



MONACO EXPLORATIONS
Reconnecting Humanity and the Sea

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INDIAN OCEAN EXPEDITION

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What strikes me today is that expertise and research in the maritime field have never really been priorities. The Ocean remains largely unknown. Yet it holds so many treasures. A better understanding of them is essential to ensure the protection of our planet. It is for these reasons that, beyond the historical and family heritage, I felt the need to relaunch the Explorations of Monaco, inaugurated by Albert Ist a little over a hundred years ago.

*L'Homme et l'Océan - H.S.H. Prince Albert II of Monaco
Flammarion et Versilio, 2022.*



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EDITORIAL

INDIAN OCEAN EXPEDITION 2022: PROTECTING SAYA DE MALHA, THE "INVISIBLE ISLAND"

Over the last one hundred and fifty years, Prince Albert Ist (1848-1922) and then Prince Rainier III (1923-2005) have forged a strong link between the Principality of Monaco and the marine environment through their commitment and strong actions in favour of the Ocean. Since his accession to the throne in 2005, H.S.H. Prince Albert II of Monaco has not only strengthened this powerful link but has also increased Monaco's influence and action internationally. In his book *L'Homme et l'Océan, préservons les océans pour protéger l'humanité (Man and the Ocean, let's preserve the oceans to protect humanity)*, recently published by Flammarion and Versilio, He expresses His love of the blue waves and His commitment to environmental issues and the marine environment.

This commitment has resulted in the relaunch of the Principality's exploration expeditions, with the creation in 2017 of Monaco Explorations. Over the past five years, this collaborative platform serving the commitment of H.S.H. Prince Albert II of Monaco to the knowledge, sustainable management and protection of the Ocean has conducted numerous multidisciplinary expeditions throughout the world, all of which have provided a wealth of experience in contact with Nature and the Ocean and human encounters. These expeditions have been carried out with the aim of combining scientific research, public outreach, and governmental cooperation in their approach.

The new Monaco Explorations expedition to the Western Indian Ocean is part of this quest for humanism and scientific truth. The "Indian Ocean Expedition" is the first item of the "Monaco Explorations" project endorsed as a contribution to the United Nations Decade of Ocean Sciences for Sustainable Development 2021-2030. The

expedition will take place from October to November 2022 between Reunion, Mauritius, and Seychelles. The study programme is structured around the study of the Saya de Malha Bank, co-managed by Mauritius and Seychelles, the islands of Aldabra and Saint-Brandon and seamounts located along the expedition route. It focusses on meeting the needs of the Governments of Seychelles and Mauritius while also relating closely with relevant international and regional organs and initiatives, such as the Second International Indian Ocean Expedition (IIOE-2 - 2015-2025).

With an area of 40,000 km², Saya de Malha is one of the world's largest seagrass beds. Located in the high seas, it is home to little-known, remote, and difficult-to-access ecosystems that are already under threat from heavy fishing pressure. With no landforms, this shallow plateau is known as the "invisible island".

The objective of this study is to gather information to determine whether this area requires special protection and if so, to identify the management measures to be considered.

For two months, the different actors of this large-scale operation; scientists, decision-makers, artists, or outreach specialists will pool their skills and unite their efforts with the intention of raising the awareness of the widest possible audience to the value of these natural spaces and the pressures they are subject to.

A challenge and stakes commensurate with the role and commitment of the Principality and its Sovereign within the international community for the protection and sustainable management of the Ocean.

Robert CALCAGNO,
Managing Director of the Monaco Explorations Company,
Director General of the Oceanographic Institute - Prince Albert Ist of Monaco Foundation.



THE OCEAN: CONTEXT AND ISSUES

A vast, continuous ecosystem with no physical boundaries, the Ocean provides essential services to sustain life on Earth, particularly in terms of climate regulation. As a natural carbon sink essential to the planet's equilibrium, it mitigates the effects of climate change by absorbing nearly 30% of CO2 emissions and more than 90% of excess heat from human activities. It is also home to a considerable natural heritage, much of which has yet to be discovered.

In addition to these ecosystem services, there are economic opportunities offered by the Ocean. For example, 9 out of 10 objects in our daily lives are transported by sea, and 99% of digital information circulates via undersea cables. The marine fisheries sector has a major socio-economic impact. The Ocean has also immense potential in terms of renewable energy and molecular resources used in human health and cosmetics.

However, the many services provided by the Ocean to human societies are severely altered by the combined effects of climate change and anthropogenic pressures such as plastic pollution or overexploitation of the environment. In their latest report "Impacts, Adaptation and Vulnerability" (2022), the IPCC¹ scientists sound the alarm: the degradation of the Ocean and its ecosystems significantly increases the vulnerability of human populations to climate and health risks.

The shared findings of IPCC and IPBES² researchers are unequivocal about the vulnerability of the Ocean and its transformations due to climate change and the various anthropogenic pressures. It underlines the urgent need to act and to integrate ocean-climate-biodiversity issues within a global and concerted ocean policy vision.

On June 8, 2021, on World Ocean Day, the United Nations General Assembly proclaimed the United Nations Decade, following a proposal for action from over 70 countries from all latitudes. This new ten-year era aims to halt the degradation of marine ecosystems and to restore them to achieve crucial goals, including the protection of 30% of the Ocean's surface by 2030.

In 2022, the international agenda is conducive to the development of a common strategy for the effective and sound management of the marine environment. The definition of the post-2020 framework for biodiversity under the Convention on Biological Diversity, the development of an international legally binding instrument on the conservation and sustainable use of marine biodiversity (the so-called "BBNJ" negotiations), the United Nations Conference on Sustainable Development Goal 14 on aquatic life, and the forthcoming COP27 of the United Nations Framework Convention

on Climate Change in Egypt, on the shores of the Red Sea, are all calls for action, underlining the need for integrated political leadership and vision for the Ocean.

The Ocean covers 71% of the 510 million km² of our planet's surface. The exploration, knowledge, and protection of this natural heritage of humanity are more than ever major challenges to be met, as they are essential for a sustainable future.

1* IPCC: Intergovernmental Panel on Climate Change
2* IPBES: Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services





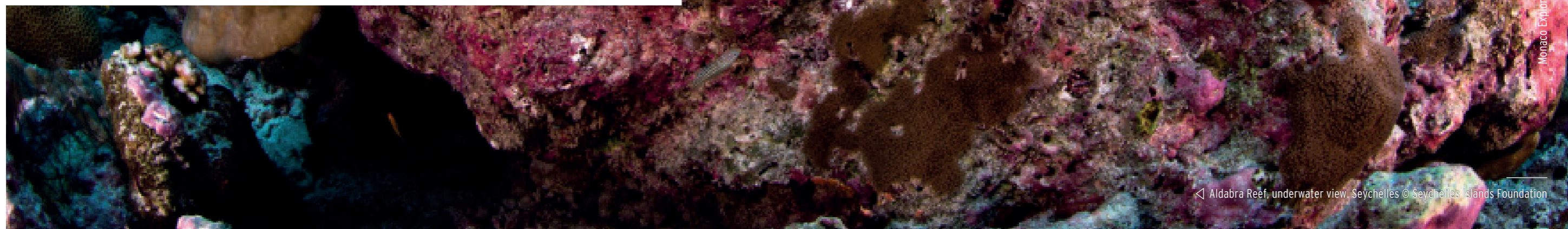
SOUTHWEST INDIAN OCEAN

THE IMPORTANCE OF REGIONAL KNOWLEDGE AND COOPERATION IN A COMPLEX GEOSTRATEGIC AND SOCIO-ECONOMIC CONTEXT

The Indian Ocean is a key geostrategic area for the balance of the world, with many crucial economic and political issues at stake, particularly for Europe, Asia, and Africa. It is home to more than half of the world's hydrocarbon and uranium reserves, more than three quarters of the world's diamond resources, and almost half of the world's gold and gas reserves. A very significant part of the world economy passes through this maritime space. The United States, India, China, the United Kingdom, France, the European Union, and Russia are major and influential players in this area.

Fisheries resources, particularly tuna fishing, are the subject of a high value-added international market, in which a very wide range of players are involved, from the sea to the plate.

In this context of strong pressure on natural resources, the challenges of sustainability and governance in this sector are more important. More than ever, a thorough knowledge of the natural environment is a prerequisite for balanced long-term management and the rational use of resources in a cooperative and collaborative approach between the States and regions concerned. The Southwest Indian Ocean is the setting for many initiatives in this direction.





▷ Aldabra Reef, underwater view. Seychelles © Seychelles Islands Foundation

WIOMSA AND IOC: TWO EXAMPLES OF REGIONAL COOPERATION

The IOC:

Created in 1982, the **Indian Ocean Commission (IOC)** is an intergovernmental organization that brings together five Member States: **Comoros, France on behalf of Reunion, Madagascar, Mauritius and Seychelles**. The only regional organization in Africa composed exclusively of islands, it defends the specificities of its Member States on the continental and international scenes. With the active support of a dozen international partners, the IOC gives substance to regional solidarity through cooperation projects covering a wide range of sectors: preservation of ecosystems, sustainable management of natural resources, maritime safety, entrepreneurship, public health, renewable energy and culture.

WIOMSA: Western Indian Ocean Marine Science Association

This association, created in 1993, is dedicated to promoting the educational, scientific, and technological development of marine sciences throughout the Western Indian Ocean region, a region made up of 10 countries: Somalia, Kenya, Tanzania, Mozambique, South Africa, Comoros, Madagascar, Seychelles, Mauritius, and Reunion (France). It aims to create and strengthen links between research knowledge and management and governance issues affecting the region's marine and coastal ecosystems.

The 12th WIOMSA Scientific Symposium will take place from 10 to 15 October 2022 in South Africa. The challenges and objectives of the Indian Ocean expedition will be presented at this event during a mini symposium dedicated to the role of marine science in the development of a regional strategy for ocean governance beyond national jurisdictions.



H.S.H. PRINCE ALBERT II OF MONACO

IN THE FIELD OF SCIENCE, ENGAGEMENT, AND DIPLOMACY

Inspirer and guide of this new expedition of Monaco Explorations in the Indian Ocean, H.S.H. Prince Albert II of Monaco continues the personal commitment of his great-great-grandfather Prince Albert Ist and his father Prince Rainier III for the environment of our planet. He listens to the scientific community and does not hesitate to observe the threats to the environment directly in the field, being the only Head of State to date to have visited both North and South Poles.

In the context of diplomatic relations, the expedition will be coordinated with an official visit to the region by H.S.H. Prince Albert II of Monaco, scheduled for 20-27 October 2022. Other official activities of the

Sovereign Prince related to the objectives of the expedition, in particular His interventions in various forums dealing with the protection of the Ocean, may illustrate the context related to the political dimension of the expedition.

The region's political decision-makers will be able to rely on His singular commitment to the knowledge and protection of the marine environment to relay the voice of these countries and the scientific community, but also to mobilize the international community to bring about and disseminate solutions to reduce environmental degradation.

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The sea is the last unexplored continent, and we have so much to do to better understand all its mysteries. The work of scientists from all over the world in this field is a priceless treasure in this respect.

It is my duty to do my part in challenging my generation to find solutions to preserve our planet, our most precious asset.

*L'Homme et l'Océan - H.S.H. Prince Albert II of Monaco
Flammarion et Versilio, 2022.*



SYLVIA EARLE, A GREAT LADY OF THE OCEAN AT THE SOVEREIGN'S SIDE

The American press calls her "Her Deepness". At more than 80 years old and after more than 7,000 hours under the world's seas, Sylvia Earle still travels the world as National Geographic's resident explorer. After more than 100 directed oceanographic expeditions, 250 publications and 150 awards for her leadership in science, exploration, conservation and communication, the energy of this great ocean scientist and feminist activist remains intact; an eye on the world and a voice that matters. A member of the Expedition's Advisory Committee, she will be present alongside the Sovereign during His visit to the region.



THE EXPEDITION: TO CONTRIBUTE TO NEW KNOWLEDGE

WHY STUDY THE SOUTHWEST INDIAN OCEAN?

