothed whales, seals and albatrosses, yet fundamental knowledge gaps remain about their distribution and population structure due to the logistical challenges of sampling. Species identification has traditionally relied on morphological analysis of chitinous beaks from predator stomachs, but this is limited by availability of specialist expertise and unable to resolve cryptic species or fine-scale population structure. The BEATS project integrates genetics, stable isotopes, expert morphological taxonomy and image-based artificial intelligence (AI) to study Antarctic squid diversity at scale. By analysing beaks from an extensive collection (>5,000 beaks from >30 species) at the University of Coimbra, complemented by material from collaborators, we will extract and sequence mitochondrial and nuclear DNA to assess species identity and population connectivity, and use stable isotopes to assign origin. In parallel, deep learning and vision transformer models will be developed for automated species identification from beak images, validated using genetic and expert morphological classifications. Preliminary deep learning classification models trained on the squid *Filippovia knipovitchi, Moroteuthopsis longimana, Gonatus antarcticus* and *Psychroteuthis glacialis*, showed promising results, able to distinguish species from beak imagery, and underlines the feasibility of a scalable AI-based approach for taxonomic identification. Our results demonstrate the potential of integrating computer vision with molecular and expert taxonomic assignment to overcome long-standing bottlenecks in species assignment. The open-access models and reference dataset will provide a transferable framework for automated species identification useful for assessments of marine biodiversity, trophic ecology and population dynamics, helping target management and conservation efforts, worldwide.

SHORT-TERM RESILIENCE WITH HIDDEN COSTS: PHYSIOLOGICAL AND MOLECULAR RESPONSES OF JUVENILE *NOTOTHENIA ROSSII* TO SIMULATED MARINE HEATWAVES

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ABSTRACT

Marine heatwaves (MHWs) are becoming more frequent and intense, posing a particular threat to cold-specialized Antarctic fishes. We investigated the acute thermal limits and recovery of juvenile *Notothenia rossii* following exposure to simulated MHWs, focusing on physiological and molecular responses to acute and prolonged warming and the extent of metabolic plasticity and recovery. The first experiment included the assessment of juvenile *N. rossii* for critical thermal maximum (CT_{max}) using dynamic warming. For the main experiment, fish were exposed for five days to 5, 8, or 11 °C and sampled either immediately after exposure or following recovery at 2 °C. Oxygen consumption, plasma biomarkers, muscle glycogen, hepatic and brain oxidative-stress markers, and tissue-specific gene expression were quantified. Lastly, a separate intermittent-respirometry ramp experiment exposed fish to 2, 5, 8 and 11 °C, with 3 °C temperature steps every 4 h, to characterize short-term metabolic responses and establish relevant warming levels.

All fish survived up to 11 °C, indicating a degree of short-term tolerance to acute warming. Oxygen consumption increased markedly at 8 and 11 °C, but returned to baseline after recovery, showing reversible yet energetically costly metabolic adjustment. Oxidative damage was not fully resolved during recovery, with delayed lipid peroxidation and temperature-dependent shifts in plasma and hepatic biomarkers. Muscle glycogen was largely preserved and rapidly restored after re-cooling. At the molecular level, classical heat shock responses were weak, whereas antioxidant and metabolic genes showed tissue-specific regulation, including cardiac patterns consistent with shifts in mitochondrial function and substrate use. Overall, juvenile *N. rossii* display moderate short-term plasticity, but recovery carries physiological costs that may reduce resilience to more frequent or prolonged marine heatwaves.

Keywords: Marine heatwaves, *Notothenia rossii*, thermal tolerance, physiological responses, respirometry, oxidative stress, gene expression.

HAEMATOLOGICAL HEALTH INDICATORS OF SOUTHERN OCEAN SEABIRDS IN A CHANGING ENVIRONMENT

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ABSTRACT

Rapid environmental change in the Southern Ocean is reshaping pathogen dynamics and contaminant exposure, with consequences for seabird health. However, haematological and physiological data are unavailable for many species, limiting comparative assessments of responses to environmental stressors. In this study, we established a suite of baseline haematological health indicators in four sympatric seabird species breeding on Livingston Island, South Shetland Islands, a region that is well known to be impacted by climate change. Blood smears of chinstrap (*Pygoscelis antarcticus*; n=30) and gentoo penguins (*P. papua*; n=30), snowy sheathbills (*Chionis albus*; n=9), and southern giant petrels (*Macronectes giganteus*; n=6) were analysed for leukocyte profiles, white blood cell (WBC) counts, heterophil-to-lymphocyte (H:L) ratios, and haemoparasites. Mean WBC count estimates were highest in gentoo penguins (59.6±24.3 WBC per 10,000 erythrocytes) and snowy sheathbills (57.9±15.6), and lowest in chinstrap penguins (39.7±18.4). Mean H:L ratios, commonly used as indicators of physiological stress, were highest in southern giant petrels (2.9±3.0), followed by snowy sheathbills (2.5±1.2), gentoo penguins (1.9±1.5), and chinstrap penguins (1.4±1.4). Snowy sheathbills also showed the highest heterophil proportion (64.4±13.0%), whereas chinstrap penguins showed the highest lymphocyte proportion (46.5±16.4%). No haemoparasites were detected microscopically. The modest sample sizes mean these differences should be interpreted cautiously. Nevertheless, these patterns suggest interspecific variation in physiological stress indicators and leukocyte composition. Planned analyses of mercury and corticosterone in the same individuals will investigate potential associations between environmental exposure and individual health.

REGIONAL IMPACTS OF EXTREME WEATHER ON THE BREEDING SUCCESS OF ADÉLIE PENGUINS (PYGOSCELIS ADELIAE)

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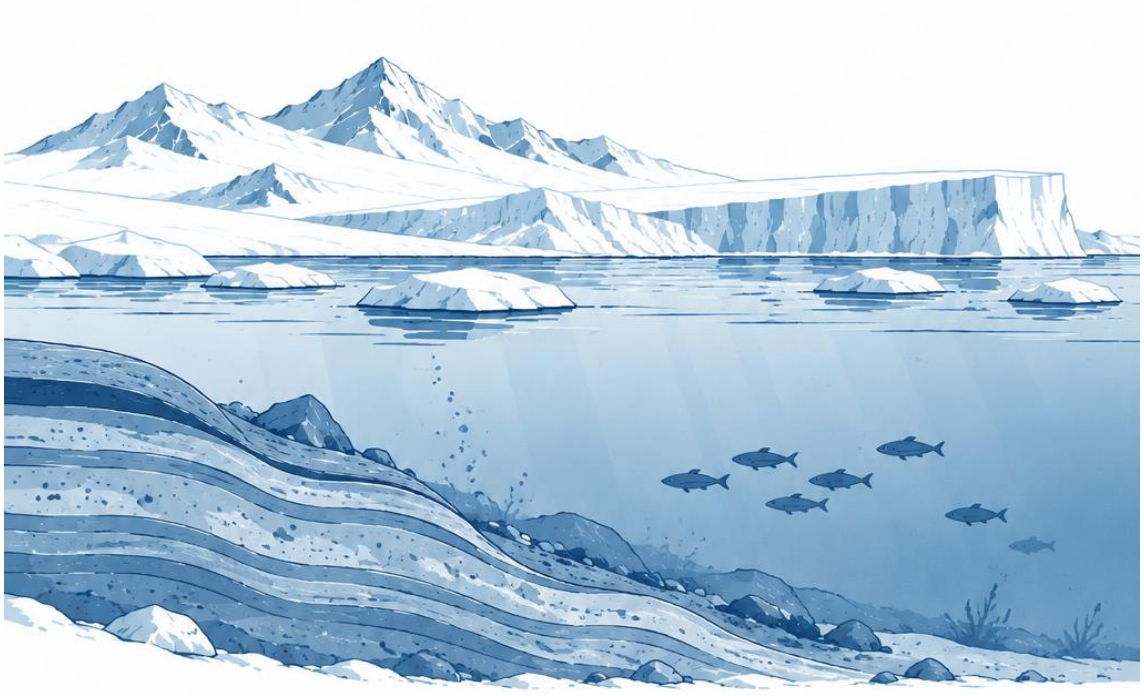
ABSTRACT

Climate change is affecting Antarctica, where extreme weather and climate events are becoming more frequent in some regions, potentially affecting the breeding success of Adélie penguins (*Pygoscelis adeliae*). Previous studies have reported contrasting regional population trends of Adélie penguins including declines and complete breeding failures in some areas. However, linking breeding success to extreme weather events requires fine-scale spatio-temporal data. Here, we use long-term high-resolution monitoring data from Pétrel Island (East Antarctica) and King George Island (northern Antarctic Peninsula) to compare the effects of extreme weather events on breeding success, considering egg and chick survival. Regional climate data are obtained from ERA5 and the regional climate model MAR. Moreover, we use in situ and ground-based remote sensing meteorological data including near-surface air temperature, precipitation, and wind speed. Precipitation data from vertically profiling radars at both sites are used to quantify how precipitation phase transitions and extreme events affect egg and chick survival. Breeding phenology differed between the colonies, with breeding starting on average nearly three weeks earlier at Admiralty Bay than on Pétrel Island. Both colonies experienced annual fluctuations in egg failure and offspring mortality rates. At Admiralty Bay, egg failure contributed more strongly to overall breeding failure, whereas chick mortality accounted for a larger proportion of breeding failure on Pétrel Island. We found that single extreme weather events were associated with sharp increases in breeding failure. For example, heavy snowfall on Pétrel Island at the beginning of the guard stage during the 2025/26 season was associated with a 60% increase in breeding failure. However, high mortality following extreme meteorological parameters was not consistently observed. By comparing two geographically distinct breeding colonies, we highlight how regional climatic conditions and extreme weather events relate to penguin breeding success, contributing to the priorities of the Antarctica InSync international initiative.

C

From Ice to Ocean

Cryosphere, Sediments and Chemical Cycles



CRYOGRID SIMULATION OF PAST AND FUTURE EVOLUTION OF PERMAFROST TEMPERATURES IN THE NORTHWESTERN ANTARCTIC PENINSULA

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ABSTRACT

The temperature dynamics of permafrost is crucial for ecosystem processes in the ice-free areas of Antarctica. However, the lack of knowledge regarding its evolution is particularly relevant in the Antarctic Peninsula, a climatic hotspot of the continent where an increase in MAAT of 3.4ºC has been recorded since 1946, together with an increase in the frequency and intensity of warm-weather events. The consequences of this warming on permafrost are difficult to predict due to the limited coverage and short duration of monitoring records. To address this gap, we modelled past and future permafrost temperature evolution at five PERMANTAR observatories in the Northwestern Antarctic Peninsula using the CryoGrid Community Model. Simulations forced by ERA5 reanalysis data reproduced permafrost temperature evolution since 1950, revealing an average warming rate of 0.18ºC.dec-1 at 20 m depth. Future projections using the ACCESS-CM2 model under SSP1-2.6, SSP2-4.5, and SSP5-8.5 reveal progressive permafrost thaw with a widespread transition to positive mean annual ground temperatures at 20 m depth during the 21st century, with timing and magnitude strongly influenced by elevation and snow cover duration. In the SSP1-2.6, an average warming rate of 0.21ºC.dec-1 is modeled, likely leading to extensive permafrost thaw at low altitude. Under SSP2-4.5, all sites are projected to develop positive mean annual ground temperatures at 20 m in the 2040s and 2080s, with an average warming rate of 0.35ºC.dec-1, implying increased permafrost thaw and increased susceptibility of coastal terrestrial ecosystems in the Northwestern Antarctic Peninsula to climate-driven change. Under the SSP5-8.5, with an average warming rate of 0.51 ºC.dec-1, the thawing of permafrost is predicted to occur more rapidly, with positive values reached from the 2040s to the 2070s.

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Keywords: Permafrost; CryoGrid; Evolution; Projection; Antarctic Peninsula.

