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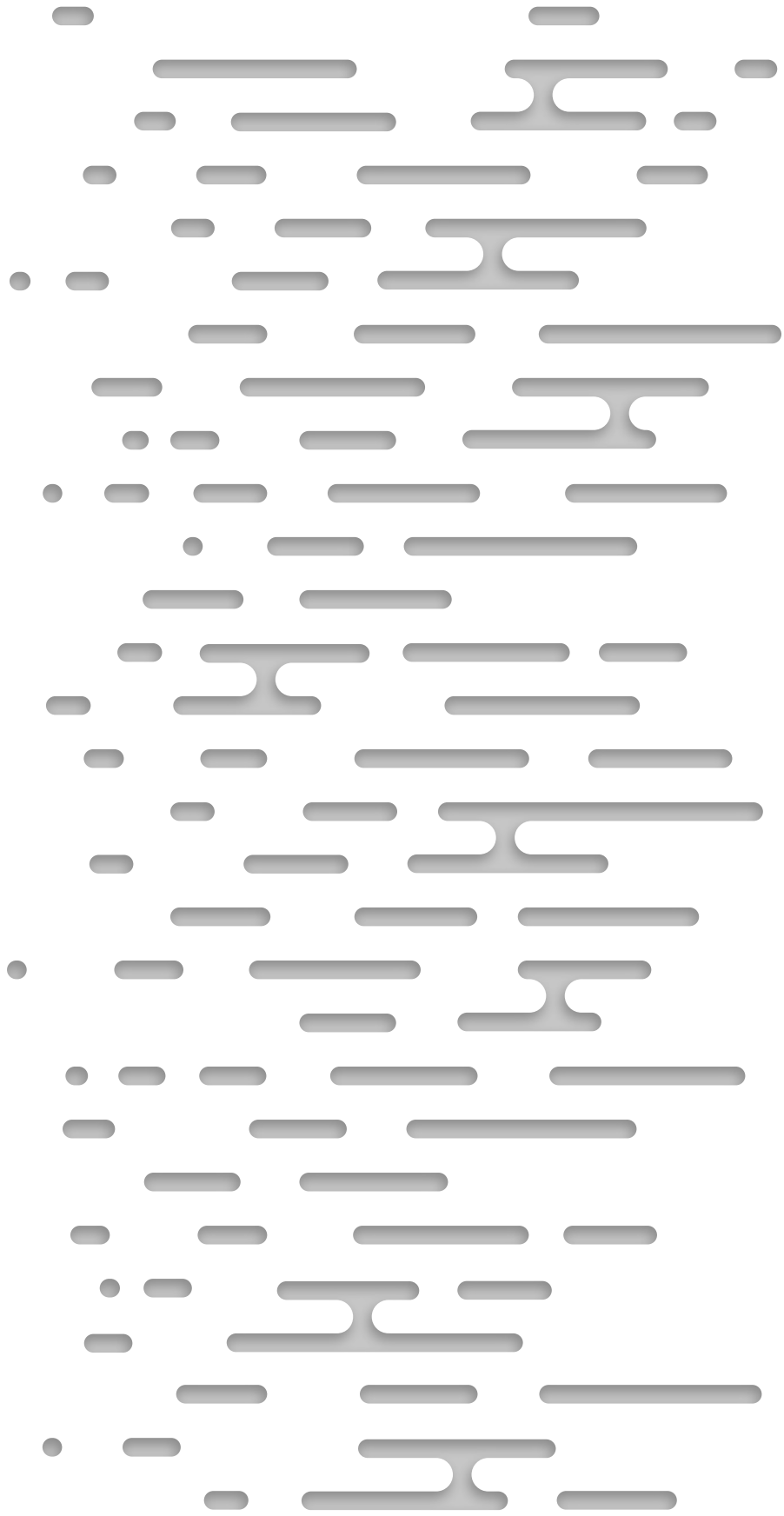
Ifremer

A YEAR WITH IFREMER

2020



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COVER IMAGE: Two Ifremer divers installing a temperature sensor on a fish aggregating device (FAD) anchored near Réunion. © Ifremer / Jérôme Bourjea

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Well-known around the world as a leading institution in marine sciences and technologies, Ifremer is committed to both sustainable development and open science. Ifremer conducts research, innovates and advises in order to protect and restore the ocean, ensure that marine resources are used responsibly and share knowledge and data about the ocean to create new opportunities for economic growth that coexist harmoniously with the marine environment.

Ifremer has a presence on all of mainland France's coasts and in some overseas territories. Around twenty sites across the three main oceans (Indian, Atlantic, Pacific) host its laboratories. Ifremer operates the French Oceanographic Fleet on behalf of the French government and for the benefit of the national scientific community. It designs its own cutting-edge marine vehicles and equipment to explore and observe the ocean, from the coast to the high seas, and from the deepest depths to the atmospheric interface.

Its 1,500 employees, which include close to 600 researchers and engineers and 300 technicians, connect with the international scientific community while improving our knowledge of one of the least-explored frontiers on our planet. Their expertise informs public policy as well as innovation for a sustainable blue economy. Their mission also involves raising public awareness of the issues at stake for our seas.

Founded in 1984, Ifremer is a public industrial and commercial establishment under the joint supervision of the Ministry of Higher Education, Research and Innovation; the Ministry of the Sea; the Ministry of the Ecological Transition; and the Ministry of Agriculture and Food.

Pascal Lamy,

Chair of the Mission Board for the European Commission's "Healthy oceans, seas, coastal and inland waters"

© Institut Jacques Delors

2020 will remain ingrained in our collective memory as the year in which the SARS-CoV-2 virus mushroomed into a pandemic.

It has had a profound impact on all of humanity, including Ifremer and its activities. However, we might dare to hope that it has also illuminated the need for more investment in science and in the understanding of our ecosystems in order to attenuate the systemic risks that affect them.

As we will see in this report, the pandemic-related constraints did not prevent major projects from marching onward, whether they centered on the underwater drone *UlyX* or the Argo profiling floats, and they did not prevent Ifremer from quickly redirecting resources toward sampling and analyses to confirm the absence of the virus in shellfish and in waters reaching the sea.

This year has also been marked by the beginning of Ifremer's contribution to the EU project Starfish 2030, an initiative inspired by the missions of the 1960s' Apollo program. This project is a novelty among European programs, which consist of investing massively in research and innovation to solve some of our continent's most pressing challenges, in this case the regeneration of our hydrosphere. (The hydrosphere is, of course, the system that connects the waters of our ocean, our seas, our rivers, our lakes and our groundwater.) The Starfish 2030 mission is unlike the others due to its premise that such a significant transformation cannot possibly occur without unprecedented grassroots mobilization—an idea firmly backed by Ifremer and that we have seen in action during the event that Ifremer organized last December.