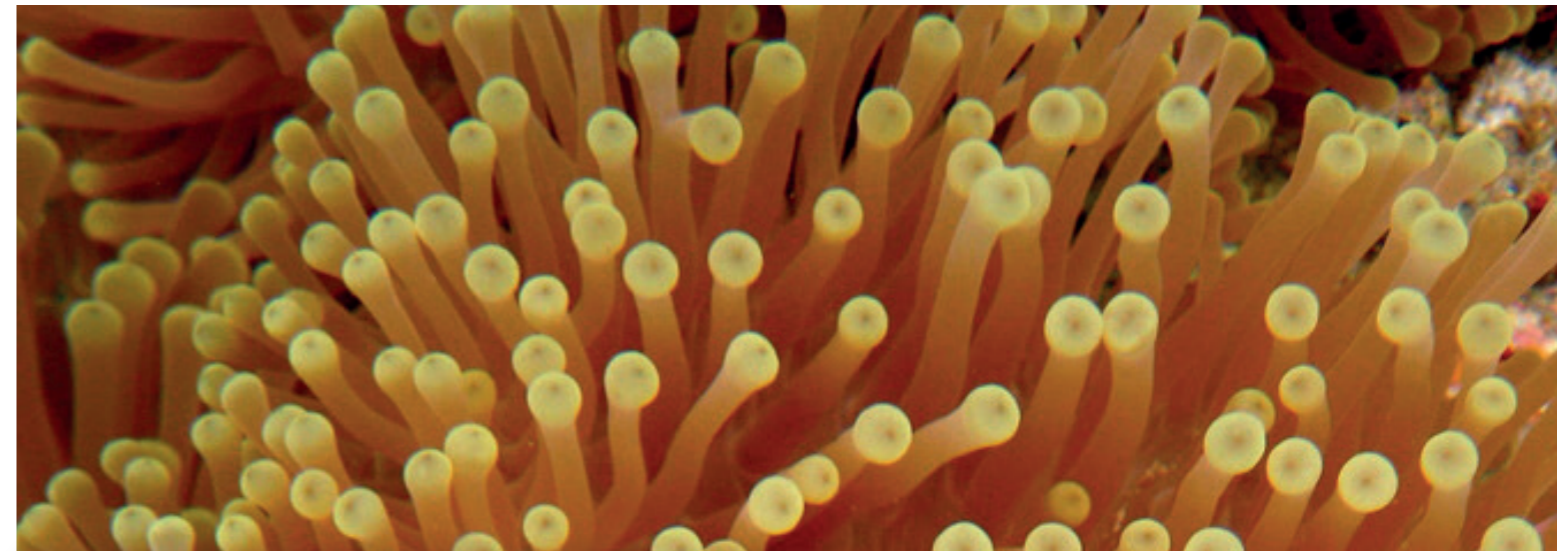
Parts of the Western Indian Ocean have already received attention. However, many regions located on the high seas beyond the States' EEZs (Exclusive Economic Zones), such as the Saya de Malha Bank and the Mascarene Plateau, remain to be explored in detail, as the state of knowledge on physical and biological oceanography, biodiversity, or the impact of pollution on natural balances remains partial and insufficient.

This is one of the reasons why the Monaco Explorations expedition raises high expectations, particularly on the part of the coastal States of Seychelles and Mauritius, with the prospect of acquiring new knowledge mainly on the Mascarene Plateau, including the Saya de Malha Bank, and secondarily on the other sites targeted by the expedition such as Aldabra Atoll and Saint Brandon, an island for which knowledge remains limited.

GAPS TO BE FILLED

The state of knowledge established by the expedition's Advisory Committee has revealed gaps that the expedition will help to fill. The expedition is multidisciplinary and will deal with a wide range of subjects:

- Contribution to the precise mapping of the seabed and the characterization of the various habitats,
- Study of the interactions between currents and marine organisms in the context of complex oceanographic processes, inventories and census of species biodiversity, level of endemism on the Saya de Malha Bank, functioning of food webs, study of the productivity of the area through plankton, etc.
- The carbon storage capacity of the Saya de Malha Bank, one of the world's largest seagrass beds, will also be assessed as seagrass beds like this one are among the most powerful carbon sinks in the biosphere and play a key role in climate change mitigation.
- Characterization of plastic pollution, its origin and the threats of waste accumulation.
- Assessment of the impacts of fishing, tourism and other human activities exerting pressure on the ecological and social values of the area are also on the agenda of the expedition.



2021 United Nations Decade
2030 of Ocean Science
for Sustainable Development

This "Indian Ocean" expedition is the first element of the "Monaco Explorations" project, approved within the framework of the United Nations Decade of Ocean Sciences for Sustainable Development 2021-2030 (known as the "Ocean Decade").

The major objectives of the expedition:
to understand, share and mobilize.

To understand, through a multidisciplinary scientific approach, the ecosystemic status and functioning of the area explored and to advise stakeholders through a holistic scientific approach (sustainability science);

To share the issues and knowledge with the greatest number of people through an ambitious outreach programme;

To mobilize governments, through diplomatic action, by making available information and analyses to support the sustainable management of maritime areas.



THE ITINERARY

Departure from Cape Town on October 3, 2022

S.A. Agulhas II will leave its home port of Cape Town in South Africa on October 3, 2022 with a first contingent of around twenty scientists and technicians. They will be joined a few days later in Mauritius and then in Reunion by other teams for a total of about one hundred people: scientists, young researchers and students from the onboard school, filmmakers and photographers, divers, artists, authors, communicators, etc.

On the programme

4 stopovers, a journey of approximately 7,300 nautical miles (13,500 km) and 2 months of navigation punctuated and driven by the various research and field operations programmed throughout the vessel's journey and during the stations planned around the Aldabra Atoll, on the Saya de Malha Bank, where 15 days of investigations are planned, and finally around the island of Saint Brandon.

On board *S.A. Agulhas II*

This South African oceanographic vessel of the Department of Forestry, Fisheries and Environment is chartered by Monaco Explorations for the Indian Ocean 2022 expedition. It is managed on behalf of the South African Government by African Marine Solutions (AMSOL).

S.A. Agulhas II is a 12,000 kW diesel-electric system. She is crewed by 44 people and can accommodate 100 passengers. Designed to support South Africa's Antarctic Programme, she is one of the largest and most modern research vessels in the world. She is equipped with numerous laboratories and facilities for oceanographic operations and marine, environmental, biological and climate research. She provides a powerful and efficient platform for multidisciplinary research.

Built in 2012 in Finland, *S.A. Agulhas II* is 134 meters long and 22 meters wide. She is powered by a 12,000

DID YOU KNOW THAT?

Cape Agulhas, or Cape Agulhas, is located 177 km southeast of Cape Town, South Africa. It is the southernmost point on the African continent. It is also the official landmark to mark the passage from the Atlantic to the Indian Ocean. The origin of the word Agulhas is Portuguese. The Cape was discovered in 1488 by explorer Bartolomeu Dias.

A VERSATILE VESSEL

Designed for ice navigation (she can break through ice one meter thick at five knots), *S.A. Agulhas II* is both a supply ship serving South Africa's Southern and Antarctic research stations and an oceanographic research vessel. She recently distinguished herself in March 2022 by finding the wreck of English explorer Sir Ernest Shackleton's ship *Endurance* in the Weddell Sea, which was crushed by ice in 1915.

S.A. Agulhas has previously visited the tropical waters of the Western Indian Ocean during a 2017 research and training campaign as part of the second International Indian Ocean Expedition along the East coast of Africa from Durban, South Africa to Dar es Salaam, Tanzania.



△ The vessel *S.A. Agulhas II* © AMSOL.

Ocean Indian Expedition in numbers:

- 13500 km covered
- 2 months of navigation
- 4 stopovers, 3 integration sites
- more than 100 scientists involved
- 1 onboard school
- 2 artists onboard



THE ADVISORY COMMITTEE: ENSURING A HOLISTIC APPROACH

An Advisory Committee, composed of fourteen international experts and personalities, has been set up to ensure the relevance and coherence of the expedition's objectives and its relevance in the regional and international context. Its role is to ensure a multidisciplinary and transdisciplinary approach, including natural and social sciences, in line with the principles of sustainability science.

The list of topics which the Committee considered worth for further in-depth investigations is vast: oceanography and hydrodynamics, coral reefs and seagrass beds, pelagic and deep-sea ecology, seamounts, fisheries, the blue economy, human and social sciences, international governance, etc.

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Based on their in-depth expertise of the region and global issues, the Committee members have developed a synthesis of the current state of knowledge and concerns: inventory of previous expeditions and work, governance issues, scientific issues, communication, and mediation issues. This detailed review will guide the scope and conduct of the expedition.

SUSTAINABILITY SCIENCE

Sustainability sciences aim to provide answers to current global challenges and to contribute to the major transitions in society in a context of global change. This approach is based in particular on the co-construction of knowledge and know-how, based on collaboration between scientists from different disciplines, decision-makers and civil society actors, in a collaborative and committed approach. This is one of the founding principles of the Indian Ocean expedition.

— Carl Gustaf Lundin (Chair)

Executive Director of Mission Blue, USA, formerly Head of IUCN's Marine and Polar Programme.

— Dominique Benzaken

Expert in blue policy, economics and finance, Australian National Centre for Ocean Resources and Security, University of Wollongong, Australia; consultant to the World Bank.

— Nick D'Adamo

Research Fellow, Oceans Institute, University of Western Australia, formerly Director of the Perth Programme Office in support of the Intergovernmental Oceanographic Commission.

— Sylvia Earle

Founder and President of Mission Blue; National Geographic Explorer in Residence; Founder of Deep Ocean Exploration and Research, USA.

— Tessa Hempson

Senior Scientist and Programme Manager, Oceans Without Borders.

— Nirmal Jivan Shah

Director General, Nature Seychelles.

— Heather Koldewey

Senior Technical Advisor, Zoological Society of London; Bertarelli Marine Science Programme Manager; Honorary Professor, University of Exeter, UK.

— Olivier Laroussinie

Director of Maritime Planning and Major Projects, Risks, Water and Sea Technical Directorate, Cerema, France.

— Margaret Leinen

Executive Director of the Scripps Institution of Oceanography, Vice Chancellor for Marine Science and Dean of the School of Marine Science, University of California, San Diego, USA.

— Nadine Marshall

Environmental social scientist, formerly with the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia.

— David Obura

Director, Coastal Ocean Research and Development - Indian Ocean (CORDIO), East Africa.

— Alex Rogers

Scientific Director, REV Ocean, Norway; Professor of Conservation Biology, Oxford University, UK.

— Anwar Rumjaun

Associate Professor, Mauritius Institute of Education.

— François Simard (Secretary)

Previously Deputy Director of IUCN Marine and Polar Programme.

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THE SCIENTIFIC PROGRAMME: A GLOBAL, MULTIDISCIPLINARY, AND INTERNATIONAL APPROACH

SEVEN RESEARCH PROJECTS, HALF OF THEM IN THE OPEN SEA

The scientific programme is structured around the study of two well-identified marine areas: the Saya de Malha Bank and a selection of islands and seamounts located along the expedition route. This programme is guided by the four main themes of Monaco Explorations: coral protection, megafauna protection, marine protected areas, and new exploration techniques. It focusses on meeting the needs of the Governments of Seychelles and Mauritius while also relating closely with relevant international and regional organs and initiatives.



RESEARCH PROJECT

MULTIDISCIPLINARY STUDY OF THE SAYA DE MALHA BANK. A BENTHIC BIODIVERSITY SURVEY

Saya de Malha project combines open water and bottom measurements. The water column, both on the bank (ranging in depth from 15 to 120 m) and up to 35 km beyond the slopes, will be sampled using vertical CTD* profiles with water sampling at various depths to determine physical, chemical, and biological parameters. These measurements will be carried out mainly at night. The most important part of the project will be a survey of the benthic biodiversity (fauna and flora attached to the bottom) by means of scientific rebreather dives, enabling work to be carried out at depths of over 60 m, and by means of towed gear.

This project is designed with the objective of "science for marine governance and planning assistance". Led by the French National Research Institute for Sustainable Development (IRD) in collaboration with the French National Museum of Natural History (MNHN), the onboard team includes representatives from Seychelles and Mauritius: researchers, students, representatives from the Department of Blue Economy, Marine Resources and Fisheries, universities, etc. Other international organizations are represented, such as the University of Lodz in Poland and Nelson Mandela University in South Africa.

1* CTD: instrument to measure the sea conductivity and temperature against depth.



RESEARCH PROJECT 1

Five types of resources and outputs are expected to be produced:

- The collection of scientific information on an area that is still poorly known;
- Carrying out an inventory of benthic biodiversity, assessing its particularities, in order to map essential and sensitive habitats that may require specific conservation measures;
- The elaboration of summary sheets on the habitats and communities of the Saya de Malha Bank;
- The production of a concise post-expedition policy paper for institutional actors and policy makers in Seychelles and Mauritius;
- Scientific promotion in international journals.

Four types of scientific operations and activities will be implemented:

- Mapping of the Saya de Malha Bank and characterization of the nature of the seabed;
- Study of the water column properties and circulation on the Saya de Malha Bank and slopes;
- Sampling of plankton, neuston and suspended microplastics;
- Inventory of benthic biodiversity.