FROM EXTERNAL LOADING TO INTERNAL CYCLING: THERMOKARST LAKE BIOGEOCHEMISTRY ALONG A PERMAFROST GRADIENT

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ABSTRACT

Permafrost thaw is reshaping ecosystem dynamics across Arctic and subarctic regions, producing distinct landscape features such as thermokarst lakes. However, the biogeochemical functioning of these lakes remains poorly resolved at a mechanistic level. This work examines seasonal water column and sediment dynamics in thermokarst lakes across sporadic, discontinuous, and continuous permafrost zones, using analytical techniques to study dissolved organic matter (DOM), terminal electron acceptor (TEA) cycling, and sediment layering, yielding a unified benthic-pelagic snapshot. Results reveal that landscape context strongly determines the balance between internal and external controls on lake dynamics. In sporadic permafrost, strong hydrological connectivity between waterlogged peat soils and lakes drives high terrestrial inputs, producing acidic, CDOM-rich, light-limited systems where heterotrophy dominates, oxygen depletes rapidly, and methane oxidation may occur in surface waters. Across discontinuous and continuous permafrost, connectivity weakens and lake functioning shifts toward autotrophic production and benthic-driven controls. Greater light penetration enhances autotrophic activity and organic matter processing in surface sediments, promoting assimilation of methane-derived carbon by autotrophs as a potential carbon fixation pathway. Sediment profiles show a consistent degradation gradient, with degraded, isotopically lighter surface layers overlying recalcitrant material at depth. In discontinuous and continuous zones, lakes shift toward circumneutral pH, lower CDOM, and higher TEA concentrations, with lower stratification potential given reduced CDOM. These findings show thermokarst lake functioning is not determined by permafrost zone alone but emerges from landscape-scale hydrological conditions and internally regulated benthic-pelagic coupling, offering a transferable basis for anticipating lake function as permafrost landscapes change.

EXPLORING THE SETTLING BEHAVIOUR OF FINE-GRAINED MARINE SEDIMENT FROM THE ARCTIC REGION

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ABSTRACT

Marine sediment cores are necessary for reconstructing past climate conditions and environmental change in the Arctic region. Nevertheless, the processes associated with the transport and deposition of fine-grained sediment in the marine environment remain incompletely understood. This knowledge gap is particularly relevant in the context of ongoing loss of glaciers and ice-sheets and anticipated increase of sediment flux to the ocean, with implications for nutrient release and marine ecosystems in the Arctic. The SECOND-BIT project aims to investigate the settling of fine-grained marine sediment by means of controlled laboratory experiments, using an approach originally designed for shallow estuarine and coastal environments. The investigation is centred on the impact of salinity on the settling conditions. The sediment sample was collected during the Extreme25 expedition in Bear Island Trough (Bjørnoyrenna) in the SW Barents Sea. Experiments are being conducted at LNEC in a settling column for various salinity values and a constant initial concentration of suspended sediment. Preliminary results indicate that, under quiescent conditions, increasing salinity increases the settling velocity due to flocculation. The impact of salinity variation appears to be predominantly concentrated within the low salinity range (freshwater to transition conditions).

Transnational access to the UiT core repository within the SECOND-BIT project is supported by the EU POLARIN Consortium. The Extreme25 expedition is thanked for allowing the use of sediment for this project.

Keywords: Cohesive sediment; settling velocity; Barents Sea.

WHAT CONTROLS MERCURY FLUXES ACROSS WATER/SEDIMENT INTERFACES IN VOLCANIC ENVIRONMENTS? THE CASE OF DECEPTION ISLAND

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ABSTRACT

Volcanism is a natural source of trace elements, including mercury (Hg), a toxic contaminant with strong potential for long range transport through ocean and atmospheric currents. While anthropogenic Hg sources are well studied, natural sources like volcanism remain poorly understood, limiting our understanding of the natural vs anthropogenic Hg balance, underpinning mitigation strategies. Deception Island (DI), an Antarctic active volcano in the South Shetland Islands, offers a pristine setting to study how geothermal activity shapes Hg cycling far from human influence. We measured Hg and methylmercury (MMHg) fluxes across water/sediment interfaces, at freshwater and saline sites with varying geothermal influence, using a recently developed benthic flux chamber. The MMHg fraction of total Hg (0.1-4.7%) increased with biogeochemical intensity, favouring methylation at mineralized, nutrient-rich sites (Fumaroles, Pendulum, Colatina and Bahia Telefono). Total Hg (4.43-182.70 ng/L) showed the opposite trend, peaking at high pH/EH and freshwater sites (Crater Lake, Crater 70), indicating that Hg concentration and methylation efficiency follow near-opposite gradients. Total Hg and MMHg fluxes (-76.49-123.58 and -0.85-1.82 ng/min.m2) correlated weakly with biogeochemical parameters. This suggests physical, rather than chemical controls on Hg mobilization (tidal flushing, degassing-driven agitation, and steep porewater-to-water-column concentration gradients: porewater Hg up to 34× higher than overlying water). Influx and efflux occurred at all sites, with directional concordance in only ~51% of events, arguing against a shared chemical mechanism overall. Site patterns diverged: at Crater 70, Hg-MMHg concordance was high (71%), pointing to shared transport, though total Hg fluxes averaged 32x higher than MMHg, implying only a small Hg fraction is methylated and/or available. In the Fumaroles, concordance was low (29%), suggesting stronger localized biogeochemical control on methylation/demethylation.

D

Polar Futures

Climate, Governance and Society



OBSERVED AND PROJECTED CHANGES IN MELTING-LAYER HEIGHT OVER THE ANTARCTIC PENINSULA: ROLE OF ATMOSPHERIC RIVERS AND IMPLICATIONS FOR RAINFALL

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ABSTRACT

The Antarctic Peninsula (AP) is experiencing rapid warming, increasing rainfall and surface melt, with important consequences for ice-shelf stability and ice loss. We investigate observed and projected changes in zero-degree height (ZDH) and melting-layer height (MLH), key indicators of precipitation phase and liquid-water production, and the role of atmospheric rivers (ARs) in driving extreme elevations of the melting layer.

Precipitation radar and radiosonde observations from King Sejong Station during 2023–2025 demonstrate close correspondence between MLH and ZDH. During AR events, MLH can rise to ~3 km, including during winter, reflecting intense warm and moist air advection and favouring rainfall. ERA5 reproduces observed ZDH with good skill and reveals significant increases during 1979–2025, particularly in austral autumn. CESM2 simulations under SSP3-7.0 project a robust ZDH increase across the AP by the end of the century: future autumn ZDH exceeds present-day summer values, while winter and spring develop persistently elevated ZDH. These changes indicate a deepening and seasonal expansion of above-freezing atmospheric layers, favouring more frequent and warmer rainfall and enhanced surface melt.

Continued long-term and event-targeted observations are essential to capture these rapidly evolving conditions. Through the new Antarctica InSync Working Group "Extreme Event Impacts on the Cryosphere", such measurements will be increasingly coordinated across Antarctic regions, linking ARs and other atmospheric and marine extremes to rapid cryospheric responses and building towards coordinated observations during the 5th International Polar Year.

ULTRA-HIGH-RESOLUTION MAPPING TO SUPPORT THE MANAGEMENT OF LANDING SITES ON THE ANTARCTIC PENINSULA: THE CASES OF CUVERVILLE ISLAND AND COLLINS BAY

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ABSTRACT

Antarctic coastal ice-free areas are environmentally sensitive environments where biological communities and human activities are concentrated. However, detailed spatial information at the local scale remains limited, constraining the characterization, monitoring and management of sites increasingly affected by tourism, scientific and logistical activities. The potential of ultra-high-resolution cartography to support the management of Antarctic coastal environments was evaluated at Cuverville Island and Collins Bay, two areas with different environmental characteristics and forms of human use: tourism and research, respectively. UAV surveys were conducted in February 2024 using a DJI Matrice 300 RTK equipped with RGB, multispectral and thermal sensors. Centimeter resolution RGB orthomosaics and digital surface models were produced and integrated with multispectral and thermal information in a GIS environment. These datasets supported detailed thematic mapping of geomorphological units, vegetation communities, fauna and features associated with human presence and use. The integration of thematic mapping with topographic, spectral and potential surface drainage analyses enabled identifying the spatial organization and relationships between the environmental components. In Cuverville, 94 penguin colony and nest areas were mapped alongside approximately 9.77 km of penguin paths, highlighting their spatial relationship with vegetation, coastal access and existing visitor management areas. In Collins Bay, extensive vegetation communities were mapped alongside geomorphological and anthropogenic features associated with scientific activities. This integrated spatial information was used to develop site specific management proposals. In Cuverville, the 2024 cartography was integrated with the existing Visitor Site Guidelines to propose an additional area closed to visitors. In Collins Bay, the mapping provides a spatial basis for planning research, minimizing potential interference with sensitive vegetation. The proposed workflow provides both a detailed baseline for future monitoring and a transferable framework for supporting management in other Antarctic coastal areas.

This research contributes to the project THAWIMPACT funded by the FCT and to COASTANTAR2024 co-funded by the FCT and the University of Lisbon.

Keywords: Unmanned aerial vehicle (UAV); Ultra-high-resolution mapping; Environmental management; Tourism; Antarctica.

ANTARCTIC TOURISM UNDER PRESSURE: STAKEHOLDER PERSPECTIVES ON CURRENT CHALLENGES AND FUTURE MANAGEMENT

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ABSTRACT

The growth and diversification of Antarctic tourism have intensified concerns about environmental pressures, operational constraints, visitor management, and governance. Tourism is regulated through the Antarctic Treaty System (ATS) and supported by operational guidelines developed by the International Association of Antarctica Tour Operators (IAATO). Increasing visitor numbers and the spatial concentration of tourism activities nevertheless raise questions about long-term sustainability. This study examines how Antarctic tourists and tourism operators perceive environmental impacts, sustainability, and management of marine and coastal tourism. Data have been collected since July 2026 through two structured surveys addressing environmental pressures, sustainability, regulatory effectiveness, challenges, and management measures. Preliminary analysis includes 91 eligible tourists and 92 consenting respondents representing tourism-related organisations. Among tourists, 98% considered Antarctica highly or very highly important to planetary health, 77% perceived at least a moderate need for stricter tourism regulation, and 80% expressed high or very high support for limiting visitor numbers or restricting access to important areas. Pollution, ship and boat noise, and physical disturbance to landing sites were perceived as the most significant tourism-related environmental impacts. Among tourism operators, 76% perceived at least moderate environmental pressure from tourism, while 75% rated ATS regulations and 85% rated IAATO guidelines as at least moderately effective in supporting sustainable tourism management. Furthermore, 85% expected climate change to affect operations to at least a moderate extent over the next decade, and 71% expressed high or very high support for stronger spatial protection and management measures. Competition, limited suitable landing sites, and crowding emerged as the principal operational challenges. These findings provide evidence on stakeholder perceptions and support assessment of whether marine spatial planning could complement existing Antarctic spatial management, protection, and governance approaches through area-based measures addressing tourism concentration, pressures on frequently visited sites, operational constraints, and interactions with conservation and other Southern Ocean activities.

Keywords: Antarctic tourism; Environmental governance; Stakeholder perceptions; Cumulative impacts; Marine Spatial Planning.