We hope that 2021 will see the launch of the Starfish 2030 program, and that the prospect of unlocking new scientific advancements through a wealth of European resources will supersede the sense of helplessness that overcame many of us during this difficult time that, hopefully, is coming to a close.

François Houllier, Chief Executive Officer of Ifremer

© Ifremer / E. lenglemetz

We have all witnessed how the COVID-19 pandemic turned our personal and professional lives upside down; it disrupted our organization and delayed, threatened and even canceled some of our projects. As a group, we drew together and showed resilience. We adopted new protective, preventive and health measures and organized our work differently, changing and improving our internal communication.

Some activities did suffer, but we were able to keep moving forward. Everyone contributed in their own way: researchers and doctoral students; engineers and technicians; laboratories and the oceanographic fleet; the administrative departments; and managers and employee representatives, who were party to many discussions.

Two examples of this remarkable collective resilience are the MAYOBS13 oceanographic cruises, which took place off the coast of Mayotte during the first lockdown. These were a success thanks to the mobilization of Ifremer personnel; excellent collaborations with the BRGM, the CNRS and the IPGP; and the support of the French Navy and the ministries in charge of research, the overseas territories and the environment.

On a deeper level, this year changed the way we conceive of the world, and of sustainable development. I believe that we have not yet measured the scope of these consequences, which go well beyond the context of Ifremer, marine sciences and marine technologies.

Despite the difficulties, 2020 brought its share of highlights and triumphs, which bolster the Institute's 2030 strategic plan. This report is an opportunity to recount them. They run the gamut of the 2019–2023 Statement of Objectives that was signed on World Ocean Day (June 8, 2020) at an event showcasing our research and partnerships in the Pacific, Atlantic and Indian Oceans, as well as along the English Channel and in the Mediterranean.

The International Day for Biological Diversity (organized with the Office français de la biodiversité) and the preparation of the Ocean & Climate priority research program (with the CNRS) showed our capacity to take on major challenges that affect oceans around the planet.

Thanks to our partners' hard work, the national consultation that we led for the European project Starfish 2030 showed that our fellow citizens are also aware of these stakes and of the relationships between inland waterways and marine waters, and that they too feel invested in the health of our oceans and seas.

The press conferences that we have held have demonstrated our long-standing commitment to providing scientific expertise to support the sustainable management of fisheries resources and the monitoring of coastal and shoreline water quality. They have equally shown our ability to innovate and to collaborate with private companies to design the underwater vehicles that scientists need to explore the ocean's depths.

In 2020, we sketched out our ideas for the future by finalizing three major investment plans that will unfold over the next ten years: the real estate investment project for the Nantes and Brest sites will receive support for the Nantes site, starting in 2021, from the France Relance recovery initiative; the plan to modernize and renovate the French Oceanographic Fleet, which began in 2017, is the fruit of years of hard work and now calls for the completion of one project after another; and the Exceptional Investment Plan illustrates how investment in innovation can, in turn, support research infrastructures, broaden horizons in sustainability sciences, and feed into partnership and information-sharing policies for innovation.

This year began with a quality label bestowed upon the MERS Carnot institute, which is backed by Ifremer and the École centrale de Nantes, and with the acquisition of the third ERC contract in three years. It ended with the four resounding successes from the EquipEx+ call for projects within the Program for Investments in the Future. Therefore, 2020 has allowed us to continue preparing for our future, just as the UN Decade of Ocean Science for Sustainable Development begins.