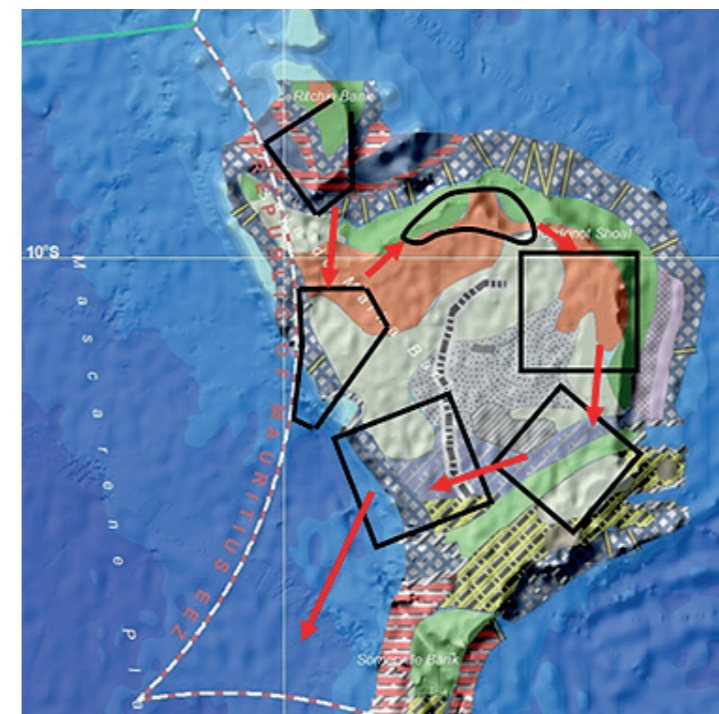
Means used to carry them out:

- Filtration of water samples;
- Hydrological stations, CTD;
- Manta (surface), Bongo (0 to 200m), Multinet (0 to 1000m) towed nets;
- Diving;
- Towed gear: sledges, dredges, beam trawls;
- Saab Seaeye Cougar-XT ROV.

MANTA NET: WHY THIS NAME AND WHAT IS IT FOR?



Manta nets are made of a special fabric, with very fine calibrated meshes, allowing the collection of, among other things, plankton, and plastic micro-particles on the surface, at the water-air interface, in the sea or in rivers. They are usually towed at low speed behind the ship. Stainless steel "wings" are placed on either side of the opening or mouth of the net to hold it open during the tow. When deployed and in fishing action, the net is shaped like a manta ray.



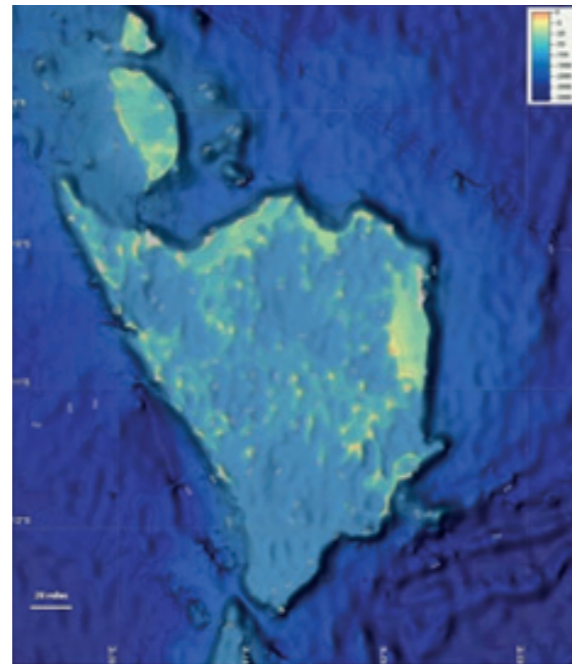
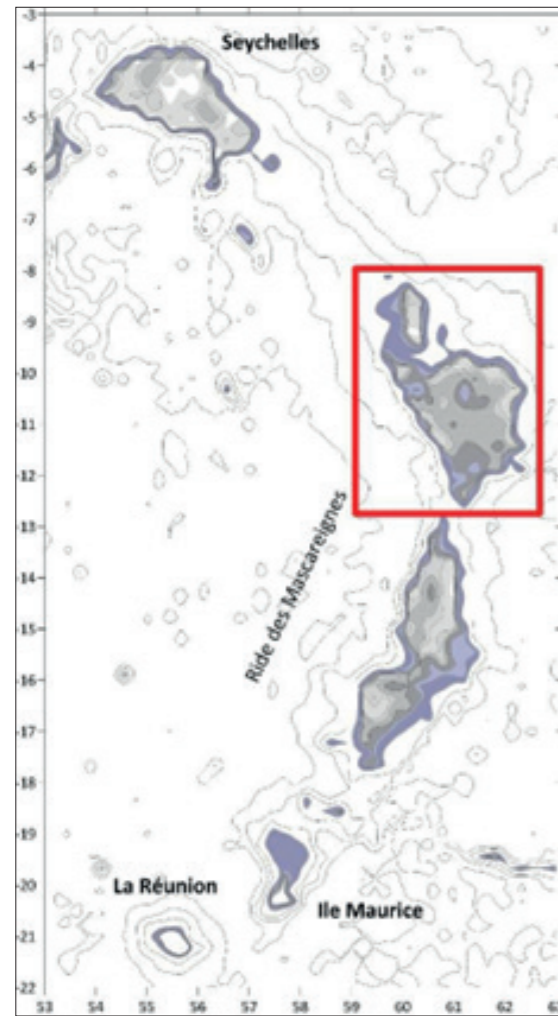
The areas to be studied during the expedition are highlighted in black below. The choice of these areas was made to complement studies already carried out elsewhere.

Source: IRD

THE SAYA DE MALHA BANK: A VAST HERBARIUM AS BIG AS SWITZERLAND

Discovered 500 years ago by Portuguese navigators, the Saya de Malha Bank was first surveyed by Captain Robert Moresby of the Royal Navy in 1838. Located at the northernmost point of the Mascarene Ridge between Seychelles and Mauritius, the Saya de Malha Bank is one of the largest seagrass beds in the world. Its area, 40,000 km², is equivalent to the size of Switzerland. This vast seagrass bed dotted with coral reefs is made up of two distinct geological structures: the small Ritchie Bank in the North, separated from the immense South Bank by a 30-to-50-km-wide channel. Of volcanic origin, it was formed about 65 million years ago. This ecosystem is known as a breeding ground for humpback and blue whales. It is home to a very

high diversity of species, but this biodiversity is still insufficiently documented. One of the challenges of the expedition is to better understand and study this natural environment in order to better manage and protect it. Several scientific expeditions have been carried out in that area since the early 1960s, the last one in 2021 by Greenpeace on board *Artic Sunrise*, the previous ones in 2018 and 2002. The expedition should provide an overview of the rich flora and fauna associated with the seabed. As an area of potential outstanding universal value, it could merit protection as a UNESCO World Marine Heritage Site in the context of a future treaty on the protection of marine biodiversity beyond national jurisdictions.



Bathymetry of the Mascarene Ridge, from Reunion to Seychelles (left) and the Saya de Malha Bank (right), located in the red frame of the general map. Source: ETOPO1 Global relief Model and GEBCO

STRONG GOVERNANCE ISSUES

Seychelles and Mauritius obtained in 2011 the status of extended continental shelf as defined by the United Nations Convention on the Law of the Sea for the Saya de Malha Bank. Within the joint governance framework established by agreements signed in 2012, the two States benefit from exploitation rights for the following resources: sedentary living resources (attached to the seabed), mineral resources of the soil and subsoil (metals, oil, gas). This joint management by two States is a unique case at present at international level, which makes it a specific study model retained by the United Nations Development Programme (UNDP) SAPPHERE project (2017-2023). This project supports the

implementation of a strategic action programme for the sustainable management of marine ecosystems in the Western Indian Ocean region. Objectives: to build management capacity through marine spatial planning, to demonstrate the benefits of an innovative mechanism for ocean governance and best practice, to improve existing arrangements and to guide similar initiatives that could be launched in other regions of the world. In addition to rights, the status of the zone also confers duties on both States. The development of economic activities and the exploitation of this environment are closely linked to the development of the blue economy of the two countries and should cause a minimal impact on the ecosystem.

IRD: A COMMITTED SCIENCE

The French National Research Institute for Sustainable Development (IRD) is a French public research institution that promotes an original model of equitable scientific partnership with developing countries and interdisciplinary, citizen-oriented science, committed to achieving sustainable development goals. The IRD relies on its network of regional delegations in metropolitan France and representations in overseas countries and abroad to organize its collaborations.



A word from the project leader: Francis Marsac

It is important to be able to identify possible biodiversity hot spots in this area, to inform on the potential risks of degradation due to poorly controlled exploitation of the various resources. This information will provide elements of choice for the marine spatial planning that Seychelles and Mauritius are undertaking in this area.

△ Francis Marsac © IRD - Edwige Lamy



RESEARCH PROJECT

MICROPLASTIC AND CORAL PATHOGENS - MADCAPS

The objective of this study is to characterize plastic debris transported by ocean surface currents, which are potential inert vectors of coral pathogenic microorganisms, via integrative approaches using state-of-the-art technologies. This project will subsequently offer multiple perspectives in the fields of biology, medicine, and ecology due to the metadata that will be collected. The interactions between Ocean and health are complex and remain largely unexplored. As the problem of plastic pollution is growing and little studied in the Indian Ocean, WIOMSA is funding seven

countries in the South-Western Indian Ocean (Tanzania, Seychelles, Mauritius, Mozambique, South Africa, Kenya, and Madagascar) in order to carry out and implement a coastal marine litter monitoring programme within the framework of the Nairobi Convention: WIOMSA Marine Litter Monitoring project.

The MADCAPS programme brings together several scientific organizations and associations: UMR Entropie at the University of Reunion, IRD Marseille, The Ocean Clean Up and Best Run.

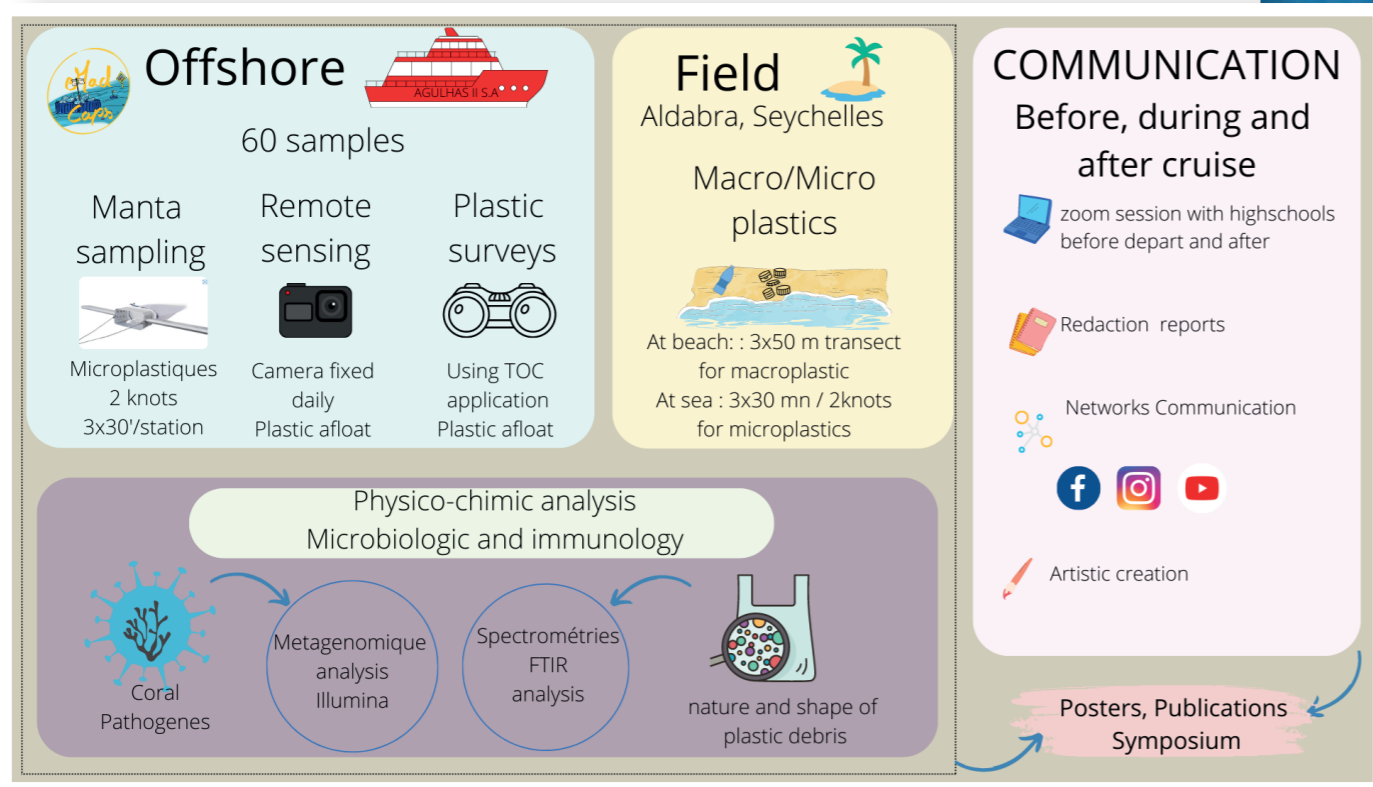
Are plastic debris carried by ocean currents an inert vector of coral pathogenic micro-organisms?