FROM ANTARCTIC SCIENCE TO THE CLASSROOM: THE COLOSSAL SQUID AS A CONTEXT FOR SCIENCE EDUCATION

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ABSTRACT

Antarctica offers a powerful context for science education because its unique environments and organisms connect scientific knowledge with broader understandings of biodiversity, adaptation, ecology and the nature of science. This communication presents a science-based educational activity centered on the colossal squid, *Mesonychoteuthis hamiltoni*, a Southern Ocean cephalopod and the world's heaviest living invertebrate. Reaching up to 6 m in total length and a recorded weight of 495kg and possessing the largest eyes known in the animal kingdom, the species provides an engaging example through which pupils can investigate Antarctic biodiversity, organism–environment relationships and adaptations to extreme environments (Rosa et al., 2017; Xavier et al., 2016; Xavier & Cherel, 2021). Designed for pupils aged 6–10 and adaptable to different levels of scientific understanding, the 50–60-minute activity follows a Connect–Learn–Act approach, tested already in a Portuguese school (preliminary results will be provided). Furthermore, this activity was also presented at the Antarctic Treaty Consultative Meeting (ATCM) 2026 (Hiroshima, Japan), during the II ATCM Workshop on Education and Outreach (an overview of the results of the Workshop will also be presented), reenforcing the role of Portugal in Education and Outreach at ATCMs (Xavier et al. 2023). Pupils first connect with Antarctica through its geography, history and fauna; then learn about the Southern Ocean and the morphology and ecology of the colossal squid; finally, they consolidate their learning through a practical activity. This progression promotes observation, scientific vocabulary, information interpretation, evidence-based argumentation, critical thinking and scientific communication. This activity also illustrates how collaboration between scientists and educators can make polar science accessible to younger learners. Such initiatives will reinforce the educational value of connecting research, education and outreach in preparation for the International Polar Year 2032–33 across formal and non-formal educational settings worldwide, under an Antarctic Treaty context.

Keywords: Antarctica; Colossal Squid; Polar Science; Science Education; Scientific Literacy.

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A

Ecosystems in Transition

Microbes, Vegetation and Environmental Changes



PROKARYOTIC FINGERPRINTS OF A CHANGING OCEAN IN THE PACIFIC ARCTIC REGION

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ABSTRACT

The Arctic Ocean is undergoing rapid environmental changes driven by global warming and increasing inflow of Pacific Ocean waters through the Bering Strait, a process known as “Pacification”. Understanding how these changes influence prokaryotic communities is essential for predicting ecosystem responses in this vulnerable region. This study investigated the horizontal and vertical distribution of prokaryotic communities in the Pacific Arctic Region by integrating 16S rRNA gene sequencing with environmental parameters. Water samples were collected during a 24-day expedition aboard the R/V *Mirai* (JAMSTEC, Japan) in September 2023. Water samples were collected at the depth of maximum chlorophyll-a concentration (DCM) and at the deepest region of each station. Four depth layers: DCM (6–70 m), Epipelagic (30–80 m), Mesopelagic (200–600 m), and Bathypelagic (1000–4000 m). Also, six water masses were detected: Alaskan Coastal Water (ACW), Bering Summer Water (BSW), Meltwater/Meteoric Water (MWM), Newly Ventilated Winter Water (NVWW), Remnant Winter Water (RWW), and Atlantic Water (AW). Bioinformatic analyses characterized taxonomic composition, diversity, and ecological structure by integrating sequencing data with environmental parameters (CTD and nutrient profiles), examining variation along depth gradients and across water masses. Phototrophic taxa, particularly Cyanobacteria, dominated surface waters, whereas deeper layers showed greater abundances of archaeal groups involved in nitrogen cycling, including Crenarchaeota. Water mass identity also influenced community composition. AW exhibited the highest diversity and number of unique amplicon sequence variants (ASVs), while ACW showed a high relative abundance of Cyanobacteria. Prokaryotic communities were structured by both vertical stratification and hydrographic boundaries. This study provides new insights into Arctic prokaryotic biogeography and highlights the need to understand better how increasing Pacific inflow may reshape microbial communities in a rapidly changing Arctic Ocean.

Key-words: Arctic, Pacification, Prokaryotes, Diversity, Water Mass.

EXPLORING MICROBIOME DIVERSITY IN THE ARCTIC OCEAN ICE PLATFORM

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ABSTRACT

Background & Aim: *Climate change* is rapidly transforming the Arctic Ocean, which is warming more than twice as fast as the global average. *The decline* in sea ice extent is altering ecosystems and the microbial communities inhabiting the ice, which play key roles in carbon and nitrogen cycling and form the base of the *Arctic food* web. *Understanding these* communities is essential to predict ecosystem responses to ongoing environmental change. *This study* aims to explore microbial diversity, by analyzing how their composition varies across different spatial locations and ice depths. Methods: *Twelve ice* cores were collected in the Fram *Strait during* the Arctic Ocean 2023 campaign, sampled at four stations and sectioned into three depth intervals (0–5, 5–10, and 10–30 cm). DNA was extracted using the DNeasy PowerWater Kit, and 16S rRNA gene sequencing was performed on the *Illumina platform*. *Sequences were* processed with DADA2 pipeline and taxonomic assignment was conducted with SILVA 138.2 database. Results/Conclusions: *Phylum level* profiles showed communities dominated primarily by *Bacteroidota and Pseudomonadota across* all stations and depths, with Verrucomicrobiota, Actinomycetota, Plantomycetota, and *Bacillota present* in lower proportions. *Archaea were* detected mainly in station 1ICE, particularly in deeper layers. At the genus level, communities were consistently dominated by Polibacter, Colwellia, Lutibacter, Lewinella, Paraglaciecola, Sulfitobacter, Loktanella, Octadecabacter, and Nonlabens. *Some depth* related tendencies emerged (e.g., *Polibacter increasing* with depth), but overall patterns were weak. *Richness varied* moderately among stations, with 1ICE showing the highest values and 3ICE/9ICE the lowest. *Shannon diversity* ranged from 2.7 to 3.6, with the lowest value in the surface layer of 3ICE. *These patterns* suggest that spatial heterogeneity plays a stronger role than vertical stratification in structuring sea-ice microbial communities.

RETHINKING EDNA METABARCODING TAXONOMIC ANNOTATION: A PROBABILISTIC FRAMEWORK APPLIED TO ARCTIC VERTEBRATE DATA

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ABSTRACT

Environmental DNA (eDNA) metabarcoding has become a pivotal tool in marine biodiversity monitoring, characterising biological communities in remote regions. A vital step in this methodology is the taxonomic identification of eDNA sequences. Common practice assigns sequences to the closest matching species, with the ability of the marker to distinguish species and the completeness of reference databases rarely accounted for. Species distributions, when considered, are applied manually and case by case. When ambiguity persists, assignments are collapsed to a broader taxonomic level, discarding information about competing candidates. To address this, we present the Multi-component Integrated Taxonomic Annotation (MITA), a probabilistic framework that formalises these sources of uncertainty. MITA combines four independent components, namely sequence identity, geographic plausibility, phylogenetic context, and reference database completeness, each expressed as a parameterised function. The resulting probabilities are normalized across all candidates, with the output therefore a probability distribution rather than a single assignment. This framework was tested in an independent, published 12S rRNA eDNA dataset of Arctic marine vertebrates from coastal Greenland, adjusting geographical and marker-specific parameters. From all target taxa sequences, 44% returned a single species, while the remainder returned up to 92 competing candidates. In 28% of these, the leading candidate exceeded the next by a probability of more than 0.3, indicating confident species discrimination, whereas in a third the margin fell below 0.05, reflecting genuine species-level ambiguity. Compared with a best-hit approach, MITA unveils ties behind 18% of species-level assignments and resolves 11% of those assigned to a higher taxonomic level. The framework flagged that 16% of the species in the region had no sequences in data repositories. By integrating multiple sources of evidence and making uncertainty explicit, MITA offers a transparent basis for eDNA metabarcoding species identification, which increasingly underpins conservation in rapidly changing regions such as the Arctic.

IMPROVING NITRIFICATION MODELING IN THE ARCTIC OCEAN THROUGH INTEGRATION OF MICROBIOME DATA

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ABSTRACT

In the Arctic Ocean, nitrogen limits primary production and controls the biological carbon pump [1]. Within this cycle, nitrification plays a central role by converting ammonia into nitrate, driven by ammonia oxidation as the key rate-limiting step [1]. This is primarily limited by substrate availability (ammonia), pH, oxygen, temperature and light [1]. Although standard biogeochemical models rely solely on abiotic parameters [2], we show evidence that these models fit poorly to real data. Therefore, this study evaluates the potential of incorporating molecular data to complement the biogeochemical models and improve our understanding of Arctic nitrification rates.

Using the Tang et al. [3] dataset, we conducted two complementary analyses. First, we tested three widely used biogeochemical models against measured rates and a mock model (mean rate). In parallel, to explore variables in the Arctic (>60°N), we evaluated Spearman rank correlations between measured rates and nitrifiers (Total AOA (archaea) abundance and Thaumarchaeota 16S rRNA). The models failed to explain real observations, showing negative coefficients of determination, negative correlations and higher error than the baseline null model. Besides this, Total AOA abundance was positively correlated with ammonia oxidation rates and Total AOA was strongly correlated with Thaumarchaeota 16S rRNA. Future work will test the hypothesis that integrating microbiome data can improve these biogeochemical models, a crucial step toward improving our ability to project marine nitrification in a changing Arctic Ocean.

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PLANT SPECIES AND MERCURY AND ARSENIC RELEASE COLLECTIVELY SHAPE THE STRUCTURE OF PROKARYOTIC COMMUNITIES IN ARCTIC SOILS (SISIMIUT, GREENLAND)

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ABSTRACT

The *Arctic disproportionally* suffers the effects of global warming, one of which is the thawing of permafrost which leads to the release of previously frozen organic matter as well as potentially hazardous elements, such as mercury and arsenic, into topsoils. We experimentally examined the structure and taxonomic composition of the active prokaryotic communities in vegetated topsoil from Sisimiut, Greenland, and their response to mercury and arsenic amendments at environmentally common concentrations. We manipulated the active soil layer (n = 60 replicate samples, 03, 36 and 69 cm depths) covered by the plants *Empetrum nigrum* (black crowberry) and *Salix glauca* (grey willow) with spikes of mixed species of either arsenic or mercury, during a 24-h incubation experiment at room temperature. High-throughput amplicon sequencing of 16S rRNA genes amplified from cDNA obtained from metatranscriptomic RNA soil extracts was performed to assess eventual shifts in the active prokaryotic communities.

The bacterial phyla Pseudomonadota, *Acidobacteriota and Actinomycetota dominated* all samples, followed by Planctomycetota, *Myxococcota and* Verrucomicrobiota. *The class* Alphaproteobacteria (particularly the family Xanthobacteraceae) was most prevalent across all samples, with other ubiquitous classes including *Planctomycetia and* Acidobacteriae. *Plant species* was the main force shaping the structure of active prokaryotic communities in vegetated soils, while mercury or arsenic amendments had a significant impact on crowberry-associated prokaryotic communities. Intriguingly, bacterial genera known to mediate mercury (reduction, demethylation) and/or arsenic (oxidation) transformations -including Clostridium, Rhizobacter, and Pseudarthrobacter, among others, were enriched across vegetated soils by the end of the 24-h experiment, suggesting that the plant rhizosphere recruits competent microbial taxa that may play an important role in detoxification processes in *Arctic topsoils*.

COLD-ADAPTED MICROORGANISMS INFORM HABITABILITY ON FROZEN AND ICE-COVERED EXOPLANETS

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ABSTRACT

Exoplanet habitability is still largely defined by modelling potential surface liquid water depending on the planet's distance to its star. Long-term habitability, however, requires active metabolism and replication, and habitability research should therefore incorporate quantitative biological concepts.

We present a biologically grounded habitability approach based on a dataset we gathered of 19,819 cultured prokaryotes. We analyse growth conditions for temperature, pH, and salinity, together with other relevant traits, particularly oxygen tolerance.

We applied this dataset and analyses to study cold rocky exoplanets, a likely common class of potentially habitable worlds, focusing on TRAPPIST-1 e and LHS 1140 b. We used climate model predictions to define plausible environmental conditions on these planets and then identified cultured prokaryotes whose known physiological tolerances were compatible with those conditions. For TRAPPIST-1 e, which may have a mean dayside temperature below 0 ºC, we selected organisms capable of subzero growth. Most cold-adapted candidates are aerobic, although anaerobic methanogens such as *Methanogenium frigidum* could act as chemolithoautotrophic primary producers. For LHS 1140 b, a potentially ice-covered ocean world, we focused on oligotrophic and pressure-tolerant organisms, reflecting possible nutrient cycling limitations and a deep global ocean.