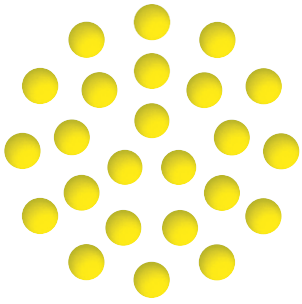
2020 by the numbers

RESEARCH

622 PUBLICATIONS

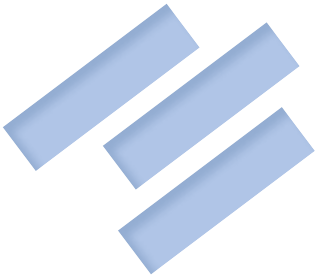
333 OPEN ACCESS PUBLICATIONS

23 RESEARCH UNITS



9 MIXED RESEARCH UNITS

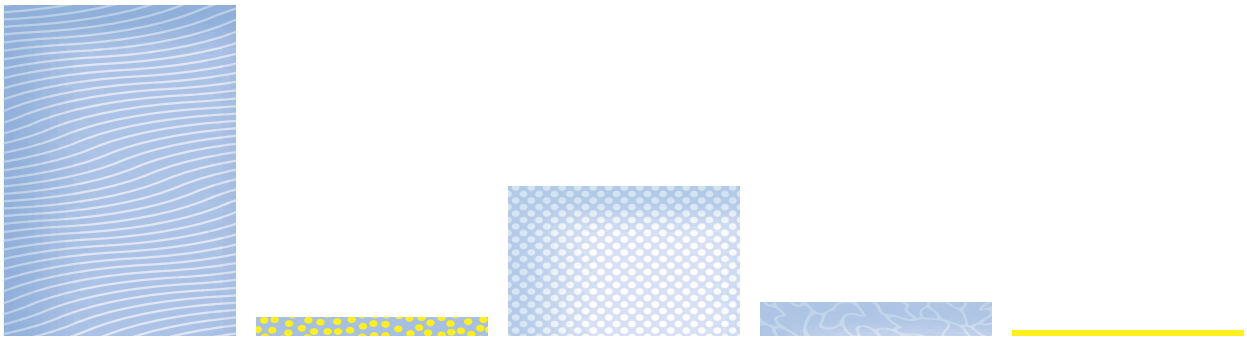
3 ERC PROJECTS UNDERWAY



EXPERTISE

107 EXPERT OPINIONS AND STATEMENTS ISSUED IN 2020

HUMAN RESOURCES



1516 EMPLOYEES

87 HDR DIPLOMA HOLDERS (certification in directing research)

684 RESEARCHERS & ENGINEERS

152 DOCTORAL STUDENTS

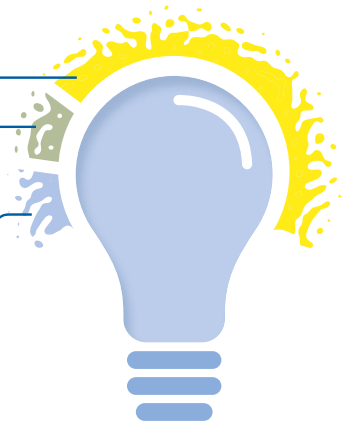
27 POST-DOCTORAL RESEARCHERS

INNOVATION

102 INDUSTRY ACTORS BENEFITING FROM KNOWLEDGE SHARED BY THE INSTITUTE

14 MATURE PROJECTS UNDERWAY

12 INVENTION DISCLOSURES

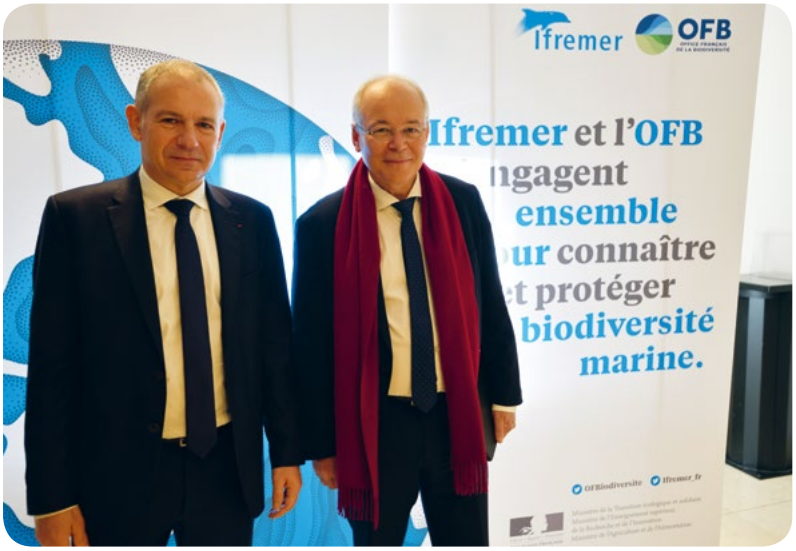


BUDGET

230 MILLION EUROS IN 2020

(FÉB.) **MERS, THE ONLY CARNOT INSTITUTE DEDICATED TO THE OCEAN, RECEIVES A QUALITY LABEL**

Created by the Ministry of Higher Education, Research and Innovation, the Carnot institutes promote research partnerships between public laboratories and other socioeconomic actors. The most recent round of quality labels granted in 2020 saw the emergence of the first Carnot institute focusing on the ocean. Backed by Ifremer and the École Centrale de Nantes in partnership with the CNRS and the universities of Nantes, Bretagne Occidentale and Bretagne Sud, MERS intends to contribute to the growth of a sustainable blue economy that preserves our oceans. Photo © Centrale Nantes/Patrick Roustang



(MAR.) **IFREMER AND THE OFB JOIN FORCES FOR MARINE BIODIVERSITY**

On March 12, 2020, Ifremer and the Office français de la biodiversité (OFB), the leading expert on biodiversity, co-orchestrated a colloquium on the theme "Protecting marine biodiversity together: knowledge for action." Pictured at left: Pierre Dubreuil, General Director of the OFB, and François Houllier, CEO of Ifremer. The event brought together close to 40 speakers and 180 participants from a wide variety of ocean-related fields (scientists, fishermen, elected officials, NGO members, institutional representatives, managers of protected areas, and more). The goal: to present a summary of the research on biodiversity and draft solutions to preserve it. Photo © Ifremer / Stéphane Lesbats

(MAR.) **AN ALTERNATIVE TO ANTIBIOTICS: ERC GRANT AWARDED TO DYNAMIC**

Good news for the Institute in March 2020: Frédérique Le Roux, an Ifremer researcher in molecular microbiology at the Roscoff Marine Station (CNRS/Sorbonne Université) won an Advanced Grant from the European Research Council (ERC). She was one of 185 award recipients among the 1,881 applicants. The €2.5 million awarded will finance the DYNAMIC project, which studies phages in marine environments. These marine viruses, which prey on bacteria, could in fact serve as a future alternative to antibiotics as multidrug-resistant bacteria continue to proliferate. Photo © Station Biologique Roscoff

(MAR.) ALLIANCE FORMED WITH GERMAN MARINE RESEARCHERS

In line with the Institute's international strategy, which aims to consolidate strong bilateral partnerships, Ifremer laid the foundation for a broader partnership with Germany upon the creation of the German Marine Research Alliance (DAM) in March 2020. This alliance brings together fifteen German oceanographic institutions. François Houllier, the CEO of Ifremer, participated in the launch of this new organization to show support (from left to right with his counterparts Peter Herzig, the director of the German research institute GEOMAR, and Ed Hill, the chief executive of the National Oceanography Centre in the United Kingdom). Photo © DAM/Dirk Enters

(JUN.) MINISTER FRÉDÉRIQUE VIDAL VISITS IFREMER

During her "Tour de France" of the country's knowledge centers, Frédérique Vidal (Minister of Higher Education, Research and Innovation) visited universities, research entities and local authorities. On June 20, 2020, she honored Ifremer with her presence, reaffirming the importance of marine sciences for French research and commending the work of an institute that balances local attachments with an international span. This visit provided the opportunity for discussion of the recovery plan's priorities for research and innovation in response to the COVID-19 crisis.
Photo © Terra / Damien Carles

(JUN.) NEW STATEMENT OF OBJECTIVES RATIFIED

On World Ocean Day, Élisabeth Borne, then-Minister of the Ecological and Inclusive Transition; Frédérique Vidal, Minister of Higher Education, Research and Innovation; and Didier Guillaume, then-Minister of Agriculture and Food, signed the Institute's new Statement of Objectives along with François Houllier, CEO of Ifremer.
The Statement of Objectives, structured around six main goals, is the strategic document that formalizes the commitments binding Ifremer and its supervising ministries. It will continue to serve as a guiding light for the Institute through 2023. Photo © Terra / Damien Carles

(SEPT.) **CLARA ULRICH WINS THE ICES OUTSTANDING ACHIEVEMENT AWARD**

Every year, the International Council for the Exploration of the Sea (ICES)—which brings together an international community of 6,000 scientists specializing in marine resources and ecosystems—bestows an award upon one of its members. In 2020, it was our Deputy Scientific Director Clara Ulrich who was honored with this prize. The award commends her excellent work on "mixed fisheries," which target several species at the same time. Her expertise will further inform the Common Fisheries Policy (CFP). Photo © Ifremer / Clara Ulrich

(SEP.-OCT.) **IFREMER TAKES UP RESIDENCE IN ITS NEW HEADQUARTERS**

The 160 salaried employees at Ifremer's headquarters in Plouzané were able to move into their new offices in autumn. The new site has a small environmental footprint due to its use of renewable materials; its energy performance has been certified as "High Environmental Quality."