To answer this question, the study has three major objectives:

- To acquire qualitative and quantitative data on the spatial distribution of microplastics in the surface layer of the water column in the Southwest Indian Ocean.
- Characterize the complete microbial flora via metabarcoding, i.e. by the metagenomic technique of high-throughput DNA sequencing with Illumina technology.
- Communicate, educate, raise awareness, and consult on the project with local, regional, and international stakeholders to improve understanding of the waste issue and support actions already in place.

Means used to achieve them:

- DNA extraction kit;
- Cold storage -20°C;
- Spectrophotometer, laboratory equipment, centrifuge;
- Manta net, 330-micron mesh.



Summary diagram of the different stages of the project, from sample collection to data processing, for each plankton net launch. Source MADCAPS

DID YOU KNOW THAT?

Anthropogenic environmental changes are causing changes in precipitation patterns leading to increased drought and severe flooding events. These floods drain terrestrial microorganisms into the seas, which attach themselves to floating marine debris. These marine debris, through degradation by sun, salt and wind, are gradually reduced in size until they can enter the food chain, thereby significantly affecting the marine animals and potentially humans that consume them.

THE BEST RUN ASSOCIATION

This association was founded in 2017 by the students of the master's degree Biodiversity of Tropical Ecosystems (BEST) of the University of Reunion, supported by their professors from the ENTROPIE Joint Research Unit, including Professor Mathieu Le Corre. The objectives of this association are to preserve, raise awareness and educate people about the natural heritage of La Reunion and the Indian Ocean. BEST RUN regularly organizes waste collection operations on the coasts of Reunion Island, open to the public. During these participatory science operations, each piece of waste is sorted and categorized according to a precise scientific protocol which is then fed into a database called DALI.

A word from the project leader: Margot Thibault

Plastic pollution is a big problem, as are other forms of pollution. Combined with the effects of global warming, the impact on corals is dramatic. Today the world's coral reefs are on borrowed time. It is up to us to act. The future depends on whether we can preserve nature.

This young researcher is a doctoral student with The Ocean Cleanup Foundation, the University of Reunion and the University of Toulouse. Her thesis topic: "Characterizing and assessing the sources of plastic debris accumulating in the subtropical gyre of the Indian Ocean". The MADCAPS team is based at the UMR ENTROPIE, University of Reunion. It provides expertise in marine pollution and microbiology in the Indian Ocean.

△ Margot Thibault © Adrien Fajeau. MADCAPS/Association BESTRUN



RESEARCH PROJECT

STUDY OF THE GENETIC STRUCTURE AND LEVELS OF CONTAMINATION AND STRESS IN MARINE TURTLES - GECOS

The entire Ocean is now affected by human activities, in addition to the strong pressures of climate change. Biodiversity and habitats of coastal ecosystems are the first to be impacted and have decreased by 30 to 60%. The increase in the human population and the growing anthropic and climatic pressures on marine ecosystems raises the question of the sustainability of the exploitation and conservation of these marine ecosystems. This conservation depends above all on our ability to measure these changes on a daily basis, to make this information collection sustainable over the long term and to develop relevant and reliable indicators of these pressures on the ecosystems.

Marine megafauna is particularly sensitive to these pressures and there are unfortunately many examples of entire populations disappearing. The case of marine turtles is particularly interesting because, as emblematic species of marine diversity, they have contributed to the development of a species-based approach to the conservation of a habitat, community, or ecosystem.


This project is led by the French Research Institute for Exploitation of the Sea (Ifremer) in partnership with Kelonia and the University of Aalborg, Denmark. It follows on from the NEXT project led by Ifremer.

Objectives and expected results: Means used to carry them out:

- to acquire data, currently missing from certain sites in the Southwest Indian Ocean, on the genetic structuring of green and hawksbill turtle populations (use of historical mitochondrial genetic markers);
 - to exploit the new samples collected to refine the current population structure of the region by sequencing the entire mitochondrial genome (maternal lineage) and nuclear markers of green turtles;
 - to study the influence of highly contrasting environments on the exposure of green turtles to inorganic contaminants and their consequences on the stress levels of individuals by comparing the data acquired as part of the NEXT project carried out in Reunion (supported by IFREMER) and that of the GECOS project. The idea of this component is to develop biomarkers of the state of health of these species that reflect the quality of their environment.
- Motorised dinghy;
 - Argos GPS beacons;
 - Biopsies, scale samples, blood samples for analysis;
 - Eppendorf tube centrifuge;
 - Liquid nitrogen;
 - Freezer -80° C.

KELONIA, THE MARINE TURTLE OBSERVATORY OF REUNION ISLAND

Kelonia is a centre for interpretation, education and awareness of the marine environment, open to the public and to schoolchildren, with 1500 m³ of seawater-fed tanks. Kelonia participates in research and protection programmes for marine turtles and their habitats in Reunion and the Indian Ocean. The centre takes in injured or sick turtles and releases them back into the sea once they have recovered. Stéphane Ciccone, its director, an oceanologist, and marine turtle specialist, will be one of the scientists from the GECOS programme on board *S.A. Agulhas II*.




A word from one of the project leaders: Jérôme Bourjea

Sea turtles have been in the oceans for 110 million years and have survived many climate changes and disasters. We need to learn from them and ensure that our children can experience the thrill of watching a female turtle lay its eggs or seeing hatchlings on a beach. Experts agree that there is a serious lack of data on the abundance and threats to juvenile turtles. Yet these stages represent the future generations that will ensure the recovery of today's threatened populations.

Jérôme Bourjea

Dr Jérôme Bourjea is an expert in marine megafauna, specializing in fisheries and conservation biology. In large-scale approaches, he is particularly interested in the structure and spatial dynamics of populations of migratory marine species, whether in the Indian Ocean or the Mediterranean. By using multidisciplinary approaches such as population genetics to understand the major conservation structures, or biologging (electronic tagging) to understand fine- and large-scale migration processes and habitat use, it develops applied research. This research aims to contribute to better management and conservation of exploited or threatened species. For almost 20 years, he has specialized in marine turtle models, particularly in the Western Indian Ocean, a region for which he chairs the Marine Turtle Specialist Group of the International Union for Conservation of Nature.

△ Jérôme Bourjea © IFREMER

Quentin Schull

Dr Quentin Schull is an expert in ecophysiology, specializing in the impacts of global change on marine species. He is interested in how animals acclimatize and/or adapt to anthropogenic stresses such as pollution and fishing in the context of climate change. In the Indian Ocean and the Mediterranean Sea, he is studying the links between habitat use and exposure to contaminants to assess how these factors influence the health of marine turtles and fish. Combining experimental approaches and long-term monitoring, he investigates how species such as gorgonians and fish might find refuge in mesophotic areas and/or might physiologically acclimatize to changing environments. Using multidisciplinary approaches, from the genome to the organism, and working on a scale ranging from the individual, the population, and the ecosystem in an integrative statistical framework, he aims to dissociate the effects of natural constraints from anthropogenic constraints (fishing, contaminants) which must be fully integrated in a perspective of sustainable management of natural resources.



RESEARCH PROJECT

STUDY OF THE COMBINED IMPACT OF COASTAL HUMAN ACTIVITIES AND CLIMATE CHANGE ON MARINE ECOSYSTEMS - 4SEA

The global Ocean is being affected by human activities and the strong pressures of climate change. Biodiversity and habitats of coastal ecosystems have declined by 30-60%. Demographic growth is taking place near the coasts with 8 out of 10 people living within 100 km of the coast.

The 4Sea project aims to disentangle the combined impacts of coastal human activities and climate change on marine ecosystems in the Western Indian Ocean. By deploying autonomous observing systems in pristine and anthropogenically impacted ecosystems, in confined areas (lagoons) and in the open ocean, this research programme aims to answer key scientific questions.

The images and data collected will be used for mapping, bathymetry, and photogrammetry to obtain 3D habitat maps. These data will serve as reference points and comparisons for stations already sampled in the past.

This project will be linked to Ifremer's participatory science project "Seatizen" involving members of UMR MARBEC. The project is also supported by the GECOS project, with a view to pooling resources. A link has also been established with the research programme on the Saya de Malha Bank.



Objectives and expected results:

- Whether the rate of change in the physical and biological environment is equivalent in ecosystems under human stress and in pristine ecosystems.
- Know the resilience of the ecosystem in "confined" areas and compare them to the open sea.

Means used to carry them out:

- Stand-alone board with measuring instruments;
- Sounder, differential GPS, temperature sensor, camera, remote control system for autonomous vehicles);
- Zodiac, drone;
- Kite and paddle to sample hard-to-reach areas;
- Snorkelling.

INNOVATIVE AND NON-IMPACTING TECHNOLOGIES

This project will use low-cost, low-impact technologies to facilitate the collection and processing of underwater and aerial images in the various marine ecosystems visited by the campaign. The autonomous board, kite or paddle will allow sampling of areas that are difficult to access given the sometimes very shallow depths of the lagoons.

OPEN ACCESS DATA

The objective of the project is to collect a very large set of data on the marine environment by developing innovative equipment adapted to the conditions of lagoon areas. Four main objectives have been identified to meet the challenges of Open Science:

- **Open Hardware:** developing low-cost collection systems so that these tools are available to as many people as possible.
- **Open Data:** providing a large dataset to the scientific community and the public.
- **Open Source:** developing processes to provide free services from the data.
- Raise awareness among the public by allowing them to visualize the information collected via augmented reality tools.



A word from one of the two project leaders: **Sylvain Bonhommeau**

The philosophy of the 4Sea project is to provide open data through an information system, widely accessible to the global community, and an open software and hardware approach to facilitate the development and use of this observing system by anyone.

Sylvain Bonhommeau & Julien Barde

The project is led by Sylvain Bonhommeau, a researcher in marine ecology at the Ifremer delegation in Reunion, and Julien Barde, a research engineer in scientific computing at IRD (UMR Marbec in Sète).

△ Sylvain Bonhommeau © IFREMER



RESEARCH PROJECT

THE **BGC-ARGO** MONITORING PROGRAMME OR HOW TO TAKE THE PULSE OF THE OCEAN? EXTENSION OF THE PROGRAMME TO THE AREA EXPLORED BY THE EXPEDITION

The international BGC-Argo programme aims to instrument the Ocean with a fleet of 1 000 profiling floats. They measure physical, chemical, and biological variables essential to understanding the evolution of the ocean's health and its response to climate change.

These variables, measured every 10 days between the surface and 2 000 m depth, are: temperature, salinity, pH, oxygen, nitrate and chlorophyll a concentration, suspended particles, as well as illumination.



Objectives and expected results:

- To contribute to the extension of the BGC-Argo programme in this area of the Indian Ocean by deploying a significant number of floats.
- To contribute to the REFINE* programme by adding a sixth oceanic reference area where a new generation of BGC-Argo "Jumbo" floats, more focused on living resources and the "twilight zone", will be deployed for the first time.
- To acquire, through a multi-instrumented CTD-rosette, reference measurements that will allow the calibration of robot sensors, just before their deployment
- To acquire, by means of a profiling spectro-radiometric sensor and a dedicated profiling float, the sea truths allowing to validate and calibrate the satellite measurements (ESA, NASA) "ocean colour" in a very poorly documented area.
- To acquire, throughout the campaign, at high spatial resolution (~300m) and by means of a so-called "continuous surface" system, hydrological, bio-optical and phytoplankton composition data enabling a better characterization of island effects in the region and their impact on the first trophic levels of pelagic ecosystems, while linking these observations to the large-scale vision accessible by satellite data.