This work provides a quantitative bridge between microbiology and exoplanet science, and a step toward biologically realistic assessments of habitable worlds.

CONTROLS ON ANTARCTIC VEGETATION: WHERE DOES MICROSCALE END AND MESOCLIMATE BEGIN?

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Antarctic terrestrial ecosystems comprise simplified but specialised vegetation communities sensitive to environmental change. While regional warming is reshaping ice-free areas, projections still rely on coarse climatic data that cannot resolve the microhabitats in which lichens, bryophytes and the two native vascular plants occur. Microtopography, near-surface hydrology and wind exposure strongly structure fine-scale vegetation patterns. Nevertheless, the extent to which this control generalises across the Antarctic Peninsula remains unknown.

Our aim was to ask a question with broad implications: where does microscale end and mesoclimate begin? For that we will compare fine-scale and regional controls across four sites with ultra-high-resolution data (<10 cm/px): Cuverville Island, Livingston Island, and Collins Bay and Barton Peninsula in King George Island. From orthomosaics and digital surface models, we will map functional-type cover (lichens, bryophytes, vascular plants) and derived microscale morphometrics (valley depth, topographic wetness, wind exposure, slope/ruggedness, distances to channels and coast). Regional climatic layers (temperature, precipitation, wind) will be harmonised to each site. Our modelling framework will contrast three scenarios, microscale-only, climate-only, and combined, using abundance-based models and quantifying variance partitioning, cross-site transferability, and niche consistency along the regional gradient. We will evaluate how well models trained in one site predict others, identifying conditions under which microscale buffering breaks down and climate becomes dominant. By explicitly comparing scales, functional types and landscapes, this study will provide a process-oriented framework to improve forecasting of vegetation change and to locate potential microscale refugia. The outcomes will inform the selection of ecologically meaningful predictors for high-resolution distribution models and guide conservation targeting and policy prioritisation in ice-free areas. Ultimately, the work bridges fine-scale mechanisms and regional forcing in a testable design.

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FROM CLIMATE TO MICROSCALE: ANTARCTICA'S FIRST VEGETATION SPECIES DISTRIBUTION MODELS

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ABSTRACT

Antarctica hosts some of the most pristine and fragile ecosystems on Earth, where simplified vegetation communities persist under extreme climatic conditions. *These communities* are dominated by lichens and bryophytes, with vascular plants restricted to the milder maritime regions of the Antarctic Peninsula. *These ecosystems* are highly sensitive to microclimatic variation, and while rapid regional warming across the Antarctic Peninsula is causing visible changes in these vegetation groups, there remains an urgent need for large-scale species distribution models at the regional scale to understand current patterns and predict future responses. Mapping of *Antarctic vegetation* remains challenging due to the continent's remoteness and harsh conditions, with no spatially explicit models currently available to predict species occurrence across the landscape or capture the fine-scale processes influencing their distributions.

By integrating ecological field data, regional climate data, microscale terrain variables and spatial structure, this study aimed to develop the first comprehensive species distribution models (SDMs) for dominant vegetation species across ice-free areas of the Antarctic Peninsula. A Random *Forest hurdle* model framework was developed to predict the presence and abundance of the lichen *Usnea antarctica* Du Rietz, the bryophyte *Sanionia uncinata* (Hedw.) Loeske, and the native vascular plants *Deschampsia antarctica* É.Desv. and *Colobanthus quitensis* (Kunth) Bartl. *The models* revealed that microscale environmental variables exert stronger influences on distribution patterns than broader climate factors, highlighting the importance of local habitat heterogeneity in extreme polar environments and the need for conservation strategies to account for fine-scale variation alongside climate change projections. Together, these first regional-scale SDMs for *Antarctica establish* an essential framework of species-environment relationships, identifying potential microrefugia and projecting future changes in habitat suitability to inform climate impact assessments across this rapidly changing region.

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LICHEN ISOTOPIC SIGNATURES AS A POTENTIAL ECOLOGICAL INDICATOR FOR CLIMATE SHIFTS IN THE ANTARCTIC PENINSULA

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ABSTRACT

Antarctic terrestrial flora is comprised of specialised organisms whose distribution is constrained by extreme climatic conditions. Changes in these communities have been associated with shifts in temperature, water availability and other environmental conditions, highlighting the need for ecological indicators that can help assess vegetation responses to a changing environment.

Stable isotope signatures offer a potential means of investigating these responses. In Antarctica, bryophyte isotopic signatures have been used to reconstruct past water availability and provide evidence of long-term drying conditions. However, the potential of lichen isotopic signatures as indicators of local climatic conditions remains underexplored.

This study aims to evaluate the potential of stable isotope signatures, such as $\delta^{13}C$, in lichens as ecological indicators of local climatic conditions across the Antarctic Peninsula. Thirty samples of *Usnea* sp., collected from different locations along a climatic gradient in the Antarctic Peninsula, will be analysed to assess whether spatial variation in $\delta^{13}C$ is associated with variation in climatic conditions, and other environmental variables deemed relevant. These relationships will be used to evaluate the extent to which lichen isotopic signatures reflect the climatic gradient and their potential application in environmental monitoring.

By examining lichen isotopic variation across contrasting climatic conditions, this study may provide a basis for developing indicators of vegetation responses to future environmental change. The findings may complement climate data and contribute to a better understanding of the environmental controls on Antarctic vegetation, supporting future assessments of its responses to climate change.

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OBSERVER ERROR IN IMAGE-BASED ESTIMATES OF ANTARCTIC VEGETATION ABUNDANCE ACROSS ENVIRONMENTAL GRADIENTS?

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ABSTRACT

Image-based vegetation surveys offer key advantages in extreme, environmentally sensitive ecosystems such as Antarctica. *They reduce* sampling time, allowing more sites to be surveyed, minimise vegetation collection, and provide permanent records for post-campaign verification and independent reassessment. However, observer interpretation during abundance scoring may introduce uncertainty, affecting comparisons across environmental gradients.

This study aims to quantify observer error in photographic assessments of *Antarctic vegetation* functional groups and explore its potential sources. *Five observers* with different disciplinary backgrounds and experience levels will assess the same quadrat photographs from 30 sites spanning climatic and microscale environmental gradients. *The validated* assessment of one experienced observer will serve as the reference for the other four. *All observers* will follow an established protocol using a grid of 100 cells, with the number of points recorded per functional group representing its abundance. *The exact* image coordinates of each point will also be retained.

We will quantify the magnitude and direction of observer error, identifying underestimation and overestimation relative to the reference. We will examine whether errors vary among functional groups and abundance levels, and whether they are associated with climatic or microscale conditions, including distance to the sea. *Point locations* will guide inspection of discrepancies, exploring whether observers preferentially record larger or more conspicuous vegetation features while overlooking less recognisable forms.

This study will identify potential sources of observer error and conditions associated with more reliable photographic assessments. *The findings* will inform observer training and support the quality of vegetation data used in environmental analyses and distribution modelling.

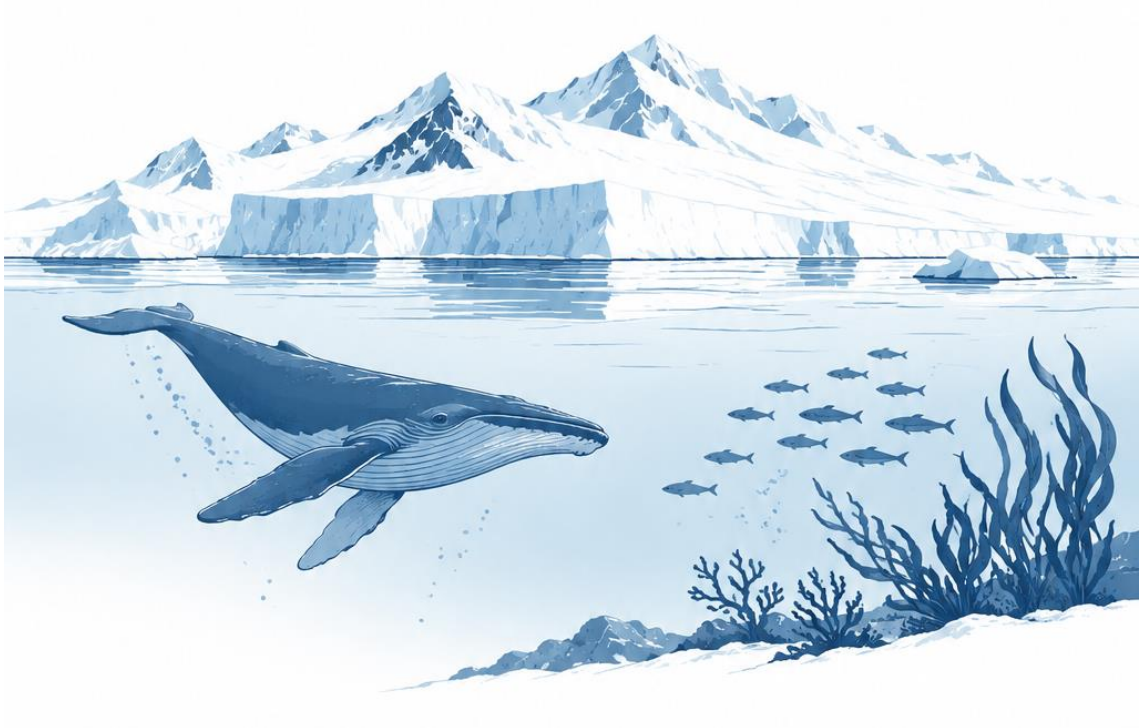
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B

Life at the Limits

Biodiversity, Food Webs and Resilience



PHYTOPLANKTON BLOOMS IN THE NORTHERN ANTARCTIC PENINSULA: INSIGHTS FROM IN-SITU AND SATELLITE OBSERVATIONS

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ABSTRACT

The Antarctic Peninsula is experiencing substantial environmental change, with potential consequences for phytoplankton dynamics and marine ecosystems. Phytoplankton blooms, characterized by elevated chlorophyll-a concentrations, may have important ecological and biogeochemical implications. However, their occurrence and characteristics remain insufficiently documented, and their detection through satellite ocean-colour observations can be challenging in the complex environmental conditions of the region. This study investigated phytoplankton bloom events in the Northern Antarctic Peninsula by integrating in-situ observations with satellite ocean-colour data. In-situ observations were used to identify and characterize bloom events and their phytoplankton community composition, while satellite-derived chlorophyll-a was used to investigate bloom occurrence, spatial distribution and temporal variability. A matchup analysis was performed to compare satellite-derived and in-situ chlorophyll-a concentrations. A total of 37 blooms were identified from in-situ observations across the Bransfield Strait, Gerlache Strait and James Ross Island regions. Diatoms dominated 30 blooms, while cryptophytes and dinoflagellates dominated 5 and 2 blooms, respectively. Satellite observations showed low correspondence with the blooms identified in-situ, as only one of the 37 had a valid coincident satellite observation; however, this event was not classified as a bloom using the satellite bloom-detection criteria. Of the 847 in-situ sampling stations, 85 resulted in valid satellite-in-situ matchups. Although the two datasets showed a significant relationship for chlorophyll-a, satellite estimates were generally lower than in-situ concentrations, particularly at higher values. Positive chlorophyll-a tendencies were observed in some sub-regions, although with high variability and low explanatory power. No significant temporal trends were observed in bloom frequency or mean bloom magnitude. These results indicate that satellite observations provide valuable information on phytoplankton variability but may not consistently represent localized or high-biomass bloom events. Combining satellite and in-situ observations is therefore important for improving the detection and characterization of phytoplankton blooms in the Antarctic Peninsula.