Photo © Ifremer / Stéphane Lesbats

(OCT.) **AURÉLIE BOISNOIR WINS THE 2020 FRANCE RISING TALENTS PRIZE FROM THE L'ORÉAL-UNESCO FOR WOMEN IN SCIENCE PROGRAM**

A postdoctoral researcher at Ifremer's Antilles station in Martinique, Aurélie Boisnoir is now part of the select group of 2020 winners of the L'Oréal-UNESCO Rising Talents prize for women in science (35 prizes awarded out of 700 applicants). Aurélie Boisnoir received this distinction for her work on toxic benthic dinoflagellates associated with ciguatera, a type of food poisoning that is caused by fish contaminated by these microalgae and that has serious health and economic consequences in the Caribbean Photo © Fondation L'Oréal

(OCT.) ***ULYX*: THE NEW SEAFLOOR EXPLORER**

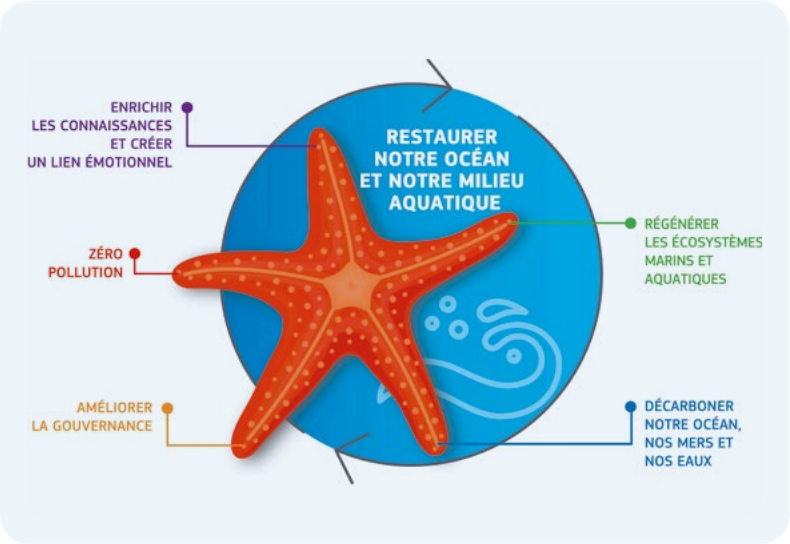
On October 23, 2020, *UlyX*, the new submarine robot belonging to the French Oceanographic Fleet (operated by Ifremer), was christened at Ifremer's Centre Méditerranée in La Seyne-sur-Mer. The new autonomous submersible can dive up to 6,000 meters deep with its cutting-edge equipment and navigates like no other vehicle before. It represents a true advancement in deep-sea exploration. Only four countries have devices like this designed specifically for scientific purposes. France has always been a pioneer in exploration of the sea's depths, and with *UlyX*, it confirms its leading position. Photo © Ifremer / Ambre Bodénès

(NOV.) **FOUR VENDÉE GLOBE SKIPPERS TURN THEIR ATTENTION TO SCIENCE**

Four skippers from the Vendée Globe—Fabrice Amédéo, Boris Herrmann, Alexia Barrier and Louis Burton—have agreed to go beyond sporting adventures and take up a scientific mission for Ifremer. The goal: to collect data from little-traveled areas of the Southern Ocean and gain the keys to understanding climate change and plastic pollution. Three sailing ships have been equipped with a device that measures temperature, salinity and CO2. Three Argo floats (autonomous devices that transmit data via satellite) have also been dropped. A notable exploit during their expeditions: a filter system on Fabrice Amédéo's boat made it possible to collect microplastics (see photo). Photo © Jean-Marie Liot

(NOV.) **SIGNATURE OF THE COOPERATION AND TRANSPARENCY CHARTER**

On November 27, 2020, Ifremer and seven other public entities providing scientific and technical research, expertise and/or evaluations (INRAE, ANSES, BRGM, IFSTTAR, IRSN, Ineris and Santé publique France) joined together to sign a charter promising cooperation and transparency in their activities. These eight bodies believe that knowledge-sharing goes hand in hand with a better understanding of risks and more active citizen participation in risk prevention. They are committed to transparency in order to foster discussions in society and inform public decision-making. Photo © European Union, 2020



(DEC.) **EUROPEAN MISSION STARFISH 2030**

As part of the Horizon 2030 research and innovation program, the European Union has identified five main strategic challenges, one of which is restoring the health of our waterways (oceans, seas, lakes and rivers). This mission, named Starfish 2030, is being led by former EU Commissioner Pascal Lamy. Ifremer is a key actor in this project in France.
Along with partners in the maritime world, Ifremer created and coordinated a wide-ranging survey on this theme that sought input from the French population. The survey received nearly 6,500 responses. The results were published online and have successfully reached 6,000 readers. Photo © Starfish/Koctehko

(DEC.) **IFREMER, A DRIVING FORCE BEHIND THE OCEAN & CLIMATE PRIORITY RESEARCH PROGRAM**

Along with the CNRS, Ifremer is responsible for the priority research program "Ocean & Climate: An ocean of solutions." This program aims to build an ambitious scientific policy for France that spans the major transitions currently underway in our society.
The program was announced in December 2019, finalized in 2020 and launched in 2021.
Its three main objectives are predicting the ocean's response to climate change; using the ocean sustainably and preserving its biodiversity; and reducing ocean pollution and studying the effects of anthropogenic stressors on the marine environment.
Photo © Ifremer / Jérémy Barrault

Adapting to the public health crisis

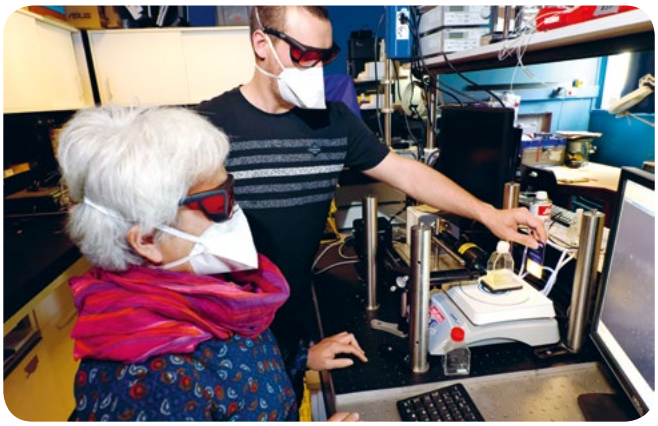
The COVID-19 pandemic sent shockwaves through many institutions and disrupted their usual operations. The lockdown and other public health measures required Ifremer to adapt its plans and practices to this unusual situation in order to protect the health of its staff, preserve its infrastructure and continue its marine research and monitoring activities. After the initial shock, the measures taken proved fruitful.

STAFF SAFETY AND CONTINUING KEY ACTIVITIES

The lockdown that began in March 2020 had unprecedented consequences. Activities were brought to a halt, sites were closed, the fleet's ships were held at port, and research and oceanographic cruises were put on hold. All of this protected Ifremer's staff, although it severely disrupted the Institute's functioning. Some essential operations and missions had to be maintained, so Ifremer implemented an activity continuity plan as soon as possible. This enabled Ifremer to continue providing key administrative services, maintaining infrastructures and performing human/animal health monitoring. At the same time, the shift to remote work allowed researchers to pick much of their work back up. Ifremer's staff must be commended for their commitment and their ability to adapt during this crucial time.