Field operations and activities implemented:

- Water samples from the entire water column between 0 and 2,000 meters in depth
- Deployment of some 30 profiling floats along the expedition route
- Using the optical profiler spectroradiometer
- Analysis of biological samples and measurements of physico-chemical parameters in the laboratory
- Sharing and analysis of satellite data.

Means, instruments, and tools used:

- CTD-rosette 24 bottles;
- Profiling floats BGC Argo, O2 Argo, new generation BGC Argo Jumbo, Proval;
- Optical profiler spectroradiometer.

* REFINE : Robots Explore plankton-driven Fluxes in the marine twilight zone

THE "TWILIGHT ZONE", A KEY AREA OF THE MARINE ECOSYSTEM

The twilight zone is the water column between 100 and 1,000 meters depth, between the well-lit surface zone and the zone of total darkness where sunlight no longer penetrates. It is actively involved in the capture, transport, and storage of atmospheric CO2. However, the factors that influence its performance are not well known. Profiling floats and other tools used to study it are contributing to a better understanding of the mechanisms involved.



A PROFILING FLOAT: HOW DOES IT WORK?

There are currently more than 3,000 profiling floats drifting in the Ocean, taking measurements from the surface to a depth of 2 km. They operate for about 3 years. Released by a ship, they descend slowly (10cm/sec) to the programmed depth, called the "parking" depth, where they drift for 10 days. During the ascent, the float switches on its sensors and measures, for example, temperature, salinity, chlorophyll a or oxygen concentration. Once at the surface, it transmits the

measured data to the laboratory and/or the vessel via the satellite. The float, equipped with a sim card, can 'phone' the satellite. The scientist can then immediately view and analyse the vertical profile of these measurements on his computer. He can decide to change the float's programming, such as the depth to be reached, and activate other sensors. The float then sinks and 'parks' at the desired depth where it drifts with the currents for another 10-day cycle.

The different types of observation and measurement equipment used to collect data and send them to satellites: underwater glider, profiling float, ship, rosette, surface drone, drifting buoys, oceanographer animals, etc.

△ "My Ocean and Me" © LOV-IMEV Villefranche-sur-Mer

THE WESTERN INDIAN OCEAN: AN AREA THAT HAS BEEN UNDER-EQUIPPED UNTIL NOW

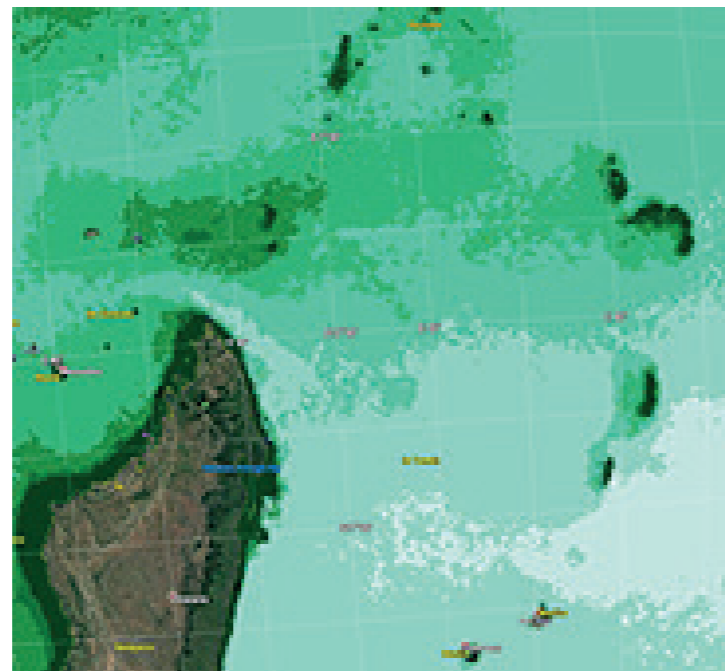
The deployment of a significant number of floats during the Indian Ocean expedition will contribute to a better coverage of this area, which has been under-equipped until now, in the framework of the general BGC Argo project.



Map of BGC-Argo floats deployed to date.

Grey: inactive floats; green: active floats. The region to be explored is characterized by obvious under sampling.

Chlorophyll a concentration measured by the MODIS water colour satellite in May 2018 and illustrating the island effect in the region. The gradient from light to dark green indicates the productivity gradient.



THE ISLAND EFFECT

The numerous islands and shoals that characterize the surveyed area generate many so-called "island effect" situations. These phenomena are characterized by very significant increases in phytoplankton concentration (chlorophyll a seen by satellites) in the vicinity of coral islands in tropical and sub-tropical environments. These oases of productivity provide the basic energy resources for the higher trophic levels that support fisheries-based human populations.



A word from the BGC Argo project leader: **Hervé Claustre**

Involving and training young researchers and students from the region in this process is a priority. We also need to make the fishing fleets aware of the presence of profiling floats in the area and their role. They can be valuable allies for us by recovering the profilers before the end of the battery life. This would allow us to enter a virtuous cycle of recovery, reconditioning and re-commissioning of this expensive equipment with a reduced environmental impact.

Hervé Claustre is an oceanographer, observer, and research director at the CNRS. He is based at the Oceanography Laboratory in Villefranche-sur-Mer. In particular, he is the co-leader of the international BGC-Argo programme, which aims to deploy a flotilla of multi-instrumented profiling floats in the global Ocean.

△ Hervé Claustre © IMEV/LOV



RESEARCH PROJECT

WORLD CORAL CONSERVATORY A DELICATE OPERATION TO SAMPLE LIVE CORAL COLONIES IN ALDABRA

The Oceanographic Institute and the Scientific Centre of Monaco, both initiators of the World Coral Conservatory project, have planned an operation to collect living coral colonies in Aldabra during the expedition. These colonies will enrich and complete the list of species

already conserved in aquariums around the world. For this first collection cycle, coral species with certain characteristics will be targeted: endangered corals, resistant corals, species that are easy to cultivate and propagate, endemic species.

To this end, 4 types of operations will be necessary during the expedition:

- **An operation to collect colonies at sea:** for each species, 4 colonies will be collected and then sent to 5 different structures, to maximize the chances of survival of each of these 4 species within the Conservatory. These colonies will have been located and selected by diving beforehand.
- **A marking and conditioning operation for the living colonies:** the harvested corals will be labelled, identified, and immediately preserved in storage tanks with a seawater supply, aeration, and lighting, natural or artificial depending on the configuration.
- **A research sampling operation:** from each colony obtained, research samples will be taken for different types of analysis, including DNA sequencing.
- **A transport operation:** the colonies are transported via the international airport closest to the facility, or to a relay facility as close as possible to the destination.

Coral reef preservation: What strategy in the context of global warming?

Due to climate change, coral reefs are suffering. They are in serious decline and bleaching events have increased in recent years, such as recently on the Great Barrier Reef in Australia. The latest IPCC reports (October 2018 and September 2019) highlight that by 2100, coral reefs will decline by 70-90% with a global surface warming assumption of 1.5°C, while almost all (>99%) will be lost with a 2°C rise. Under the combined effect of ocean warming and pollution, coral reefs are now reaching a breaking point.

Increasing the percentage of Marine Protected Areas (MPAs) is an important step and will have many positive effects on marine biodiversity, but climate change is global. Temperature increase and acidification will not stop at the boundaries defined by MPAs. It seems therefore necessary to develop a new strategy and to consider new solutions to save the reefs.

The Scientific Centre of Monaco and the Oceanographic Institute - Prince Albert 1st of Monaco Foundation have therefore initiated the World Coral Conservatory project. Their strategy and that of the partners associated with

the project: to preserve corals in aquariums and therefore in a controlled environment with the aim of conserving natural strains in good conditions and then re-implanting them in areas damaged or destroyed by the effects of global warming.

Today, approximately 250 species of corals are already maintained and cultivated in aquariums around the world. The new live coral colonies collected from the natural environment will be maintained in aquariums around the world that are known for their expertise in coral maintenance. Using public and private aquaria, and building on existing professional networks (EUAC, EAZA, WAZA, IAN), the Conservatory will establish and maintain a large collection of scleractinian coral species and strains (eventually at least two thirds of known species) in the form of live coral colonies.

The Global Coral Reef Repository will also be used to provide corals to research laboratories to develop research programmes to increase coral resilience and select more resistant strains, with the aim of promoting and facilitating the future restoration of coral reefs.



The words of the Global Conservatory project leaders:
Didier Zoccola, Monaco Scientific Centre

Beyond the environmental and scientific interest, the Indian Ocean expedition will allow a global understanding of coral reef protection thanks to the involvement of the most prestigious aquariums.



Olivier Brunel, the Oceanographic Institute - Prince Albert 1st of Monaco Foundation

The vocation of aquariums is also to be, in addition to their mission to raise awareness and educate the general public and the younger generations, major partners in conservation and research projects carried out by scientists in the field, by putting their technical and biological know-how at the service of species preservation.

Didier Zoccola

Since 2000, Dr Didier Zoccola has been a senior researcher at Monaco Scientific Centre (CSM) and is interested in bio-mineralization, ocean acidification and symbioses. He participated in the Tara Ocean (2010), and Tara Pacific (2017-2018) expeditions, where he was also coordinator.

△ Didier Zoccola on expedition in Palau, 2019 © Magali Boussion Monaco Explorations

Olivier Brunel

Olivier Brunel has been in charge of the Aquarium of the Oceanographic Museum of Monaco since 2016, which he manages on a daily basis with a team of 12 careers. Since 2019, he has also been in charge of the Care Centre through which programmes related to Monegasque wildlife are developed in partnership with the government.

△ Olivier Brunel © Frédéric Pacorel. Oceanographic Institute



RESEARCH PROJECT

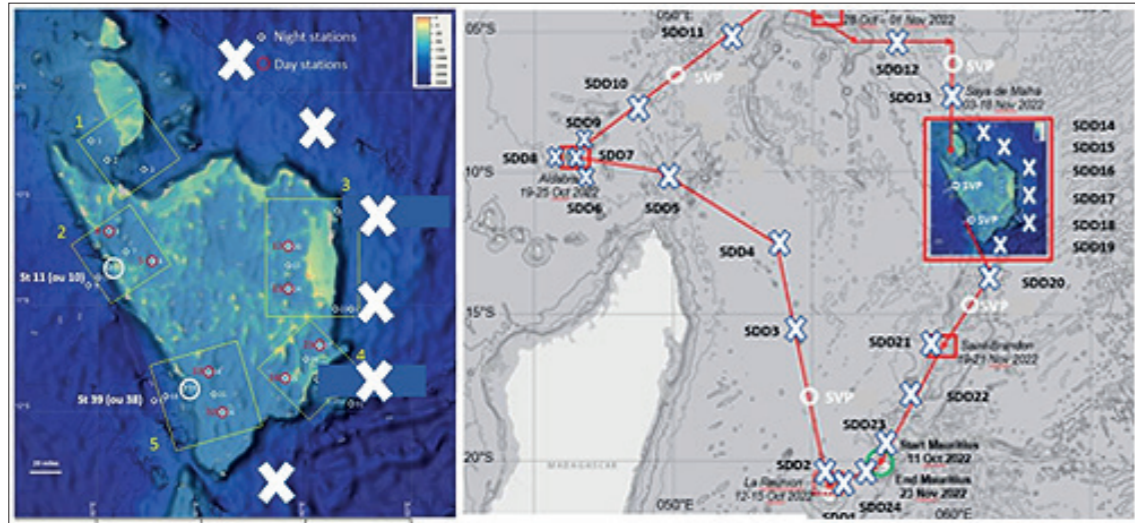
DEPLOYMENT OF SURFACE DRIFTERS

The University of Western Australia Oceans Institute (UWA-OI), the French National Research Institute for Sustainable Development (IRD) and Météo-France have decided to join forces to carry out a joint project during Monaco Explorations Indian Ocean expedition. The project is led by Nick D'Adamo (UWA-OI), in collaboration with Jean-François Ternon, researcher at IRD and Olivier Desprez de Gesincourt, from Météo-France. They plan to deploy a total of 30 surface drifters along the expedition route; 24 for the Institute of Oceans and 6 for Météo-France. Those developed by the Institute of the Oceans are small and light (~ 0.6 m

in length, ~ 1.5 kg in weight), tracked by GPS (satellite) and housed in a PVC envelope.

The proposed deployment programme will provide a better understanding of the circulation of surface currents, the distribution and mixing of water masses in the area explored by the expedition and, by extension, the substances contained in these water masses.

These data will be useful transversally to several of the research projects conducted during the Indian Ocean expedition.



Initial deployment plan for the 30 surface drifters
 The X's represent the 24 buoys developed by the UWA-IoT Oceans Institute
 The O's represent the 6 surface drifters provided by Météo-France



One of the lightweight drifters developed by the University of Western Australia's Oceans Institute.