POPULATION GENOMICS OF POLAR OCEANS SQUID

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ABSTRACT

The polar oceans, the Arctic and Southern Ocean, are warming faster than any other region, with profound consequences for marine biodiversity and ecosystem functioning. Cephalopods, particularly squids, are highly adaptable marine invertebrates that play key roles in polar food webs, linking lower trophic levels to top predators. Although often regarded as rapid responders to environmental change, their resilience and adaptive potential remain poorly understood. Baseline data on genetic diversity, population structure, and connectivity of polar squids are scarce, limiting our ability to predict their responses to environmental change. Advanced population genomic approaches offer powerful tools to address these gaps. In my PhD, I aim to investigate population structure, connectivity, and potential local adaptation in key polar squid species using single nucleotide polymorphisms (SNPs). The results will provide insights into connectivity patterns and adaptive potential of polar squids, informing marine evolutionary research and conservation under climate change. We hypothesize Arctic squid species to show higher population structure due to lower gene flow, but less pronounced and more recent local adaptation because of their recent evolutionary history. Antarctic squid populations, despite higher connectivity, facilitated by existing currents, may show stronger signs of local adaptation due to longer periods of evolutionary isolation.

LONG-TERM MONITORING ANTARCTIC MARINE FOODWEBS: INSIGHTS FROM COMPARATIVE STUDIES OF CEPHALOPODS

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ABSTRACT

Cephalopods are known to play an important role in Southern Ocean ecosystems, as both predators and prey. Indeed, numerous other predators (e.g. whales, seals, fish, penguins, albatrosses) feed extensively on cephalopods throughout their life cycle. This presentation will explore the implementation challenges of the long-term CEPH-BAS monitoring project, between the University of Coimbra and the British Antarctic Survey since 2010, and how it benefited the scientific community through the pioneering production of research papers and other scientific outputs on Southern Ocean cephalopods (e.g. Bastos et al. (2026), Lopes-Santos et al. (2025), Xavier et al. (2022), Caccavo et al. (2021), Abreu et al. (2020), Abreu et al. (2019), Xavier et al. (2016), Guerreiro et al. (2015)) as well as ongoing studies being communicated through international scientific meetings. This presentation will also showcase how these efforts connect with the United Nations Oceans Decade 2020-2030, and to Scientific Committee on Antarctic Research (SCAR) research programs, under a climate change context. Finally, parallels will be drawn with new recent studies of Arctic cephalopods in order to develop plans for comparative research during the Fifth International Polar Year 2032-33 (IPY-5), while providing scientific arguments to support monitoring Southern Ocean fauna.

MODELLING THE INFLUENCE OF TOURISM AND FISHERIES ON THE PRESENT-DAY AND FUTURE HABITAT SUITABILITY OF THE HUMPBACK WHALE (MEGAPTERA NOVAEANGLIAE) IN THE SOUTHERN OCEAN

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ABSTRACT

The Southern Ocean plays a critical role in global climate and ecosystem regulation, while being increasingly exposed to anthropogenic pressures. Humpback whales (*Megaptera novaeangliae*) migrate seasonally to the Southern Ocean, where their distribution is associated with sea-ice extent and krill availability. As highly mobile baleen whales, they play an important role within marine food webs and are widely regarded as key indicators of ecosystem health. Humpback whales also have high socioeconomic relevance due to their importance for tourism and strong public visibility. In this study, we use species distribution modelling to explore potential shifts associated with climate-related drivers of change on the habitat suitability of humpback whales (using predictors such as ocean temperature, primary productivity, Antarctic krill habitat suitability, among others). We further assess range shifts, as well as current and future overlaps with present-day human activities (e.g., tourism, fisheries, shipping routes). MaxEnt was used to generate maps of “probability of occurrence” as a proxy for habitat suitability for the present-day and two future time periods (2040-2050 and 2090-2100) across four global development scenarios (Shared Socioeconomic Pathways, IPCC’s AR6-CMIP6). Uncertainty related to high species mobility and data scarcity was assessed using extrapolation diagnostics and multivariate environmental similarity surface (MESS) maps, and temporal transferability was also employed. By examining the spatiotemporal overlap among projected habitat suitability, human ocean uses, and existing marine protected areas, we identify potential spatial conflicts and key future conservation areas, intended to inform “climate-smart” spatial management and planning in the region.

FROM ZOOPLANKTON COMMUNITIES TO MICROPLASTICS: EXPLORING SPATIAL PATTERNS ALONG THE ANTARCTIC PENINSULA

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ABSTRACT

The Antarctic Peninsula is experiencing rapid environmental changes that may affect zooplankton communities, which play a central role in Southern Ocean food webs. In addition, microplastics represent and additional and poorly understood stressor in polar regions. This study investigates spatial variation in zooplankton communities along a latitudinal gradient across the Antarctic Peninsula and explores their associations with environmental conditions and microplastic contamination. Samples were collected at coastal stations during the COASTANTAR expedition in February 2024. Zooplankton communities were characterized in terms of abundance, composition and diversity, while microplastics were isolated, quantified, and characterized according to their size, shape, colour and polymer type. Microplastics distribution was compared with zooplankton community patterns, and the microplastic-to-zooplankton ratio was calculated for each station. Initial analysis indicates that, copepods dominated across all stations, with *Oithona similis* being the most abundant species. Copepod community composition and diversity were generally consistent along the transect, with limited evidence of latitudinal gradient. Microplastic contamination was widespread throughout the study area. By integrating biological and pollution assessments, this study contributes to understanding anthropogenic pressures on Antarctic food webs and supports future monitoring and conservation initiatives, following the Antarctic Treaty System and contributing to the ongoing research of the expert/action/programs of the Scientific Committee on Antarctic Research (e.g. SCAR SPEG, SCAR ImPACT, SCAR C-CAGE, SCAR AnT-ICON), in the Antarctic Peninsula Region.

TEMPERATURE AND SIZE MODULATION OF OXYGEN CONSUMPTION AND METABOLIC THRESHOLDS IN THE ANTARCTIC SPINY PLUNDERFISH *HARPAGIFER ANTARCTICUS*

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ABSTRACT

The Antarctic spiny plunderfish, *Harpagifer antarcticus*, is a small notothenioid inhabiting shallow rocky habitats along the Antarctic Peninsula and the South Shetland, South Orkney and South Sandwich Islands. Its broad latitudinal distribution, sedentary behaviour and strong site fidelity suggest a capacity to cope with a relatively wide range of temperatures. However, little is known about how metabolic performance and thermal thresholds vary with body size. Understanding these responses is particularly relevant for assessing the susceptibility of different size classes to rapid temperature increases associated with marine heatwaves and to prolonged warming predicted for Antarctic coastal habitats. We investigated the effects of temperature and body size on oxygen consumption and metabolic thresholds in *H. antarcticus*, assessing whether thermal responses differed among size classes and photoperiod conditions.

Oxygen consumption increased with increasing temperature, although the magnitude of this response varied markedly with body size. Fish maintained metabolic performance at temperatures up to approximately 5 °C above their natural habitat range, although warming resulted in increased metabolic demands and potential physiological costs. Large individuals showed a marked increase in metabolic rate with warming and became less responsive at the highest temperatures tested, whereas smaller fish maintained a more consistent metabolic response across the experimental range. Intermediate-sized fish exhibited particularly pronounced increases in metabolism at higher temperatures, suggesting increased energetic requirements and potentially greater foraging demands. Size-dependent differences in thermal responses were also reflected in distinct slopes and intercepts of the oxygen-consumption relationships. Furthermore, routine metabolic rates and temperature coefficients appeared to vary with photoperiod, suggesting a possible seasonal component in metabolic regulation. Overall, *H. antarcticus* displays a degree of metabolic plasticity across temperatures exceeding those currently experienced in its natural habitat, but warming imposes size-dependent metabolic costs that may have important implications for energy requirements and vulnerability to future changes in Antarctic coastal environments.

Keywords: *Harpagifer antarcticus*, Antarctic fish, temperature, body size, oxygen consumption, metabolic thresholds, thermal tolerance, photoperiod.

DECOUPLING PHENOTYPE AND GENOTYPE: AGLOMERULISM IN ANTARCTIC NOTOTHENIOIDS

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ABSTRACT

Antarctic notothenioids dominate the fish fauna of the Southern Ocean and have evolved several physiological specializations that allow them to persist in sub-zero waters. Among these is aglomerulism, the loss of the renal glomerulus and its filtration function, which has been proposed to help retain small and essential antifreeze glycoproteins that would otherwise be lost through filtration. What remains unclear is whether notothenioids reached this phenotype through the same molecular changes seen in other aglomerular fishes. Aglomerulism has evolved independently in at least eight teleost lineages, making these groups a useful evolutionary comparison. In syngnathids, for example, the loss of glomerular filtration is associated with erosion of genes involved in the filtration apparatus.

Here, we show that Antarctic notothenioids do not follow the same pattern of glomerular gene degradation. Combining comparative genomics and transcriptomics with renal histology and in vivo experimental physiology across developmental stages, we found that key components of this programme remain conserved, while their transcriptional activity changes markedly through development. Histological and physiological data independently support the absence of functional glomerular filtration in later life stages. These results suggests a different route to aglomerulism, based on developmental regulation rather than progressive loss of the underlying genetic programme.

Notothenioids therefore provide a natural experiment for understanding how adaptation to an extreme environment can drive organ loss while retaining much of the machinery associated with that structure. This retained genetic potential, together with an unusual renal physiology, also raises the question of how developmental and physiological constraints may shape their capacity to respond to a rapidly changing Antarctic environment. More broadly, our results show that the convergent loss of a complex structure can emerge through fundamentally different molecular routes, with developmental regulation providing an alternative to erosion of the underlying genetic machinery.

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Keywords: Aglomerulism, Antarctic notothenioids, Epigenetics, Ontogeny, Ecophysiology

TOWARDS A BASELINE ASSESSMENT OF CONTAMINANT BURDENS AND BIOMARKER RESPONSES IN MYCTOPHID FISH FROM THE SCOTIA SEA

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ABSTRACT

Myctophid fishes (Myctophidae) are key components of pelagic ecosystems, playing a central role in food webs and trophic connectivity. Their broad dietary range makes them useful bioindicators of contaminant exposure considered in Southern Ocean ecosystems, including presence of mercury and other trace elements. Nevertheless, data regarding other classes of contaminants (e.g. endocrine-disrupting chemicals) remains scarce. Therefore, there is a need to establish baseline information regarding contaminant occurrence and understand the biological responses of these organisms to better understand exposure pathways and potential effects at the top levels of the food web. In this study, we detected and quantified the concentrations of brominated flame retardants (BFRs), ultraviolet filters (UV filters), musk fragrances, bisphenols and trace elements in the muscle of five myctophids species from Scotia Sea, *Krefftichthys anderssoni, Protomyctophum bolini, Electrona antarctica, Gymnoscopelus braueri* and *Lampanyctus achirus*. In addition, enzymes and biomarkers were analysed to explore potential relationships between these contaminants and the fish physiological responses. Significant correlations were observed between total length of fish and Pb (Spearman's correlation: $r = 0.9$, $p < 0.05$, $n = 5$), AChE and Pb (Spearman's correlation: $r = 1$, $p < 0.001$, $n = 5$) and ACP and ∑UV-filters (Spearman's correlation: $r = -0.8$, $p < 0.05$, $n = 6$). These results suggest a potential influence of contaminant exposure on the measured biological responses; however, further studies are needed to confirm casual relationships. Our results demonstrate the presence of all the analysed class of contaminants across the five species, while expanding the limited data on endocrine-disrupting chemicals and trace elements in myctophids from Scotia Sea. These findings provide baseline values and underscore the importance of the myctophids in contaminant pathways in the Southern Ocean.