The Human Resources department continued to provide support for staff, ensure that salaries were paid and engage in labor relations dialogue. Remote workers were provided with extra assistance to help them adjust. For example, a presentation on balancing one's personal and professional lives during lockdown was made available online. The internal newsletter, which was sent out twice as often as before, played an important role in maintaining connections among Ifremer personnel. The IT staff were in great demand during this time and rose to the challenge. Existing tools needed to be strengthened and new ones had to be created to handle the abrupt and extraordinary increase in the use of videoconference technologies, email and data transfer. Ten times as much data was transferred between homes and Ifremer as before the lockdown. Ifremer's hubs and laboratories showed their civic-mindedness by giving the medical community masks, gloves and reactants and by sharing some equipment used for analyses.

When the lockdown ended in May, new protocols were created as part of an activity recovery plan. Health and safety remained the top priorities and remote work continued to be recommended. However, some staff were authorized to return to their department, laboratory or vessel in person in order to work on the most important tasks. They were of course provided with personal protective equipment, and new measures were adopted so that the return to in-person work could take place in the safest possible conditions for everyone's health. These measures, which were updated regularly depending on the situation, remain in force today.



DUE TO THE PANDEMIC, MASKS BECAME ESSENTIAL ACCESSORIES FOR LAB EXPERIMENTS, AS SEEN HERE DURING THE DEVELOPMENT OF A TESTING MECHANISM FOR PHYTOPLANKTON. © Ifremer / Olivier Dugornay

Despite Ifremer's willingness to respond and adapt, the lockdown measures were not without consequence. The interruption (though temporary) in the collection of certain data, the delays in research and thesis work, and the postponement of oceanographic cruises caused a significant amount of disruption. Ifremer's teams continue to make efforts today, despite the continued uncertainty of the situation, to resolve these problems while also seeking ways to improve the Institute's resilience during such crises.

MONITORING THE HEALTH OF THE MARINE WORLD

INTERVIEW WITH MAUD LEMOINE ON ADAPTING REPHY (THE OBSERVATION AND MONITORING PROGRAM FOR PHYTOPLANKTON AND HYDROLOGY IN COASTAL WATERS) DURING LOCKDOWN.

MAUD LEMOINE, BIOLOGIST AND COORDINATOR OF THE MONITORING PROGRAM FOR MICROALGAE IN SEAWATER AND TOXINS IN SHELLFISH © IFREMER

WHAT ARE REPHY'S USUAL ACTIVITIES?

As part of our monitoring activities, we take samples of water from along the coast, inland and out on the sea, and we analyze them in the lab. This work, performed by the Environmental Resources labs within the Coasts unit, addresses three complementary objectives. There's a public health angle to it, because some microalgae contain toxins that can contaminate shellfish and make the people who eat them sick. Our role is to alert the authorities if we spot these toxins. Another angle has to do with regulation. These analyses allow us to evaluate coastal water quality over the long term. Finally, this work feeds into the rest of Ifremer's research on microalgae, their ecological niches and environmental changes.

WERE THESE ACTIVITIES AFFECTED BY THE LOCKDOWN?

We were not able to do any sampling for a week, but since shellfish farming continued and shellfish were still being sold, it was imperative to continue our health quality monitoring. We worked closely with the relevant government bodies to determine what it was possible to do and what solutions could be implemented. I have to say that all of the rather intense discussions I had during that time with the authorities and with my colleagues from the labs were very constructive and considerate. Everyone was really putting in their all to overcome the obstacles. We ended up organizing ourselves differently and changing how we worked to be able to start sampling and analyzing again as soon as possible.

HOW DID YOU REORGANIZE YOUR WORK?

The first step was to start sampling again without putting Ifremer's staff and partners at undue risk. As long as each person was alone in their vehicle and had the proper equipment, there were no major problems with sampling along the shoreline. However, we had to stop sampling at sea for a while. Even on small skiffs, you need at least one navigator and one sampler. Consequently, we changed our collection points and moved the ones that had been out at sea to the shoreline, while making sure that all of the shellfish production areas were still covered. We used our knowledge of the area to map out a new, fairly thorough set of sampling points, and scheduled additional shellfish analyses for the areas not covered by our water monitoring activities.

HOW DID YOU ORGANIZE THE LABORATORY WORK?

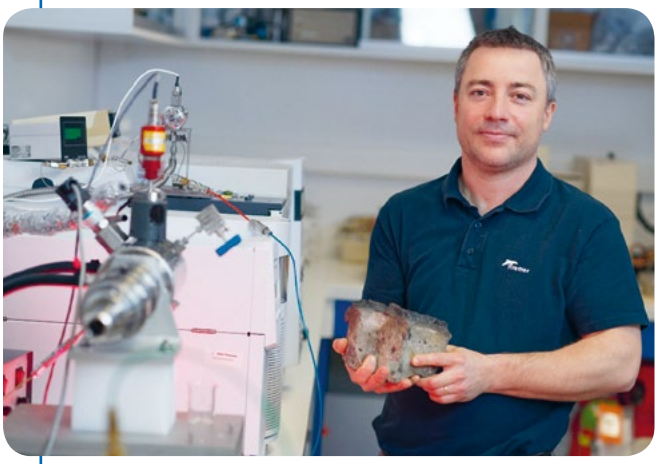
We had to adapt our analysis processes too. Typically, we take samples at the beginning of the week so we can get the results on Thursday, which means that we have to perform the analyses in a very short time. To ensure that we could continue these operations, we resorted to our activity continuity plan. We modified the lab users' schedules and authorized some of them to use the labs with strict safety protocols: only one person at a time in the lab, two people minimum in the building, health protection measures, etc. This way we were able to continue the analyses and return to our usual water quality monitoring.

WERE YOU ABLE TO WORK NORMALLY AGAIN AFTER THE LOCKDOWN?

Yes. Starting in June, we were able to take boats out again and take samples at sea—while following all of the protective measures, of course. Unfortunately, during the two months of lockdown, we were not able to perform our other regulatory and scientific monitoring activities, which resulted in gaps in our data. They aren't huge, but this experience made us think about how we could avoid similar data losses in the future if our access to our usual sites was restricted again.

MONITORING A SUBMARINE VOLCANO DURING LOCKDOWN, A TOP PRIORITY ACCOMPLISHED DESPITE THE PUBLIC HEALTH SITUATION

INTERVIEW WITH EMMANUEL RINNERT ON THE CONTINUED MONITORING OF THE SUBMARINE VOLCANO OFF THE COAST OF MAYOTTE (MAYOBS CRUISE)



EMMANUEL RINNERT, RESEARCHER IN MARINE GEOSCIENCES AND MISSION LEADER, ON MONITORING THE UNDERWATER VOLCANO NEAR MAYOTTE
© IFREMER / OLIVIER DUGORNAY

WHAT WAS THE ORIGINAL PLAN FOR THE MISSION?