© Nick D'Adamo/Institut des océans

WHAT IS A SURFACE DRIFTING WEATHER BUOY?

Today, most operational drifting weather buoys consist of spheres 35-40 cm in diameter, with a floating anchor 6-7 meters long and one meter in diameter, centred at 15 meters depth. These buoys, known as SVP (Surface Velocity Programme), weigh about 25 kg and have been participating in the Global Drifter Programme (GDP) of the Data Buoy Cooperation Panel (DBCP) for nearly 20 years. Some buoys are equipped with digital temperature probes, and sometimes even sensors for salinity and temperature.

Thanks to their displacement, SVP floats can measure the surface current. This data is used to validate ocean circulation analysis and forecasting models based on satellite observations (altimetry).

DID YOU KNOW THAT?

The creator of the first drifting buoys was none other than Leonardo da Vinci (1452-1519). To determine the speed of the current in a river, he constructed a simple device consisting of a weighted rod and a float. He measured its displacement downstream after a given period of time and thus obtained enough data to calculate the flow of the river.



A word from one of the project leaders: **Nick D'Adamo**

The circulation of different water masses and multiple surface micro-currents in this part of the world is very complex, partly due to the presence of numerous islands and seamounts. The release of these buoys will help us to make progress.

Dr Nick D'Adamo of the University of Western Australia (UWA-OI) has nearly 30 years of experience in marine engineering, biophysical oceanographic research or environmental impact assessment and biodiversity conservation. He was previously Head of the Perth Programme Office in support of the UNESCO

Intergovernmental Oceanographic Commission and is a member of the Indian Ocean Expedition Advisory Committee.

△ Nick D'Adamo © Michel Dagnino, Oceanographic Institute



— MAKING THE EXPEDITION AND ITS CHALLENGES KNOWN TO AS MANY PEOPLE AS POSSIBLE THROUGH MEDIATION

UNITE AUDIENCES, CREATE INTERACTIVITY AND DIALOGUE, GENERATE COMMITMENT

The Indian Ocean Expedition is not only based on a dense and multidisciplinary scientific programme, but its objective is also to enhance the contents, knowledge and resources resulting from this operation, by encouraging the exchange and transmission of knowledge with the greatest number of people, through a varied outreach programme which, in its various components, will address a wide public, the actors of the civil society and decision-makers.

A CONNECTED EXPEDITION: A REAL INTERACTIVE LOGBOOK!

As soon as the expedition leaves Cape Town in South Africa, it will be possible to follow its progress. The outreach operations planned for the general public and specialized audiences such as schoolchildren will be based in particular on a dedicated page on the Monaco Explorations website and on the interactivity that this tool will provide during and after the expedition: live broadcasts and conferences, dialogues and interactions with the scientists and other players in the expedition, daily news and logbook, interviews, the view of artists and creators, monitoring the vessel's journey and the weather, visits to *S.A. Agulhas II*, provision of resources, etc.

See you on October 3, 2022 for the departure of the vessel on: www.monacoexplorations.org !

ARTICULATION WITH THE DIDEM PROGRAMME

TOWARDS A DIALOGUE BETWEEN SCIENCE, DECISION-MAKERS, AND CIVIL SOCIETY

In line with the research themes of the Indian Ocean Expedition, in particular coral reefs and plastic pollution, Monaco Explorations is supporting the DiDEM scientific dissemination programme "Science - Decision-makers dialogue for an integrated management of coastal and marine environments" for the period 2020-2023, which is being developed in the Western Indian Ocean basin (Comoros, Kenya, Madagascar, Mauritius, Mozambique, Seychelles, and Tanzania). Supported by the French National Research Institute for Sustainable Development (IRD), this programme aims to facilitate and enhance dialogue between scientists and decision-

makers in the Western Indian Ocean sub-region, to develop solutions for the sustainable management of natural environments in developing countries.

The aim of this approach is to make it easier to consider and integrate scientific results, recommendations and approaches into decision-making, training, and education within the civil society. It ranges from training and communication with young people, through the private sector, multi-actor research-entrepreneurship-associations, to all civil society actors in general and decision-makers.

THE PAREO PROJECT: CHILDREN ACT FOR THE REEFS

An innovative environmental education project, the PAREO project ("the reef heritage of the Indian Ocean in our hands") combines the transmission of scientific knowledge, discovery of the environment from the perspective of new technologies and concrete conservation actions. It encourages young people to become actors in the protection and good management of their daily environment.

It takes place in four islands of the Indian Ocean, Reunion, Mauritius, Curieuse Island in Seychelles, and Moheli Island in Comoros. These islands have in common an exceptional reef heritage which is unfortunately being degraded by human pressure.

► The educational activities developed in the framework of the Marine Education Area with the Baie St-Anne school in Praslin, Seychelles © Lola Massé. PAREO/DiDEM/IRD



MARINE EDUCATION AREA IN SEYCHELLES: A FIRST

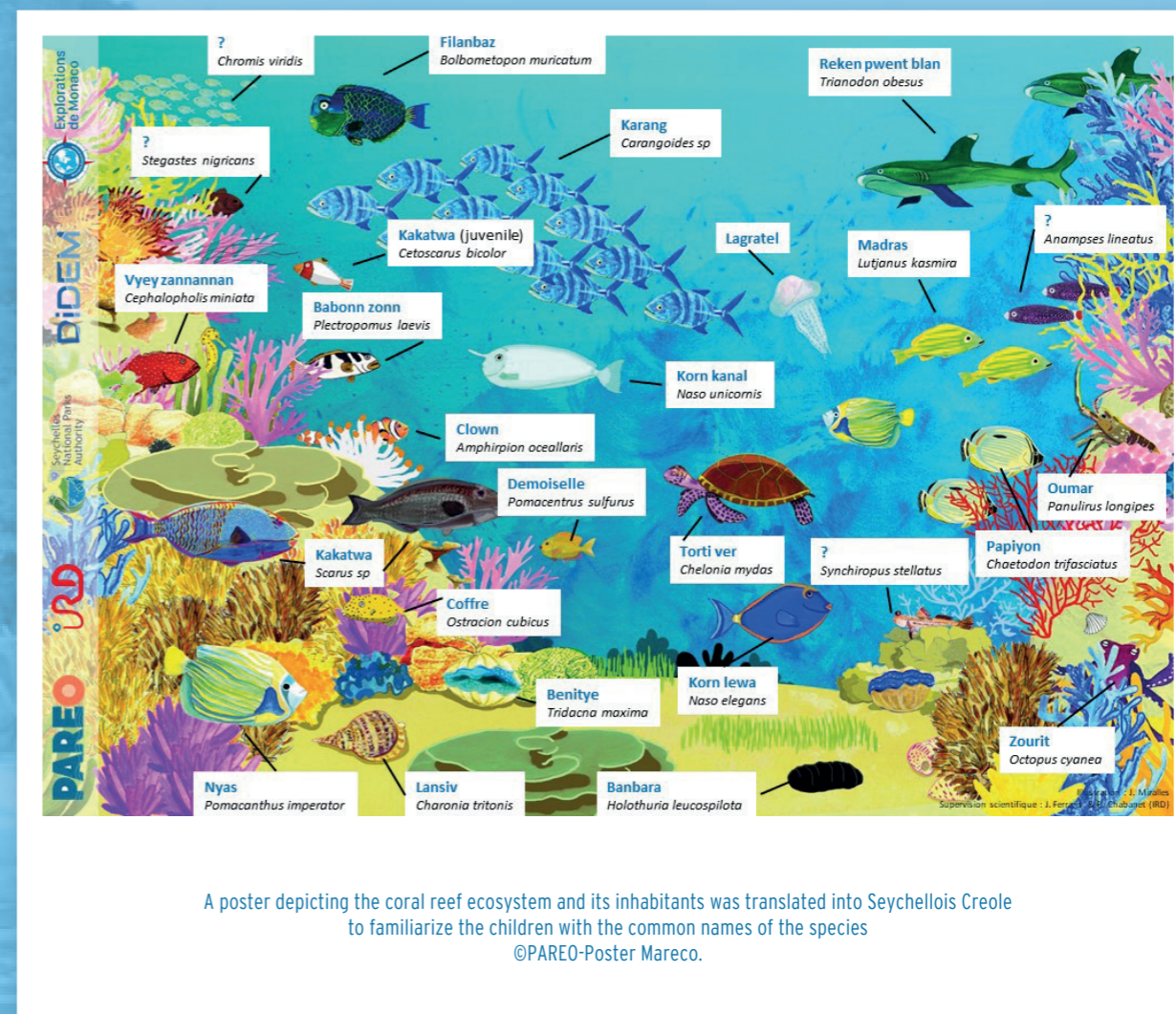
By working with the children of the islands over the course of a school year, the aim of this project initiated in 2021 is to set up conservation actions based on solutions envisaged and implemented by the children themselves to forge links between science and society. In Seychelles, where the project is supported by Monaco Explorations, the creation of a Marine Education Area in the Curieuse Island National Marine Park, in partnership with the Seychelles Parks

and Gardens Authority (SPGA) is underway and will be completed in September 2022. The children will meet with the expedition's stakeholders during the visit of *S.A. Agulhas II* to Mahe on October 28 for an exciting exchange. A meeting with the Sovereign is envisaged. During the preparation of the project, the Monaco Marine Education Area helped and advised. The concept of Marine Education Areas is currently gaining momentum in different parts of the world.



As a result of the snorkelling assignment, we go deep into scientific knowledge: yesterday the activities were about the names of fish fins and indicators of the health of coral reefs.

Lola Massé
IRD, marine biologist, mediator, and coordinator of the PAREO project.



A poster depicting the coral reef ecosystem and its inhabitants was translated into Seychellois Creole to familiarize the children with the common names of the species ©PAREO-Poster Mareco.



— THE FUTURE OF[®] PROJECT: THE FUTURE OF PLASTIC WASTE IN SEYCHELLES

As we face 5.7 billion tons of unrecycled plastic waste worldwide, the devastating impact on land and in the Ocean is clear. The staggering and ever-increasing amount of plastic packaging consumed is choking our natural habitats and amplifying the production of greenhouse gases while contributing to global temperature increases.

In Seychelles, The Future Of[®] programme, coordinated by the social enterprise SoScience, has launched a call for innovative projects in 2021 in the context of the development of the blue economy to reduce plastic waste to actors from research, business, the social economy, and NGOs to bring about multi-stakeholder collaborations designed to address previously identified environmental or societal challenges.

How to reduce plastic dependency by developing measurable and sustainable solutions for plastic collection and processing?

To address this issue, three projects were finally selected in November 2021:

- **Connect-Collect:** to promote the connection of plastic industry players and the operation of a more transparent, efficient, and sustainable recyclable waste management system through a dedicated application.
- **Awareness Campaign on Plastics:** raising awareness of plastic pollution and educating people to adopt good practices.
- **Recycling Machine:** promoting simple, low-cost, and easy-to-use technologies to treat and transform waste into valuable consumer products in the virtuous chain of the blue economy.

These three projects under development will also be presented and promoted during the vessel's stopover in Seychelles.





EVENTS AND EDUCATIONAL PROGRAMS

A COLLABORATION WITH THE FRENCH AND MONEGASQUE NATIONAL EDUCATION

To make the Indian Ocean expedition as widely known as possible, the announcement of the launch of the interactive page dedicated to the expedition is scheduled for the beginning of the school year for distribution to all the rectorates and academies in France.

A presentation of the expedition to the Principality's secondary school and cycle 3 primary school teachers has also been scheduled for the beginning of the school year.

These are great opportunities to unite the younger generation around the Indian Ocean expedition and to present the educational potential of this tool to teachers.

Indian Ocean Mission

October and November 2022



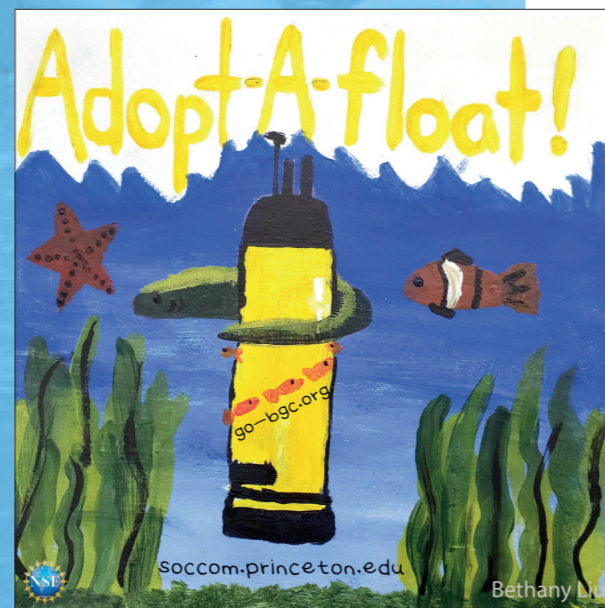


An oceanographic research expedition to be experienced in live!