ASSESSMENT OF EMERGENT POLLUTANTS IN ARCTIC PRIMARY PRODUCERS

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ABSTRACT

Contaminants of emerging concern (CECs) are increasingly accumulating in the Arctic despite its remoteness from major emission sources. These compounds threaten ecosystem health, yet their biological effects on Arctic primary producers remain poorly understood. The project ARCBIO - Assessment of emergent pollutants in Arctic Primary Producers addresses this gap by linking CEC loads to biological responses in Arctic primary producers (phytoplankton and lichens) through a cross-domain, multi-endpoint framework. In this work we present ARCBIO which addresses the overarching question: how does CEC exposure affect the physiology, microbiome function and ecological structure of Arctic primary producers across the sea-land continuum? ARCBIO aims to (1) quantify and spatially model CEC exposure in seawater and primary producers; (2) identify physiological indicators of CEC stress from photochemical performance; (3) disclose microbiome taxonomic, functional and resistome indicators of CEC exposure; (4) identify community-level ecological indicators of CEC pressure; and (5) integrate these responses to define robust ecological indicators and model species for Arctic monitoring. ARCBIO, funded by EU project POLARIN, will be implemented aboard PONANT's MV Le Commandant Charcot, in summer 2027. Sampling spans major atmospheric, oceanic, and riverine contaminant pathways, from Longyearbyen, Svalbard coast and across the Greenland Sea to Northeast Greenland. Lichen communities along the Greenland coast complement marine observations by integrating atmospheric deposition signals on land. This design captures strong environmental gradients in productivity, climate, and deposition. Results will generate new indicators of CEC stress, CEC distribution patterns, and model species for CEC ecotoxicology, and deliver harmonised open-access chemical, photochemical, and metagenomic indicators datasets. We will present the conceptual framework behind this multidisciplinary approach enabling transformative advances in understanding CEC behaviour, fate and impacts in Arctic ecosystems and delivering analytical tools applicable far beyond the polar regions. By integrating transferable methods with advanced monitoring, ARCBIO will improve global CEC risk assessment, support EU and UN goals, and deliver science-based guidance for environmental policy.

ACUTE TOXICITY OF ESCITALOPRAM TO THE ANTARCTIC COPEPOD BOECKELLA POPPEI

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ABSTRACT

Pharmaceutical inputs associated with research stations and tourism are an emerging concern for Antarctic freshwaters, but toxicity thresholds for native zooplankton remain scarce. We assessed acute mortality of the circumpolar copepod *Boeckella poppei* following exposure to nominal escitalopram concentrations from 10 to 100,000 µg L^{-1}. Static tests were conducted for 48 h at 4 ± 0.5 °C under a 16 h light and 8 h dark photoperiod, using an OECD-type design adapted to polar conditions. A four-parameter log-logistic model fitted to the recorded concentration-response data estimated a 48-h LC50 of 75,000 µg L^{-1}, with a 95% confidence interval of 57,800 to 97,400 µg L^{-1}. No mortality was recorded at 10 µg L^{-1}, the reported no-observed-effect concentration, whereas the reported lowest-observed-effect concentration was 100 µg L^{-1}. These results provide an initial lethal-effect baseline for escitalopram in *B. poppei* and support the use of native species in Antarctic pharmaceutical assessment. Interpretation should remain restricted to nominal exposure because analytical confirmation of test concentrations and comprehensive quality-control information are still required. Chronic, behavioural and reproductive endpoints may respond below lethal concentrations and should be prioritised in subsequent work, together with measured exposures and environmentally representative mixtures. The study defines a testable starting point rather than an environmental safety threshold.

ANTARCTIC COASTAL WASTE LEACHATE REDUCES SURVIVAL OF BOECKELLA POPPEI

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ABSTRACT

Waste retained in ice-free Antarctic coastal areas can generate complex leachates that reach ponds and shallow lakes during thaw. We tested whether a leachate prepared from mixed coastal-waste residue affected survival of the native freshwater copepod Boeckella poppei. Neonates younger than 48 h were exposed for 10 days at 2 °C to 0, 6.25, 12.5, 25, 50 or 100% leachate, using three vessels of ten organisms per concentration. The stock was prepared at 100 g residue L^{-1}, and the full-strength extract was analysed at five intervals by microwave plasma atomic emission spectrometry. Fe, Zn, Cr, Pb, Cd, Cu, Mn and Hg formed a time-varying mixture: mean Pb declined from 9.01 mg L^{-1} at 48 h to 2.54 mg L^{-1} on Day 6, whereas mean Zn increased from 1.54 to 2.57 mg L^{-1}. No control mortality occurred. Day-10 mortality ranged from 33.3 to 43.3% in all exposed treatments, and a vessel-level exact permutation test supported an overall exposure effect ($p = 0.0012$). The non-monotonic response did not reach 50%; therefore, an LC50 was not extrapolated. Three exposed survivors carried dense sessilid ciliate colonies provisionally identified as cf. Epistylis, without evidence of a causal relationship with mortality. The findings demonstrate whole-leachate toxicity to a native Antarctic consumer and show that time-resolved chemistry is essential for interpreting changing waste-derived mixtures.

Keywords: Antarctica; *Boeckella poppei*; coastal waste; leachate; metal mixture.

STANDARDIZATION OF ACUTE TOXICITY TESTS FOR TWO ANTARCTIC FRESHWATER INVERTEBRATES

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ABSTRACT

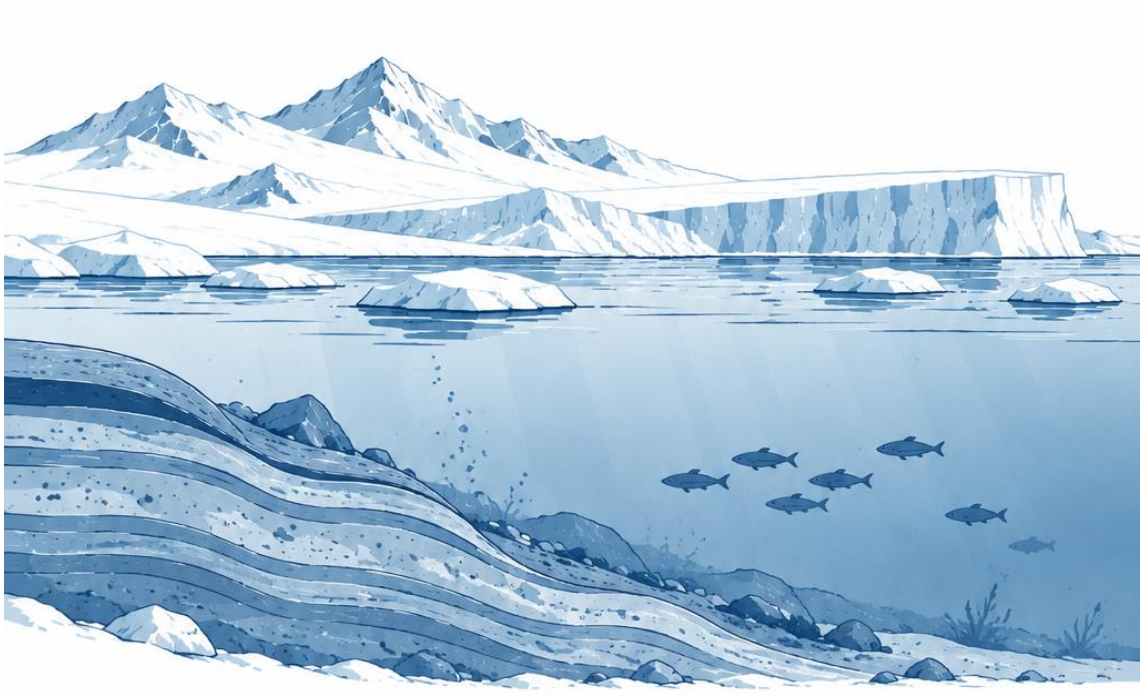
Locally relevant toxicity methods are needed for Antarctic invertebrates because protocols developed for temperate species may not represent polar life histories or exposure conditions. We developed matched 48-h acute tests at 4 °C for the freshwater copepod *Boeckella poppei* and larvae of the terrestrial Antarctic midge *Belgica antarctica* tested by immersion. Replicate concentration-response assays used sodium dodecyl sulfate as a reference toxicant and nominal copper as a contaminant of interest. Two-parameter log-logistic models were preferred for every individual and pooled dataset. Sodium dodecyl sulfate LC50 values were 571 mg L^{-1} for *B. poppei* and 756 mg L^{-1} for *B. antarctica*, with between-test coefficients of variation of 6.6% and 6.7%, respectively. Nominal-copper LC50 values were 6.03 and 7.65 mg Cu L^{-1}, with corresponding coefficients of variation of 26.9% and 16.4%. The lowest copper concentration tested, 3 mg Cu L^{-1}, increased mortality significantly in both species; therefore, the no-observed-effect concentration was below 3 mg Cu L^{-1} and the lowest-observed-effect concentration was 3 mg Cu L^{-1}. Neither species showed mortality through 96 h at 2-10 °C, practical salinity 0-2 or pH 5.0-7.31. The results establish internally reproducible, single-site methods and matched sensitivity baselines. They represent a standardization step, not regulatory validation; measured exposure concentrations, stage-controlled cohorts, additional populations and seasons, and interlaboratory trials remain necessary.

Keywords: Antarctica; *Boeckella poppei*; *Belgica antarctica*; method standardization; acute toxicity

C

From Ice to Ocean

Cryosphere, Sediments and Chemical Cycles



ASSESSING RISK ASSOCIATED TO PERMAFROST DEGRADATION IN THE ANTARCTIC PENINSULA: GENERAL FRAMEWORK

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ABSTRACT

Ice-free areas in the Antarctic Peninsula region are particularly affected by climate change, including permafrost warming and degradation, with potential implications for ground stability and geomorphological processes. These areas encompass elements such as scientific activity sites, historical sites and tourist routes that may be exposed to geomorphological hazards associated with permafrost degradation. Despite the growing knowledge on permafrost temperatures and associated geomorphological processes, the spatial relationship between potentially affected areas and existing elements has not been explored so far in Antarctida. Here, we present the general framework of the on-going research aimed at identifying areas potentially affected by hazardous geomorphological processes and assessing the spatial distribution of exposed elements. To this end, the main geomorphological processes associated with permafrost degradation and the areas potentially affectd by them will be identified and mapped, while the different elements present in the study area will be mapped and characterized. Their spatial intersection will allow exposure to be assessed by identifying elements located within this hazardous areas. The physical vulnerability of the exposed elements will be assessed through a scenario-based approach based on hazard intensity and elemento-specific characteristics. The results will be integrated into a qualitative risk analysis, considering hazard, exposure, and vulnerability. This work will contribute to a better understanding of the spatial distribution of the elements at risk in the Antarctic Peninsula region. The results may support the identification of priority areas and elements for monitoring, thus contributing to management and adaptation strategies in environments undergoing permafrost transformation.

This research is a contribution to the project THAWIMPACT funded by the Fundação para a Ciência e a Tecnologia (FCT) under grant No. 2022.06628.PTDC.

DETECTING GROUND SURFACE DISPLACEMENT IN THE ICE-FREE AREAS OF THE NORTHWEST ANTARTIC PENINSULA USING INSAR

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ABSTRACT

Ice-free areas across the Antarctic Peninsula are subject to complex interactions between thermal, hydrological and geomorphological processes, which can drive a wide spectrum of continuous and seasonal ground movements. The dynamics of periglacial environments can provide relevant information on permafrost conditions, which serves as key indicator of climate change and influence local hydrology, nutrient fluxes, and terrain stability, ultimately impacting both life and infrastructure. However, continuous monitoring of these processes is severely constrained by the scarcity of field observations and highly variable surface conditions. This study aims to analyse the surface displacement within ice-free areas in the Antarctic Peninsula using Interferometric Synthetic Aperture Radar (InSAR), using images acquired from the Sentinel-1A satellite. Over the study area, only descending-orbit acquisitions are available, with a regular revisit interval of 12 days, a condition that may result in coherence loss over surfaces undergoing rapid changes. Accordingly, a Small Baseline Subset (SBAS) approach and different multilooking resolutions were adopted to assess the reduction of those decorrelation effects. Here, we present the first results obtained for the period of December-2025 to June-2026 in the Northwest Antarctic Peninsula and discuss the potential displacements associated to changes in permafrost.

This work is funded by the FCT, project THAWIMPACT (grant No. 2022.06628.PTDC).