We had planned to carry out the mission in May 2020, using R/V *Marion Dufresne*. The goal was to obtain data from the underwater seismological stations that we had installed the previous year, and also to maintain and repair these stations. This cruise was also supposed to be an opportunity to observe the evolution of the volcanic eruption and sample the water and rocks (lava) since our last samples were from August 2019. When the lockdown was announced, we had no idea how long it would be or what impact it would have on us. Since monitoring this submarine volcano was one of our priorities, we continued to get ready for the cruise and ship our equipment, while working around a multitude of unexpected setbacks. Then, some time before departure, we had to face the facts: we wouldn't be able to carry out the mission as planned.

WHY NOT?

The vessel that we had hoped to use couldn't go to sea, because all of the vessels in the French Oceanographic Fleet had to return to French ports and stay there. Protective measures hadn't yet been devised for seafaring activities and there were many differences in practices among the crew members, technicians and scientists, all from different entities. We ended up having to use two different vessels and split the cruise into two parts: MAYOBS13-1 and MAYOBS13-2. MAYOBS13-1 had the advantage of needing neither heavy equipment nor a large team of specialists. We sought assistance from the French Navy, which invited us to use the *Champlain*, a ship normally used for overseas support and assistance. Four volunteers—two from Ifremer and two colleagues from the Centre national de la recherche scientifique (CNRS) and the Institut de physique du globe de Paris (IPGP)—spent two weeks in individual quarantine and then were able to set off together to Réunion. They came back with the desired data, having successfully redeployed most of the equipment. The Navy went above and beyond to help us continue our work and their assistance was deeply appreciated.

WHAT ABOUT MAYOBS13-2?

This cruise was trickier to organize. We needed to use specific acoustic equipment to observe the underwater eruption, study the morphology of the seafloor and record data from the water column (gas emissions, presence of certain particles). These multibeam echosounders, which can scan a very wide area and be used on the seafloor (over 3000 m deep), are few and far between. Our vessels were stuck in port and the French Navy's ships with this equipment were too far away, so we reached out to a private geophysical survey company, Fugro, which offered us the use of their ship *Gauss*. We tested the compatibility of their equipment with our needs and signed an agreement with them after receiving approval from REVOSIMA, the network in charge of monitoring this volcanic and seismic crisis. Then we began a brand new "remote operation" or "remote cruise"—we haven't yet found a term that fits. The crew and operators of the *Gauss* took measurements at the site and sent us the data.

DESPITE THE PANDEMIC, OUR SCIENTISTS HAVE FULFILLED THEIR DUTY TO CONTINUE MONITORING THE SUBMARINE VOLCANO NEAR MAYOTTE. SEEN HERE ARE THE PARTICIPANTS IN THE MAYOBS15 CRUISE ON THE *MARION DUFRESNE*. © Ifremer

We processed the data immediately so that we could tell them what to do next. Four of our acoustic data processing specialists, backed up by experts on this specific equipment (Ifremer and Genavir), and three mission leaders (Bureau de recherches géologiques et minières [BRGM], Ifremer, IPGP) formed a relay team and worked around the clock for seven days. This solution was what ultimately enabled us to carry out the mission.

WERE YOU ABLE TO CONDUCT OTHER CRUISES AFTER THE END OF THE LOCKDOWN?

We set off on the *Marion Dufresne* in October 2020, with stringent protective measures. The crew self-isolated for ten days at home first and underwent PCR and serology testing. Once confirmed to be negative, they embarked as soon as possible. On the ship, each person had their own cabin and had to wear a mask all day for 15 days, the time it took for the nurse to verify through another round of tests that no one on board had brought the virus with them. We are continuing to apply this type of protocol even today so that we can continue our cruises.

SEARCHING FOR POTENTIAL TRACES OF SARS-COV-2 IN THE MARINE ENVIRONMENT

Is SARS-CoV-2, the virus responsible for COVID-19, present in our water? Is it contaminating the marine environment? The Health, Environment and Microbiology Laboratory (LSEM) at Ifremer's Centre Atlantique sought to answer these questions. The researchers analyzed water samples and shellfish samples in the hopes of contributing to a better understanding of the virus. The first results showed that although traces of the virus were present in wastewater from treatment stations, the shellfish analyzed had not been contaminated.

SAMPLES OF SEAWATER, SHELLFISH AND WASTEWATER ARE COLLECTED AND FROZEN, THEN SENT TO IFREMER'S CENTRE ATLANTIQUE IN NANTES. © Ifremer

When the SARS-CoV-2 epidemic broke out, the LSEM was preparing to study virus circulation as part of the European project VEO (Versatile Emerging infectious disease Observatory). Naturally, the researchers chose to focus on this novel virus that was not yet well understood. They started by refining and testing their analysis protocol so it could be applied to different samples. Through collaboration with the other Environmental Resources laboratories in Ifremer's network, the researchers were able to take samples of wastewater, seawater and shellfish.

Although thought to be fragile and unlikely to be transmissible via wastewater, SARS-CoV-2 was nevertheless detected in wastewater networks in France and the Netherlands. Following this finding, the Ifremer team honed in on three wastewater treatment stations in western France, two in urban areas and one on the coast. Sampling was performed from March 16 to May 12 at the entrance to the treatment station (before retreatment). The analyses confirmed the presence of the SARS-CoV-2 genome in a majority of the samples, although the number of positive tests decreased as the epidemic waned at the end of April and the beginning of May.

In parallel, the researchers sampled seawater and shellfish while devising a sampling strategy that would allow them to test all three of mainland France's seafronts. The sites chosen—Normandy, Brittany, the Atlantic coast and the Mediterranean coast—were selected due to their exposure to sources of human fecal contamination. Clams, mussels and oysters from these sites were thoroughly examined and no trace of SARS-CoV-2 was detected.

In order to continue these analyses and track the dynamics of the virus throughout France, Ifremer joined the Obépine project (Observatoire épidémiologique dans les eaux usées) which aims to pool the results of wastewater analyses performed by French laboratories.

The French oceanographic fleet around the world

The fleet's 2020 activity must be considered in the very unusual context of the pandemic. The original schedule of scientific cruises was abruptly brought to a halt in mid-March when the government declared a lockdown. In the interest of protecting the ships' crews and scientists, Ifremer, the operator of the fleet, immediately ordered all ships to return to port in mainland France. Ifremer then had to wait until the situation improved in May before planning a return to activity.

Health protocols were established and the arduous task of rescheduling the scientific cruises began. Halfway through the year, ships were able to progressively return to sea and embark on several excellent cruises while following all of the necessary protective health measures. Almost 40% of the objectives planned before the crisis were achieved. The French Oceanographic Fleet also continued its R&D efforts and its renovations of vessels and equipment.

SEVERAL **REMARKABLE CRUISES**

Despite all of these difficulties, the fleet continued to support scientists from many institutions as they worked on their various projects: deep-sea ecosystems, climate regulation processes, marine biodiversity, hazard prediction and fisheries monitoring all remained key subjects, although much less work could be performed than usual.