For teachers and students of primary, secondary, and high schools, interaction and direct contact with the teams on board the S.A. Agulhas II, educational resources accessible on the mission's web platform and many other possibilities. A mission in which science, mediation and diplomacy will be put at the service of sustainable ocean management.

See you at the beginning of October 2022 on the platform dedicated to the mission!

www.monacoexplorations.org



THE "EXPLORER AND CITIZEN OF THE SEAS" MECHANISM

The "Explorer and Citizen of the Seas" mechanism is supported by the Academic Delegation for Artistic and Cultural Education (DAAC) of the Académie de Nice. It was designed and is implemented in partnership with the Oceanographic Museum of Monaco, within the framework of the agreement protocol on educational and cultural actions and with Monaco Explorations. This structuring academic and cross-border scheme

offers a scientific, cultural, and civic approach to the expeditions of Monaco Explorations. The operating principle is to use the resources from the expeditions to build an educational project for classes and establish a dialogue with the scientists involved. Interaction during the Indian Ocean expedition will be possible for secondary school classes enrolled in this scheme for the 2022-2023 school year.

ADOPT A FLOAT

For ten years now, the Laboratoire d'Océanographie de Villefranche-sur-Mer (LOV) has been involved in disseminating knowledge about the Ocean through scientific outreach activities based on observations collected by robots designed by the laboratory. Therefore the "Adopt a float" project, in which a class of pupils follows a robot during its journey while being accompanied by the laboratory's scientists, and "My ocean & me", a resource portal for the public and teachers, were created. The laboratory has organized numerous training sessions for secondary school

teachers (science and technology, physics, etc.) so that their teaching can make pupils more aware of the issues surrounding the ocean. Within the framework of the Indian Ocean expedition and in collaboration with Monaco Explorations and other partners involved in the expedition such as the Oceanographic Institute and its Animation and Education Department, the LOV team will develop outreach activities that are both innovative and adapted to the public, young people and teachers, in particular those from Seychelles and Mauritius.

THE OCEANO COMPETITION FOR ALL

The Oceanographic Institute and its Animation and Education Department are launching an educational competition for French and Monegasque secondary schools for the 2022-2023 school year. The aim of the competition is to forge a strong link between young people and the sea, by helping classes to discover the marine world and to carry out a project contributing to the protection of the Ocean. As part of the Indian Ocean expedition of Monaco Explorations, the competition was also announced in Reunion, Seychelles and Mauritius.

The Ocean as a common good accessible to all is the ambition of the project. The educational support offered by the Oceanographic Institute aims to: help students discover marine biodiversity, help them understand the role of the Ocean in regulating the climate, analyse the impact of human activities on the Ocean, raise awareness and act in favour of the Ocean. The educational support offered to the participating classes by the Oceanographic Institute's Animation Department includes access to the resources of the Indian Ocean expedition during its course and throughout the coming school year.



THE SCHOOL ON BOARD S.A. AGULHAS II

TRAINING STUDENTS AND YOUNG RESEARCHERS AND TRANSMITTING KNOWLEDGE FROM THE FIELD

As part of the joint teaching of the master's degree in Sciences of the Universe, Environment and Ecology (SDUEE), with specialization in Marine Sciences-Oceanography, Marine Environments, given by Sorbonne University and the European Master's degree

IMBRSea, 20 students will be present on board during the first stage of the expedition. 10 young researchers or technical students from Seychelles and Mauritius will also attend the courses given on the vessel by the three research teachers present.

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A UNIQUE OPPORTUNITY

These young students will have the unique opportunity to learn about field science and to benefit from the transmission of knowledge in the context of the technical and scientific operations in which they will be able to participate. The proposed teaching unit will address the themes of instrumentation, an expedition plan, work at sea, methodology and observation.

The students will be able to exchange with all the scientific teams and benefit from the interventions of the project managers, technicians and operators involved in the expedition.

FROM THEORY TO PRACTICE

The scientific operations carried out on board will be an opportunity to form and involve a group of young scientists from the region who will tackle the whole chain of operations enabling qualified multidisciplinary data (physics, chemistry, biology) to be obtained from new observation systems (profiling floats) and more traditional systems (CTD-rosette).

This on-board school is a privileged means of connecting different disciplinary knowledge by mobilizing and ordering theoretical knowledge to respond to concrete problems encountered.



Fabien Lombard

The variety of activities that will take place during the campaign will provide unique training and skills acquisition opportunities for students from the University of Seychelles and the University of Mauritius, as well as for young technicians and researchers from marine institutions in both countries.

If two floats can be deployed in partnership with the governments of Seychelles and Mauritius, and if young scientists from these countries can be trained in the best practices of using these robots, then longer-term actions can be envisaged.

Fabien Lombard, head of the on-board school. Teacher-researcher, LOV-IMEV.

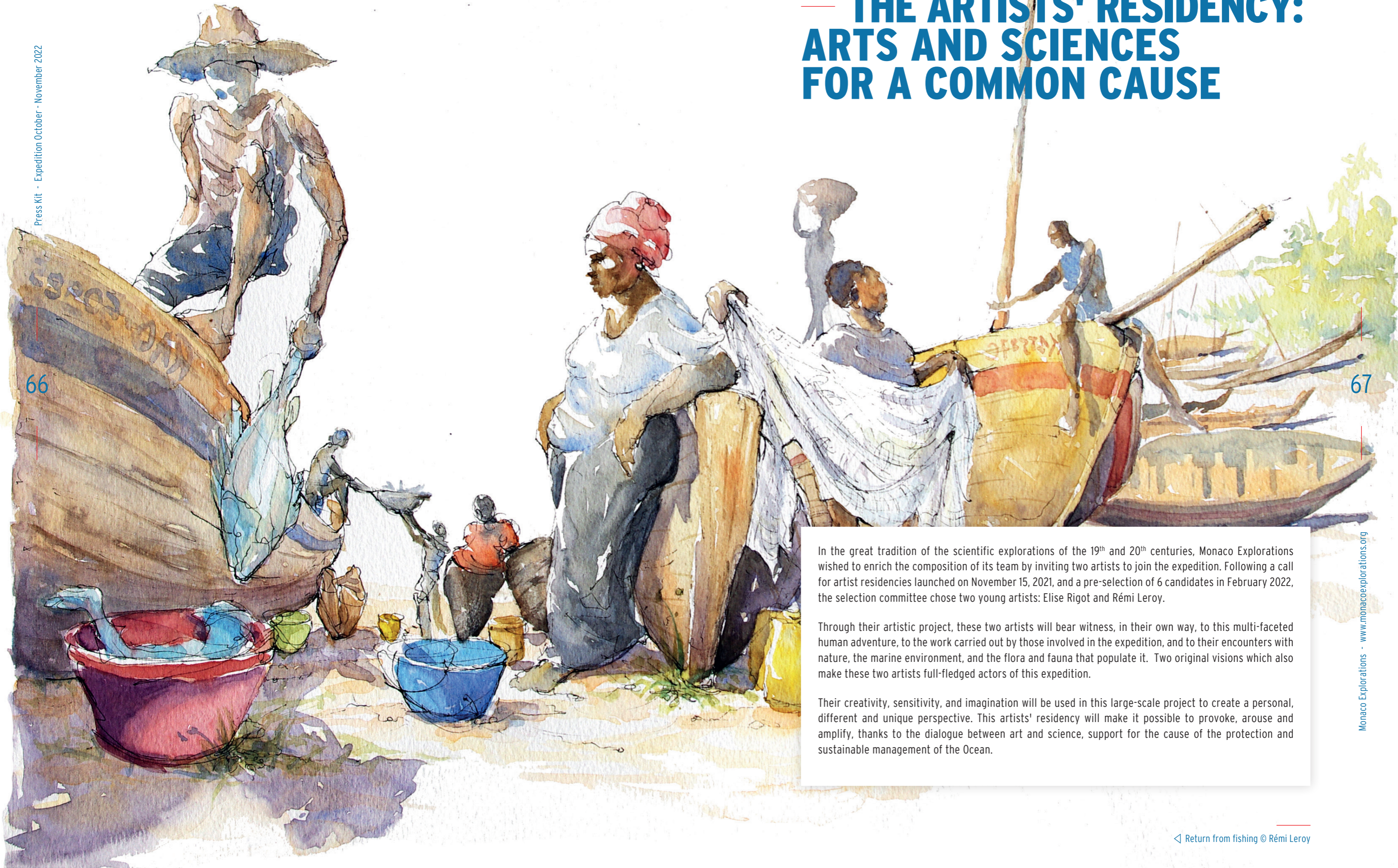
△ Fabien Lombard © LOV/IMEV

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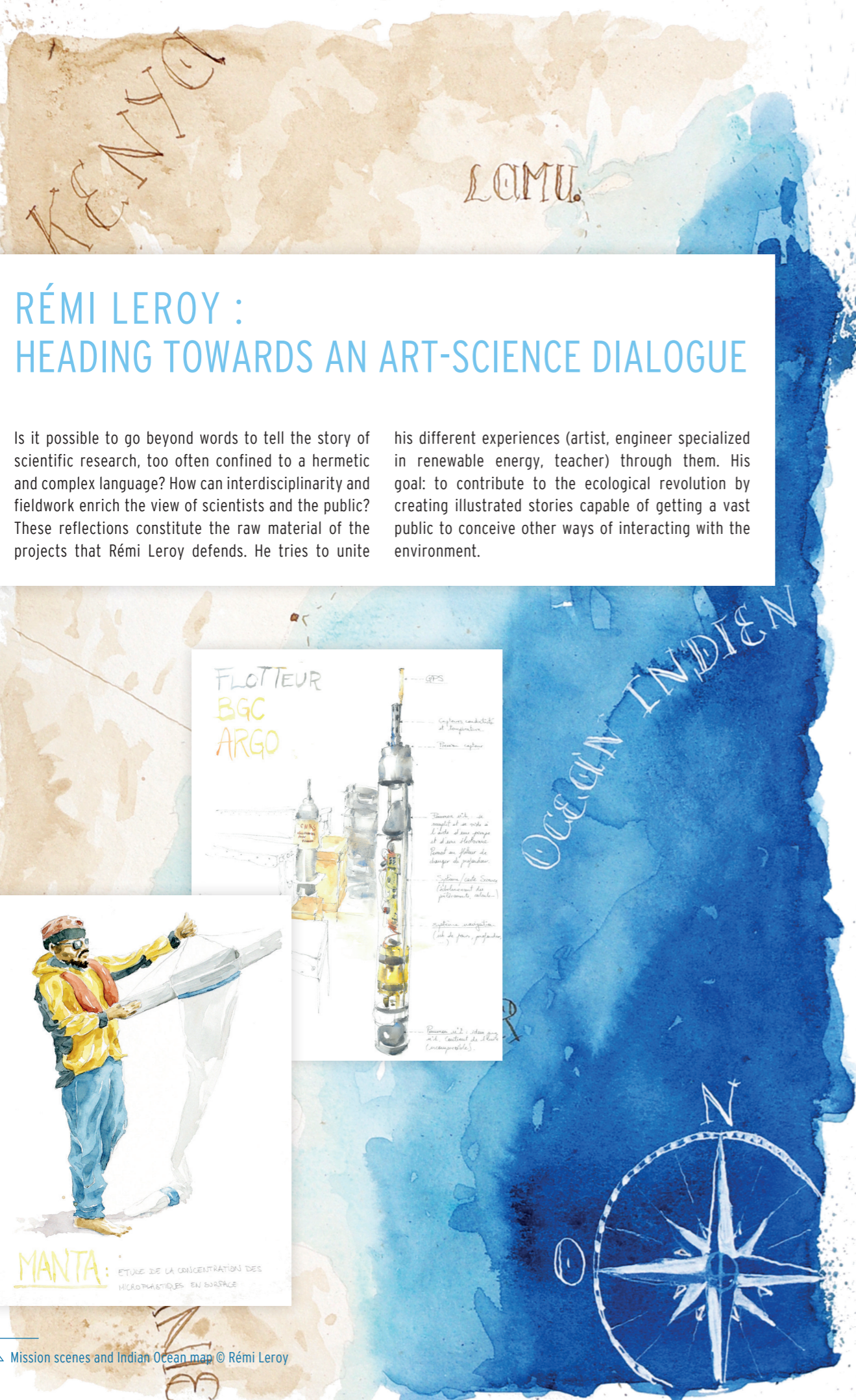
— THE ARTISTS' RESIDENCY: ARTS AND SCIENCES FOR A COMMON CAUSE



In the great tradition of the scientific explorations of the 19th and 20th centuries, Monaco Explorations wished to enrich the composition of its team by inviting two artists to join the expedition. Following a call for artist residencies launched on November 15, 2021, and a pre-selection of 6 candidates in February 2022, the selection committee chose two young artists: Elise Rigot and Rémi Leroy.