HYDROGRAPHIC AND BIOGEOCHEMICAL HETEROGENEITY IN GLACIER INFLUENCED MAXWELL BAY

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ABSTRACT

Coastal Antarctic embayments integrate glacial freshwater, shelf exchange and biological processing across coupled spatial and temporal scales. We analysed 66 surface-water samples collected during six POLAR BIOMAP surveys in Maxwell Bay, King George Island, from 8 January to 5 February 2026. Measurements included temperature, practical salinity, dissolved oxygen, pH, dissolved inorganic nutrients and fluorometric chlorophyll-a. A 19-station open-bay transect occupied on 26 January and repeated ten days later showed higher temperature, lower practical salinity at every station and lower chlorophyll-a at 18 of 19 stations. These directions persisted in the sensitivity analysis restricted to 16 station pairs separated by no more than 0.25 km, whereas silicate and phosphate showed no directional matched shift. On 5 February, all four Nelson Glacier-channel chlorophyll-a estimates, 1.07-1.66 μg L^{-1}, exceeded the 19 simultaneous open-bay estimates; the exact comparison gave $p = 0.00023$ and Cliff's $\delta = 1.0$. Regional reanalysis independently indicated January-to-February warming and freshening. Nine pooled environmental correlations survived false-discovery correction, but none remained significant after adjustment for campaign, showing that survey structure can generate misleading pooled relationships. The repeat transect, glacier-channel comparison, fixed-station observations and qualified analytical record establish a scale-aware baseline for monitoring Maxwell Bay. The observations document change between two dates and sub-bay heterogeneity; they do not define a seasonal trend or attribute the patterns to a single mechanism.

ARSENIC SPECIATION AND DYNAMICS IN ARCTIC PERMAFROST THAW ENVIRONMENTS

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ABSTRACT

Arctic and subarctic regions are warming rapidly, accelerating permafrost thaw. Thawing increases hydraulic conductivity and promotes interactions among organic matter, minerals and microorganisms, which may remobilize contaminants. Arsenic (As) is identified by the WHO as an element of major public health concern. In soils, the most relevant species are arsenite (As(III)), arsenate (As(V)), monomethylarsonic acid (MMA) and dimethylarsinic acid (DMA), whose interconversion is driven by chemical and microbially mediated processes. Within the European project ILLUQ, we present the first study of As speciation, methylation and demethylation in permafrost soils. Field incubations simulating As release and transformation during thaw were performed near Sisimiut, Greenland, and As species were quantified by HPLC-ICP-MS. Amendments with FeCl3, MD (sulphate-reducer inhibitor) and BES (methanogen inhibitor) were applied to assess the contribution of specific microbial groups. Natural As concentrations were low (<1 mg/kg), well below the global average (~5 mg/kg). No significant methylation or demethylation occurred, either naturally or after treatments, suggesting that both processes occur at similar rates, or that these soils have limited methylation/demethylation capacity at an observable scale. Inhibiting sulphate-reducing bacteria (SRB) with MD caused significant oxidation of As(III) to As(V) within 24 h when compared to the controls, hinting that SRB are important for inorganic As speciation. Inhibiting methanogens with BES also increased As(III) oxidation, but to a lesser extent than the SRBs. In conclusion, in these permafrost soils with low content of As, a part of the dynamics are governed by microbially influenced redox transformations of inorganic species, rather than by methylation. Shifts in microbial communities during thaw may therefore a_ect As mobility and toxicity in Arctic soils.

SCREENING TRACE METALS ACROSS ANTARCTIC ICE FRESHWATER AND COASTAL HABITATS

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ABSTRACT

Antarctic coastal metal distributions integrate melting ice, freshwater drainage, sediment exchange, animal inputs and local human activity. We evaluated colourimetric test-strip readings from 38 samples collected across ice-associated, freshwater and coastal habitats on Fildes Peninsula and interpreted them alongside field chemistry and published Maxwell Bay metal measurements. Strip colours were read against kit reference scales with image-assisted photometric support and are reported as semiquantitative concentration intervals, not as instrumentally confirmed dissolved concentrations. Estimated Cu ranged from 0 to 0.2 mg L^{-1} and Zn from 0 to 30 mg L^{-1}. Mn was assigned to 0.1-0.5 mg L^{-1} in 37 samples and 0.1-1 mg L^{-1} in one sample; the intervals overlapped and did not establish a spatial ranking. The receiving environments were chemically heterogeneous: coastal practical salinity ranged from 14.15 to 28.09, water silicate from 58.54 to 93.55 µmol L^{-1} and ice-associated silicate from 1.76 to 7.76 µmol L^{-1}. Published 2018 Maxwell Bay seawater measurements provided analytical context, with dissolved Fe of 4.12-10.99 nM, Co of 84.9-203.8 pM, Ni of 5.31-6.21 nM and Cu of 2.34-3.76 nM. The strip survey is therefore useful for reconnaissance and selecting samples for confirmatory analysis, but not for source attribution, pollution classification or ecological-risk calculation. Future monitoring should combine calibrated instrumental measurements, blanks, detection limits and matched hydrological observations.

Keywords: Antarctica; trace metals; colourimetric strips; screening; Maxwell Bay.

SEA STATE ESTIMATION BY THE POLAR SHIP ADM. MAXIMIANO'S ATTITUDE DURING THE 43RD BRAZILIAN OPERANTAR

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ABSTRACT

In situ measurement of wind-generated gravity waves at the sea surface is typically conducted using moored or drifting buoys, which presents a challenge in remote regions. The use of vessels in transit as mobile wave-measurement platforms has become a practical reality. This study employed a hybrid methodology—combining physical data with machine learning, to reconstruct wave time series (significant wave height, peak period and mean direction) along the trajectory of the Polar Ship *Admiral. Maximiano* during the first and second phases of the OPERANTAR 43 expedition. This sampling effort is part of the ATMOS 2 (Antarctic Modeling and Observation System) project among the Brazilian Antarctic Program. The vessel's attitude (motion) in relation to the incident wave field was calculated, and these data were used to inform a machine learning system. The system was trained using data collected during two previous campaigns (OPERANTAR 38 and 42) and subsequently tested against data from the first and second phases of OPERANTAR 43. The results were compared with ERA5 reanalysis data, yielding root-mean-square errors (RMSE) of up to 0.25 m for significant wave height, 0.3 s for peak period, and 6° for mean direction. This methodology enables the acquisition of wave data based on a vessel's motion while in transit, offering potential for operational application. Furthermore, this approach can be extended to other vessels to estimate incident wave heights along their respective routes.

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D

Polar Futures

Climate, Governance and Society



CLIMATE CHANGE, OCEAN, ARCTIC AND SECURITY NEXUS

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ABSTRACT

By exploring the nexus between climate change, the ocean, the cryosphere, and international security, focusing on how the accelerating transformation of the Arctic is reshaping maritime geopolitics and security dynamics beyond the region itself. Particular attention is given to the interaction between Arctic sea-ice decline, ocean circulation, emerging maritime routes, and the growing connectivity between the Arctic and Atlantic Oceans. Drawing on the Copenhagen School of securitization, the research examines how environmental and climatic transformations become incorporated into international security agendas and generate new forms of geopolitical competition, vulnerability, and cooperation. The progressive Atlantification of the Arctic Ocean illustrates the increasingly interconnected nature of oceanic and cryospheric systems, while the retreat of sea ice creates conditions for the expansion and transformation of maritime routes linking the Arctic and Atlantic regions. These developments have implications not only for navigation and maritime trade, but also for strategic mobility, sovereignty, resource access, infrastructure, environmental governance, and human security. The Arctic therefore emerges as a space where environmental change intersects directly with international relations and maritime security.

INSIGHTS FROM TWO YEARS OF PROJECT PLANT: CLIMATE-SMART PLANNING AND GOVERNANCE IN THE SOUTHERN OCEAN

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ABSTRACT

European project PLAnT, “Planning for Sustainable Ocean Use in Antarctica under Global Environmental Change”, funded by the European Research Council, aims to investigate the benefits and challenges of developing comprehensive climate-smart marine spatial planning (MSP) in Antarctica and the Southern Ocean. Climate-smart MSP is an idea whose time has come, as recognized by the World Bank, UNESCO, and the European Commission. Yet, until now it has not been implemented at all in the high seas, nor properly within national waters worldwide. There is no better place to trial climate-smart MSP than the Southern Ocean. It is one of the largest shared spaces on the planet, and one that faces the most extreme climate impacts today (together with the Arctic). While several initiatives have been developed to protect the Southern Ocean in the past, the time is now to build on this work by taking a new, broader path, engaging all relevant parties and stakeholders and addressing a wide range of interests in an integrated way. Climate-smart MSP could guide decisions on how Antarctic marine resources can be used sustainably even as the world changes, providing a model for international waters into the future. In this poster presentation, we will pinpoint the most important advances achieved over the first two years of project PLAnT. From PLAnT’s policy impact (through a collaboration with the delegation of Portugal to the Antarctic Treaty Consultative Meetings that resulted in the discussion of MSP for the first time in the context of the Antarctic Treaty System) to scientific publications (including a high-level publication in Science), to a newly launched Antarctic Participatory Mapping process developed to engage the Antarctic research community, this poster will reflect lessons learned to date and highlight future pathways to support climate-smart ocean governance in the Antarctic region and beyond.

BLUE JUSTICE IN THE SOUTHERN OCEAN: UNRAVELLING THE ANTARCTIC TREATY SYSTEM DISCOURSE TO INFORM EQUITABLE OCEAN GOVERNANCE

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ABSTRACT

Justice, equity and representation are increasingly recognised as key concerns in ocean governance, with the potential to reshape management systems. The Antarctic region, governed under the Antarctic Treaty System (ATS), provides a unique, and largely unexplored, setting to examine the relationship between blue justice and ocean governance in an international framework. Here, we examine how blue justice, equity and fairness are framed and operationalised within the ATS over the past six decades. Furthermore, we analyse the interplay between climate change and justice-related discussions, as climate-related impacts on socio-ecological systems raise important questions related to justice and equity. With a mixed-methods approach, this study combines a systematic literature review on blue justice with an analysis of Antarctic Treaty Consultative Meetings' (ATCMs) formal documentation from 1961 to 2025, aiming to understand who raises justice-related issues, when they appear, how they evolve over time and what challenges arise in discussions. With 22 relevant documents, justice and equity-related issues became prominent in recent ATCMs, particularly in 2023 (n = 7) and 2024 (n = 5). Social considerations were widespread in documentation, while procedural justice and equity was the most represented justice domain. Most papers were submitted to ATCMs by Consultative Parties or jointly with them. Activities related to scientific research dominated justice-related documentation, with climate change being mentioned only in 3 documents. These findings indicate an increased attention to blue justice considerations within Antarctic governance. Using a blue justice lens to analyse the ATS discourse and decision-making provides insights into how justice and equity have been embedded in a consensus-based framework requiring intergovernmental cooperation. This research can further inform equitable, inclusive, transparent and climate-smart ocean governance in the Antarctic region.

BIODIVERSITY PATTERNS IN THE SOUTHERN OCEAN GOVERNANCE DISCOURSE

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ABSTRACT

Antarctica and the Southern Ocean are among the most pristine and ecologically distinct regions of our planet, harboring a singular assemblage of highly adapted and often endemic species. Standing as one of our last global commons, it is managed through a unique governance regime – the Antarctic Treaty System – built on international cooperation and bearing ecological conservation at its core. Understanding how biodiversity has been represented and integrated into policy discussions in the region, therefore, provides precious insights into the policy-conservation nexus within an international governance framework. Here, we use text-mining to analyze species mentions across 60 years of policy discussions from Antarctic Treaty Consultative Meetings (ATCMs) and to evaluate the biodiversity patterns that emerge within the discussions. Results of our ongoing efforts suggest that while the biodiversity within ATCM discussions peaked around the early 2000s, they have since stabilized, centering on a relatively consistent set of frequently discussed species, largely focusing on seabirds and marine mammals, with limited species-level attention to other ecologically relevant groups. Preliminary results also show that policy attention does not seem to align with extinction risk, with non-threatened species receiving broader attention. Notably, discussions relating to management plans feature a high volume of species-level, serving as an indicator of ecosystem-based management within the Antarctic Treaty System. This 'discursive ecology' framework highlights how policy discussions both reflect and shape the management of the underlying ecosystem, with lessons that should extend beyond the Southern Ocean and into conservation-forward governance more broadly.