- **Momarsat** — Since 2010, scientific cruises have been scheduled annually to ensure the maintenance of the EMSO-Azores seafloor observatory and to continue exploring the Lucky Strike hydrothermal vent field where the observatory is located, 1,700 m underwater. The year 2020 saw the ten-year anniversary of this amazing program that has greatly improved our knowledge of these special environments.

- **Acclimate 2** — R/V *Marion Dufresne* puts its unique equipment to use for thirty scientists from eleven countries who braved the harsh conditions of the Southern Ocean to extract several incredible sediment cores at depths of 1,000 to 4,600 m. By analyzing these giant samples, which are over 60 m long, they hope to better understand how the ocean has evolved over the past 500,000 years and ultimately create better climate prediction models.

- **Focus X1** — This cruise's goal was to use cutting-edge fiber-optic and laser measurement technologies to observe the behavior of an underwater fault—something that had never been done before. Scientists from the CNRS, the Université de Bretagne occidentale, Ifremer and the Institut de physique de Catane took up the challenge. The French Oceanographic Fleet drew upon all of its ingenuity to design an underwater plow for this specific project. The plow, operated by the submersible *Victor 6000*, made it possible to bury a cable in sediments more than 2,000 m below the sea surface for the new seismic surveillance network off the coast of Sicily.

- **Sealex** — French and Italian researchers wanted to understand how sediments ripped from valleys in the Alpes-Maritimes area by Storm Alex had dispersed into the sea. The *Pourquoi Pas?* had a rare window of availability and the fleet was excited to take on the project. The cruise was approved in two weeks. The team of scientists was able to take measurements and samples between the Var and Roya river mouths just a month after the end of the storm.

ONGOING FLEET **MODERNIZATION AND RENOVATION**

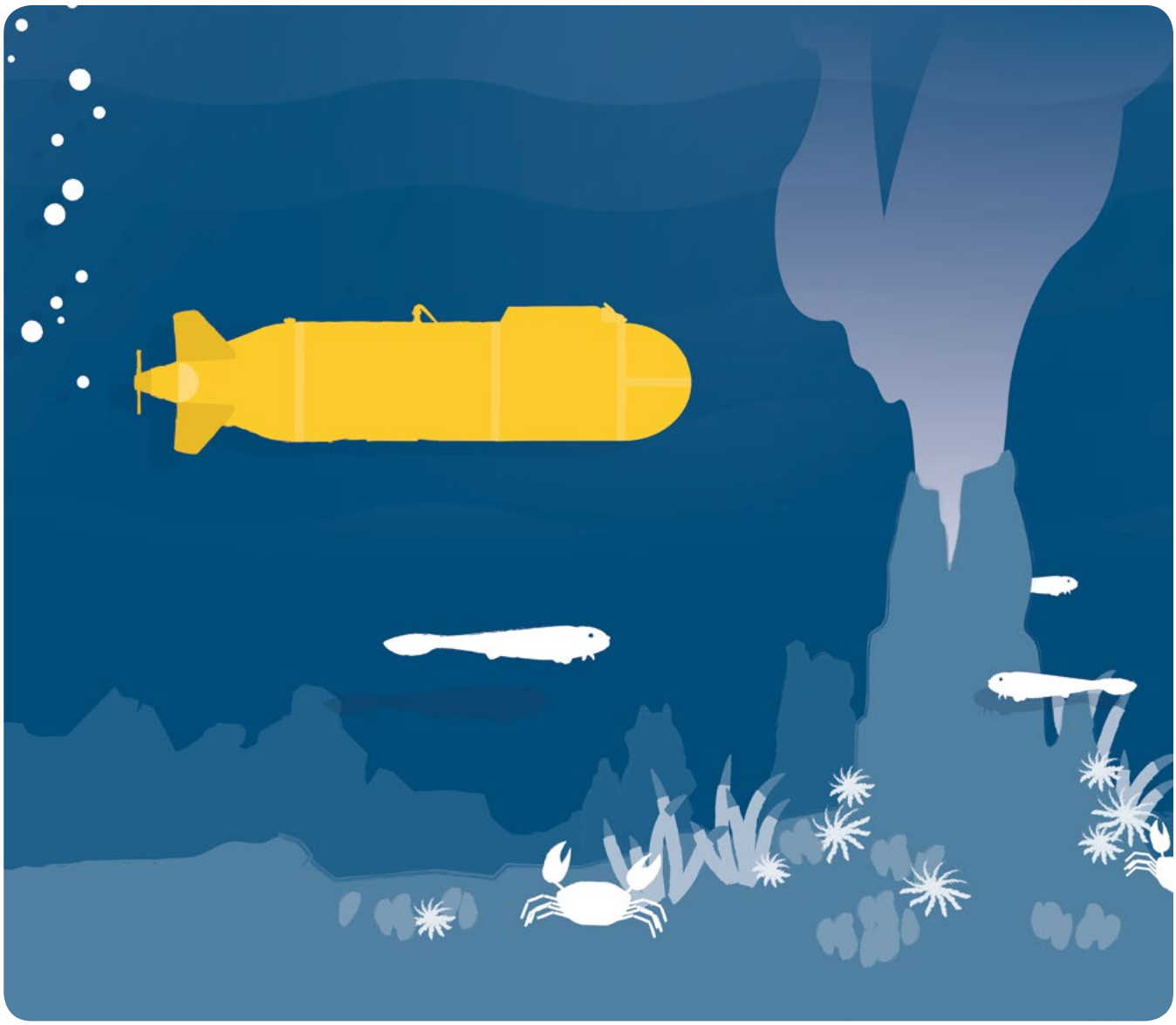
Keeping vessels and equipment in peak condition in order to offer scientists top-notch tools is a key objective for the future of the French Oceanographic Fleet. In 2020, several noteworthy advances were made in this regard.

- **Medium-term planning** — On October 8, 2020, Ifremer's Board of Directors voted on a medium-term plan for the French Oceanographic Fleet that runs through 2035. This document lays out the main investments in refits, construction and acquisitions that will replace vessels and equipment that are obsolete or at the end of their life cycle. Improving vessels' versatility and environmental performance are two of the main objectives of this plan, which also restates the fleet's desire to maintain its presence in all of the world's oceans and increase its capacities for seabed exploration.

- **Green Marine Europe Label** — Ifremer and Genavir were honored to receive the Green Marine Europe label. This new opt-in program for environmental certification offers ship owners the option to evaluate their ships based on several performance indicators. These include reduction of underwater noise—a criterion on which the fleet obtained the best possible score—reduction of emissions of greenhouse gases and various air pollutants, waste management and spill prevention.

  The issues of ship recycling and relationships with stakeholders in the maritime community are also taken into account in this evaluation.