Through their artistic project, these two artists will bear witness, in their own way, to this multi-faceted human adventure, to the work carried out by those involved in the expedition, and to their encounters with nature, the marine environment, and the flora and fauna that populate it. Two original visions which also make these two artists full-fledged actors of this expedition.

Their creativity, sensitivity, and imagination will be used in this large-scale project to create a personal, different and unique perspective. This artists' residency will make it possible to provoke, arouse and amplify, thanks to the dialogue between art and science, support for the cause of the protection and sustainable management of the Ocean.



RÉMI LEROY : HEADING TOWARDS AN ART-SCIENCE DIALOGUE

Is it possible to go beyond words to tell the story of scientific research, too often confined to a hermetic and complex language? How can interdisciplinarity and fieldwork enrich the view of scientists and the public? These reflections constitute the raw material of the projects that Rémi Leroy defends. He tries to unite

his different experiences (artist, engineer specialized in renewable energy, teacher) through them. His goal: to contribute to the ecological revolution by creating illustrated stories capable of getting a vast public to conceive other ways of interacting with the environment.

△ Mission scenes and Indian Ocean map © Rémi Leroy



ÉLISE RIGOT : TELLING THE STORIES OF SAYA DE MALHA BANK

The work of Elise Rigot, an artist and design researcher based in Toulouse, France, questions the links between the natural sciences, the engineering sciences and art. What perception do we have of the variety of living beings? How could we make ourselves more sensitive to them? Her art uses 3D technologies (3D printing, scanning, virtual reality

(VR), X-rays, etc.) for their political and aesthetic power, as well as sound and podcasts.

Putting oneself in the place of the living beings around us and adopting their point of view is one of her approaches.

△ 3D creations and sculptures © Elise Rigot



WHO ARE WE? MONACO EXPLORATIONS



The Monaco Explorations are at the confluence of most of the themes which are dear to me and which in this respect resonate particularly in me. It is an adventure that also echoes the most beautiful traditions of the Principality and is addressed to all humanity.

H.S.H. Albert II, Prince of Monaco

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The Monaco Explorations Company, coordinator of the programme and implementation of the "Indian Ocean" expedition, is a platform serving the commitment of H.S.H. Prince Albert II of Monaco to the knowledge, sustainable management, and protection of the Ocean. Created on the initiative of the Government of the Principality of Monaco, the Monaco Exploration Society brings together the Prince Albert II of Monaco Foundation, the Oceanographic Institute - Prince Albert Ist of Monaco Foundation, the Monaco Scientific

Centre and the Monaco Yacht Club. It supports the actions of these institutions through expeditions carried out at international level which combine high quality scientific research, guaranteeing the development of knowledge useful for decision-making, raising awareness among a wide public, in particular the younger generations, to encourage commitment, inform and mobilize, and a political commitment at the highest level for intelligent and sustainable management of natural environments.

The general management is ensured by the Board of Directors of Monaco Explorations, chaired by the Minister of State of the Principality, H.E. Mr Pierre Dartout.



Together with many researchers, in recent years we have initiated, promoted or funded a number of programmes in four areas: the protection of megafauna, the protection of corals, new exploration technologies and the study of marine protected areas (MPAs).

H.S.H. Albert II of Monaco
L'Homme et l'Océan - Flammarion et Versilio, 2022.



Robert Calcagno : Managing Director of Monaco Explorations

Robert Calcagno has been Director General of the Oceanographic Institute - Prince Albert Ist of Monaco Foundation, since 2009. In this capacity, he manages the Oceanographic Museum of Monaco and the Maison de l'Océan in Paris. Very involved in the development of a more sustainable and balanced society and in the protection of the Ocean, this former Advisor to the Cabinet of H.S.H. Prince Albert II of Monaco held the position of Minister for the Environment in the Principality from 2006 to 2009. He is the author of several books for the general public, including "Sea turtles - the great odyssey", "Jellyfish: conquering the oceans", "Sharks - beyond the myth" and "Corals, a treasure to protect". As Managing Director of Monaco Explorations, he works with the Board of Directors to ensure the coherence and relevance of the actions carried out in relation to the Sovereign's commitment to the Ocean at international level.

△ Robert Calcagno © Thierry Ameller. Institut océanographique



Gilles Bessero : Director of Monaco Explorations and leader of the Indian Ocean expedition

Gilles Bessero has been the Chief Operation Officer of Monaco Explorations since April 2019. A member of the French Marine Academy since 2010, he has a technical background in physical oceanography, hydrographic surveys and nautical cartography and experience at sea. He was Director General of the French National Hydrographic Service (2005-2010), Inspector at the Inspectorate of the French Defence Procurement Agency (2010-2012) and Director of the International Hydrographic Organization (2012-2017). He is the author of several books. As expedition leader, he is responsible for the coordination and implementation of all operations planned during the expedition.

△ Gilles Bessero © Magali Boussion. Monaco Explorations



FOUR MAIN STUDY THEMES:

THE FOUR MAIN THREADS OF A LONG-TERM APPROACH

Since April 2017, the beginning of this adventure, many expeditions have been undertaken throughout the world by Monaco Explorations, all of which are based on four major study themes:

Map of the Monaco Explorations expeditions conducted around the world since 2017



Protection of megafauna

The first expedition of Monaco Explorations in Madeira in September 2017 focused on one of the currently most endangered marine mammals in the world. The worrying situation of the Mediterranean monk seal (*Monachus monachus*) reflects the status of most of the large predator populations in the world, both on land and at sea. Their study and their conservation have now become essential to the preservation of natural balances. Many programmes are supported and developed in the world by the Principality of Monaco in order to contribute to the sustainable protection of the megafauna and the acquisition of the means to reach this objective; the projects of the Prince Albert II Foundation for the protection of the monk seal or the whale shark, the recent opening of a Rescue and Rehabilitation Centre for marine turtles at the Oceanographic Museum or awareness-raising among sea users are some examples.

Coral protection

Hawai'i, Palau, Eilat in Israel, the Mediterranean or Norway: Monaco Exploration and its partners have made the study of coral reefs in tropical regions and deep-water corals all around the world a priority. Several expeditions already carried out were wholly or partly devoted to them. This research work is part of the global marine biodiversity conservation policy pursued at international level by the Principality of Monaco and its Sovereign. The co-presidency until 2020, with Australia and Indonesia, of the International Coral Reef Initiative (ICRI), the Coral Reef Life Declaration launched at the 'Our Ocean' conference by H.S.H. Prince Albert II of Monaco, the expeditions organized as part of Monaco Explorations or supported by Prince Albert II of Monaco Foundation renew the Principality's commitment to the protection of corals.

The development of Marine Protected Areas (MPAs)

Currently, 2.2% of the surface area of the Ocean is under high protection (no-take areas) and 7.68% of its surface area is covered by Marine Protected Areas benefiting from specific protection regimes. International experts recommend extending the protected surface area of the Ocean to 30% by 2030. The Principality of Monaco is involved at several levels. Prince Albert II of Monaco Foundation supports numerous projects related to marine protected areas throughout the world. In March 2019, the 10th edition of the Monaco Blue Initiative, an international meeting co-organized by the Oceanographic Institute and Prince Albert II of Monaco Foundation, brought together experts on this major subject. In situ, during the expeditions, the scientific, environmental, and educational projects supported by Monaco Explorations confirm the essential role played by marine protected areas in building a harmonious, balanced and sustainable relationship between Man and Nature. This was in particular the case in Colombia in Malpelo or in Madeira.

New exploration techniques

One of the objectives of the Principality and its Sovereign through Monaco Explorations is to favour the emergence of new techniques for exploring the marine environment and its biodiversity during the expeditions, with the aim of improving the quality of field observations, facilitating the sampling, and collecting more data in better conditions. These new tools are tried and tested to expand the knowledge of the Ocean and the living creatures inhabiting it. Their implementation also requires the development of relations and cooperation between the Monegasque State and many countries in the world. The development of clean shipping using the new energies of tomorrow is an area to which the Yacht Club de Monaco is also making a significant contribution.



THE PARTNERS OF MONACO EXPLORATIONS



The determination of H.S.H. Prince Albert II to promote sustainable development in the Principality is reflected in the actions of His Government, whether it be the preservation of biodiversity, the management of resources or the implementation of a climate energy plan. The Prince's Government is pursuing an ambitious policy in favour of the preservation of biodiversity, energy sobriety and the fight against plastic waste in the Principality. Amongst these missions, the implementation of numerous international conventions and agreements ratified by the Principality, such as the Kyoto Protocol and more recently the Paris Climate Agreement. Monaco is also a historic member of the Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora, known as CITES¹, which has established a permit system.

Finally, the Principality of Monaco is actively involved in the preservation of the Mediterranean through the RAMOGE agreement, the "Pelagos" sanctuary and the Barcelona Convention, and hosts international bodies whose purpose is to study and preserve the marine environment (ACCOBAMS², IAEA environmental laboratories³, etc.).



The Prince Albert II of Monaco Foundation is an international non-profit organization committed to protecting and advancing global health for present and future generations. Created by H.S.H. Prince Albert II of Monaco in 2006, the Foundation aims to promote a new relationship with nature and the innovations that can accelerate this change. The Foundation aims to foster the development of effective solutions for our planet's biodiversity, climate, ocean, and water resources. It operates in three main geographical areas: the Mediterranean basin, the polar regions, and the least developed countries.



Founded in 1906 by Prince Albert Ist, The Oceanographic Institute - Foundation Albert Ist, Prince of Monaco, has been bringing together scientific, political, and economic players, associations, and the public for 150 years with a single objective: "to make the Ocean known, loved and protected". The Oceanographic Institute is a foundation of public utility in France which, under the impetus of its honorary president, H.S.H. Prince Albert II, contributes to the Principality's commitment to the Ocean. The Institute is responsible for numerous national and international projects (symposiums, exhibitions, educational programmes, etc.) and has an important environmental mediation mission. To this end, it relies on its two establishments - the Oceanographic Museum in Monaco and the Maison de l'Océan in Paris - as well as its digital tools and its off-site activities to disseminate the science of oceanography to as many people as possible, combining it with art, the living world and collective and individual commitment.



Dedicated to scientific research, fundamental and applied, the work developed by the teams of the Monaco Scientific Centre (CSM) are grouped into three departments: Marine Biology, specializing in the study of corals and coral reefs, Polar Biology, specializing in the study of penguin populations and Medical Biology. The primary concern of researchers in these departments is to study the bases of the functioning of organisms in order to better understand, and therefore better anticipate, the effects of environmental stresses (Physiology of Conservation) or therapeutic treatments (Translational Biology). The proximity of researchers favours rich exchanges that should bring new ideas to the boundaries of disciplines. The Centre has had a large international attractiveness with more than 70 employees coming from 15 different countries (including Europe, USA, Japan, Australia, New Zealand, Palau, Brazil, Caribbean, Canada, Oman, Saudi Arabia ...) since 2013, date of installation of the CSM in its new facilities of Quai Antoine I^{er}.



Founded by Prince Rainier III in 1953 and presided over by H.S.H. Prince Albert II since 1984, the Yacht Club of Monaco is a private and exclusive club which today brings together 2,500 members of 81 nationalities, sharing common values around its motto "One Spirit, One Team, One Club".

In accordance with its statutes, this private club has the particularity of being entrusted with a mission of public service delegation, as evidenced by its role as a facilitator of the port and catalyst for all activities related to yachting in the Principality.

The Principality has always been a major destination for yachting. Preserving a certain "Art de Vivre la Mer", safeguarding the environment, honouring the nautical heritage, and promoting the most innovative technologies..., it is through the values of its label "La Belle Classe" and well beyond its circle of members that the YCM unites owners and all those involved in the yachting industry, by offering them a platform for communication and exchange.

The YCM contributes to its promotion and influence with the aim of implementing a policy resolutely focused on environmental protection. Through the "Monaco, Capital of Advanced Yachting" project, the ambition is to position the Principality as an essential stopover for yachting by highlighting the latest technological innovations.



EXPLORATION PARTNERS • ACKNOWLEDGMENTS



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