HOW DO WE SPEAK ABOUT POLAR SCIENCE COMMUNICATION?

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ABSTRACT

The International Polar Year (2007-2008) was a key turning point for polar science communication, coining the term "Education, Dissemination and Communication" for the first time, which shined a new light on this topic. The definition of this new polar topic of interest was essential to promote research in polar science communication, define strategies, and improve the effectiveness of engagement of different audiences. However, almost twenty years later, the terminology related to polar science communication is still used inconsistently and with scattered meanings in the literature. This poster will showcase the mapping analysis of the conceptual terms present in scientific articles on science communication related to polar regions. The study performed a non-systematic literature review, which allows for a broader content scope, to obtain a sample of the most used terms in the field and point out possible solutions to standardize terminologies. The mapping analysis (n=53) reveals that “communication” appears to be the dominant and most frequently used term as a central concept in the literature, followed by “engagement” and “outreach”. “Participation,” “raising awareness,” and “dissemination” are other frequent words. Results also indicate the presence of some differences between areas, with articles related to Antarctica and the Arctic favouring the term “communication,” although polar articles (which address both regions) do not seem to demonstrate any dominant term. Additionally, few articles (only 13) define these concepts clearly in the contexts portrayed, with different terms used almost equivalently, despite not being synonymous. This mapping thus aims to clarify the lexicon of polar scientific communication in order to help reduce ambiguities in the application of these concepts, strengthen research and practical application, and comprehend what science communication truly means in the context of polar science.

FROM POLES TO PEOPLE: HOW ASSOCIATION OF POLAR EARLY CAREER SCIENTISTS (APECS) PORTUGAL COMMUNICATES WITH SOCIETY

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ABSTRACT

Polar regions, despite their key influence on the global climate and oceans, are still distant from public perception, particularly in non-polar countries, such as Portugal. Thus, making polar science understandable and relevant to non-specialist audiences is of most importance when bringing research closer to society. For nearly two decades, APECS Portugal has been promoting science communication and outreach activities. In this presentation, we showcase the diversity of communication approaches used by APECS Portugal, such as school talks (e.g. Polar Weeks), scientific fairs, workshops, and social media. To develop these activities, APECS Portugal established collaborations with researchers, educators and national and international polar organisations. These initiatives have reached more than 100,000 students and many more members of the public, creating opportunities for direct interaction between scientists and non-specialist audiences. Rather than focusing only on knowledge transfer, we discuss how these activities can promote dialogue, curiosity and raise awareness about polar regions and climate change, while helping early career researchers (ECRs) develop communication, leadership and networking skills. Drawing on these diverse experiences, we highlight practical lessons on adapting scientific messages to different audiences, choosing appropriate communication formats and sustaining interaction over time. This communication aims to showcase how APECs' science communication practices can be a blueprint that both ERCs and senior researchers can rely upon when engaging with different audiences.

THANK YOU

XVIII Portuguese Conference of Polar Sciences 2026

Thank you for being part of the XVIII Portuguese Conference of Polar Sciences and for contributing to its success.

We hope this conference provided opportunities to exchange knowledge and establish lasting connections that will inspire future collaborations in polar research.

We are grateful to all participants, speakers, authors, committee members, sponsors and institutional partners who made this conference possible.

The Organising Committee

Faro, Portugal

6–7 November 2026

AUTHOR INDEX

XVIII Portuguese Conference of Polar Sciences 2026

F = first author; P = presenting author.

Page references are marked for each contribution.

Abreu, José: 56
Afonso, Luís: 45 [F,P]
Agardy, Tundi: 75
Amaral, Inês: 28 [F,P], 59 [P]
Antunes, Alexandra M. M.: 70
Areias, Pedro: 49, 51 [F,P], 52
Assmy, Philipp: 20, 21
Avşar, Oğuzhan: 30 [F,P], 79
Badhe, Renuka: 75
Bailey, Allison: 20
Baptista, Joana: 32 [F,P]
Baptista, Mafalda S.: 21
Bastos, Lucas: 27 [F,P], 55 [F,P], 56, 79
Belém, André L.: 69
Bessa, Filipa: 58, 61
Borges, Francisco O.: 56, 57 [P], 75, 77
Boudevillain, Brice: 37
Bowen, Marina: 49, 50 [F,P], 51, 52
Brandão-Dias, Pedro F.P.: 45
Braun, Christina: 30
Brazão, João: 59
Brito, A.C.: 26
Brito, Fernando: 34
Brooks, Cassandra: 75
Brotas, V.: 26
Cabral, Beatriz: 75, 76 [F]
Cabrita, Maria Teresa: 49, 50, 51, 52, 62 [F,P]
Calado, Helena: 75
Canário, Adelino V. M.: 28, 59
Canário, João: 23, 35, 47, 70
Cândido, Mariana: 67 [F,P]
Capo, Eric: 23
Cardoso, Vasco Vaz: 47, 70 [F,P]
Castro, Filipe: 60
Castro, Leonor: 46 [F,P]
Cesário, Rute: 35, 47, 70
Colominas-Ciuró, Roger: 29
Correia, Ana Mafalda: 45
Cortesão, Marta: 48
Costa, Joana: 21 [F,P]
Costa, R.R.: 26
Costa, Rita A.: 28, 59 [F]
Costa, Rodrigo: 47 [P]
Couture, Raoul-Marie: 33
Crowder, Larry B.: 75
Cunha, Sara C.: 61
Dewar, Meagan: 29
Dias, Mário: 47, 70
Dias, Ricardo: 62
Diniz, Mário: 61
Diou-Cass, Q.: 26
Domingos, Ana Rita: 43 [F,P]
Domingos, Miguel J.L.: 63 [F,P], 64, 69
Duarte, Bernardo: 62
Duarte, Carolina: 69, 71 [F,P]
Duarte, Pedro: 21, 46
Durán-Alarcón, Claudio: 37
Ehler, Charles: 75
Espírito-Santo, Marta: 40 [F,P], 56
Favier, Vincent: 30, 37
Fernandes, José O.: 61
Ferreira, Afonso: 26 [F,P], 54
Folhas, Diogo: 33 [F,P]
Fonseca, Tainá: 69
Fonseca, Vanessa: 62
Fragão, Joana: 56, 58, 61 [F,P], 79
Francisco, Diogo: 79
Fritz, Michael: 70
Gambardella, Nicola: 23 [F,P]
Gissi, Elena: 75
Golikov, Alexey: 56
Gonçalves, Douglas Gomes: 69
Gonzalez-Herrero, Sergi: 37
Gorodetskaya, Irina: 22, 30, 37 [F,P]
Goyanes, Gabriel: 38, 49
Grant, Susie: 75
Gregório, Silvia F.: 28
Guedes, Sara: 27
Guerreiro, C.V.: 26
Guerreiro, Miguel: 56
Guerreiro, Milene Alexandra: 58 [F,P]
Guerreiro, Pedro M.: 28, 59, 60
Guimarães, Murilo Vieira: 69
Guímaro, Hugo R.: 56, 79
Havermans, Charlotte: 27, 55, 56
Hintelmann, Holger: 35, 47, 70
Hop, Haakon: 21
Hughes, Kevin: 75
Ingeman-Nielsen, Thomas: 70
Joosten, Jacqueline: 69 [P]
Kato, Akiko: 30
Katsumiti, Alberto: 62
Kish, Adrienne: 48

Lantuit, Hugues: 70
Laurion, Isabelle: 33
Leahy, Ariel: 29
Lee, Hyoungseok: 50
Lima, Domênica Teixeira de: 69
Lima, Fernando P.: 25
Liszka, Cecilia: 58
Lodi, Rachele: 70
Lopes, Eva: 20 [F,P], 22, 43, 46
Lopes, Laura: 58
Lopes-Santos, Sara: 29 [F], 56, 79
Louro, Catarina: 35 [F,P]
Maclennan, Michelle: 37
Madureira, Tiago: 52 [F,P]
Magalhães, Catarina: 20, 21, 22, 23, 43, 44, 45, 46, 48
Manno, Clara: 61
Marquez, André Lanfer: 72 [F,P]
Martinho, Filipe: 58
Martins, Diana: 79
Matos, Paula: 49 [F,P], 50, 51, 52, 62
McClintock, Will: 75
Melo, Raquel: 67
Mendes, Carlos Rafael B.: 26, 54
Miranda, Vasco: 49
Molinari, Mariana Steyer: 79 [F,P]
Moniz, Pedro: 54 [F,P]
Monteiro, Cátia: 25
Mora, Carla: 49
Mota, Afonso: 48 [F,P]
Nualart, Daniela: 28, 59
Nunes, Graça S.: 79
Oliveira, Inês: 64 [F,P]
Palanch, Maria Fernanda: 69
Pardal, Miguel Ângelo: 58
Park, Sangjong: 37
Paschke, Kurt: 28, 59
Pascoal, Francisco: 21, 45, 46
Perales-Raya, Catalina: 56
Pereira, Ana Rita: 38 [F,P]
Pereira, Cátia: 68 [F,P]
Pereira, Ricardo: 27
Pezzi, Luciano P.: 72
Phillips, Richard A.: 27, 29, 56
Pierce, Graham J.: 45
Pinho, Pedro: 51
Pinto, Bernardo: 60
Portela, Luís I.: 34 [F,P]
Prates, Gonçalo: 68
Primo, Ana Lígia: 58
Queirós, José P.: 56
Quelha, Rita: 56, 79
Quesada, António: 35
Rafacho, Matilde: 22, 37
Ramalho, Hugo B.: 47 [F]
Ribeiro, Caio Cesar: 63, 64, 65 [F,P], 69 [F], 71
Ribeiro, Cláudia: 79
Rilo, Ana: 34
Robinson, Sharon A.: 49, 50
Rocha, Bernardo: 50, 51
Rodrigues, Céline: 74 [F,P]
Ropert-Coudert, Yan: 30
Rosa, Rui: 56
Rosas, Carlos: 28
Santinni, Marcelo F.: 72
Santos, Catarina Frazão: 39, 56, 57, 75 [F,P], 76, 77
Santos, Catarina Pereira: 39, 56, 57, 75, 76 [P], 77 [F,P]
Santos, David Abreu dos: 39 [F,P], 75
Santos, Ivo dos: 29 [P]
Santos, Nuno: 48
Saunders, Ryan A.: 61
Scherer, Marinez: 75
Schofield, O.: 26
Seabra, Rui: 25 [F,P]
Seco, José: 29, 56
Semedo, Miguel: 20, 44
Siewert, Matthias: 70
Silva, Catarina N. S.: 27, 55
Silva, Elsa Costa e: 78
Silva, Joana: 27
Silva, Joana M. da: 56, 78 [F,P], 79
Silva, Rita da: 25
Soares, Maria: 79
Sousa, Diana: 44 [F,P]
Soutullo, Álvaro: 30
Sperou, Emily S.: 29
Suarez-Bregua, Paula: 45
Szelpal, Luca: 71
Teixeira, José: 60 [F,P]
Thota, Sharath Chandra: 22, 79
Valente, Raul: 45

Vargas-Chacoff, Luis: 28, 59
Vaz, Diana: 79
Vieira, Gonçalo: 32, 38, 49, 50, 67, 68
Vilela, Rocio Nieto: 25
Villalobos, Santiago: 79
Vučković, Ksenija: 22 [F,P], 79
Waite, N.: 26
Warkentin, Alexandra: 64
Wedding, Lisa M.: 75
Werdenig, Julia: 57 [F], 75
Westermann, Sebastian: 32
Wilson, Jonathan M.: 60
Wold, Anette: 21
Xavier, José C.: 27, 29, 39, 40, 55, 56 [F,P], 57, 58, 61, 75, 76, 77, 78