- **Christening of the autonomous underwater vehicle *UlyX*** The fruit of several years of development, *Ulyx*, the latest addition to the French Oceanographic Fleet, represents a technological breakthrough due to its unprecedented navigational performance and cutting-edge equipment. *Ulyx* confirms France's position as a leader in deep-sea exploration, as France is one of just a few countries in possession of an autonomous underwater vehicle (AUV) that can descend 6,000 m into the depths. All domains within ocean sciences will benefit from it: oceanography and the study of the water column, geosciences, and seabed biology and ecology. This AUV was designed to be useful for a wide range of assignments, from the study of mineral resources and deep-sea ecosystems to the biogeochemical characterization of different environments.



ARTIST'S DEPICTION OF THE ULYX SUBMERSIBLE
© Ifremer / Jérémy Barrault

More details can be found in the French Oceanographic Fleet's annual report, available for download here:
https://www.flotteoceanographique.fr/en/Who-we-are/Rapports-et-publications/Activities-reports

Protecting and restoring the seas and oceans

A vibrant, healthy, safe and resilient ocean

The ocean produces the oxygen that we breathe. It feeds us. It provides energy and it regulates our planet's climate. In monitoring the ocean and seeking to understand it, Ifremer works to preserve our shared future and keep the ocean vibrant, healthy, safe and resilient.

STUDYING, PRESERVING AND RESTORING MARINE BIODIVERSITY AND ECOSYSTEMS

WHAT FACTORS MIGHT EXPLAIN THE DISTRIBUTION OF FAUNA IN DEEP HYDROTHERMAL SYSTEMS?

For many years, Ifremer has been studying the rich ecosystems that have developed around deep hydrothermal vents situated along ocean ridges. The searingly hot fluids loaded with heavy metals that stream out of these vents play a role in the formation of large geological structures that are home to a wealth of ocean life. In 2020, biologists from the Institute focused on the factors affecting fauna distribution on these vents. They characterized and compared the fauna of several structures within a single vent field and across different vent fields.

Their work was summarized in a publication in the journal *Deep Sea Research*. Three distinct hydrothermal fields in the Azores were studied. They were far away from each other and situated at different depths. The first, Lucky Strike (1,700 m deep) is already relatively well known due to the presence of a seabed observatory that has been providing data continuously since 2010. The second, Menez Gwen (825 m), is 100 km northward, and the third, Rainbow (2,275 m), is 300 km to the south.

To conduct the study, the researchers concentrated on a species of mussel that is widespread in these hydrothermal vent fields: *Bathymodiolus azoricus*. This "engineer" species plays an important role in the development of animal communities because its three-sided structures form scaffolds in which dozens of other species can find food and shelter.

THE LUCKY STRIKE HYDROTHERMAL SITE TEEMS WITH ABYSSAL LIFE IN THE MIDDLE OF THE ATLANTIC OCEAN. © Ifremer

After studying the composition, abundance and diversity of this fauna on different vent structures, the researchers concluded that each field has its own "signature" related to its depth, chemistry, geology and evolution. However, there are similarities even between far-flung fields, like Lucky Strike and Rainbow, which show that some of these animals can spread out over a wide area to colonize other spaces. The role of currents and certain types of biogeographic barriers was also examined to see if it could explain the differences observed in fauna distribution. Studies continue today, exploring the influence of the tides on the fauna in these deep hydrothermal ecosystems.

Sarrazin J., Portail M., Legrand E., Cathalot C., Laes A., Lahaye N., Sarradin P.M., Husson B. 2020. Endogenous versus exogenous factors: What matters for vent mussel communities? *Deep-Sea Research Part I*, https://doi.org/10.1016/j.dsr.2020.103260

HOW CAN WE HELP NATURE RECLAIM A MARINE SPACE COLONIZED BY HUMANS?

Often damaged by port and urban development, coastal shallows (between 0 and 20 meters deep) are nevertheless essential for the growth of many species of fish that then migrate toward their adult habitats. Aiming to revive the ecological functions of these habitats, Ifremer researchers have worked with partners to test artificial reefs and seagrasses in the port of Toulon. The artificial reed beds reproduce the habitats of local marine species by mimicking the characteristics of Mediterranean Posidonia meadows. They are composed of concrete blocks designed and 3D-printed by the Montpellier start-up Seaboost, and they contain many pockets to shelter fish.

These structures were installed in several places in the Bay of Toulon, which is a pilot site for studying the large-scale impact of these innovative ecological restoration solutions. Regular monitoring will be carried out by biologists on dives and by remote surveillance tools (acoustic devices, stereo cameras, automatic fish recognition tools), a brand-new approach. Other ports have already shown interest in this type of system.

ARTIFICIAL REEFS TO BRING MARINE LIFE BACK TO PORTS: A PILOT EXPERIMENT IN ENVIRONMENTAL RESTORATION UNDERTAKEN BY IFREMER AND ITS PARTNERS IN THE BAY OF TOULON. © Seaboost

This project, which connects a research institute and a private company to the people managing these waters, is setting an example for others. It is one of the biggest environmental restoration projects in the Mediterranean. Ifremer's hub in La Seyne-sur-Mer has collaborated closely with the company Seaboost, which is developing new concepts for fostering marine biodiversity. The installation of these artificial structures was made possible, in part, by assistance from two actors that place high value on the protection of biodiversity: Toulon Provence Méditerranée (TPM), the port authority; and the Chamber of Commerce and Industry of the Var, the port operator.

IFREMER SCIENTISTS WATCH OVER SEA TURTLES IN THE INDIAN OCEAN AS PART OF THE NEXT AND IOT PROJECTS. © Ifremer / Dalleau Mayeul

We should not forget, however, that this type of ecological restoration depends on the specific environmental conditions of the coastal area chosen, and particularly its level of chemical contamination. Although the trend at this stage is toward improvement, the efforts (especially as regards sanitation) must continue in order to make these restoration solutions truly effective

TRACKING SEA TURTLES TO BETTER PROTECT THEM

In 2020, Ifremer prioritized the conservation of sea turtles, and two threatened species in particular: the green turtle (*Chelonia mydas*) and the hawksbill turtle (*Eretmochelys imbricata*). Scientists attached tracking equipment to several individual turtles in order to better understand their behavior in their natural environment and consequently improve population management and protection. They conducted their studies in a part of the Indian ocean known for being one of the world's largest sites for turtle reproduction and egg-laying.

In Réunion, within the context of the project NExT, a team of scientists is studying how young turtles use their habitat and how human activities alter the turtles' health. The scientists measured, weighed and took samples from around forty young turtles of both species, collecting valuable information for evaluating their stress levels as their environment changes due to (for example) predation, tourism and heavy metal contamination. Eight of the turtles were equipped with commercial GPS systems enabling the scientists to track their daily movements and learn more about their activities.

Another team spent five weeks in the Mozambique Channel on Europa Island, the largest of the Scattered Islands, which are part of the French Southern and Antarctic Lands. Since it was not possible to resupply during the mission, the scientists had to take over 820 kg of food and supplies on board. They attached next-generation electronic tags to three juvenile turtles as part of the IOT project (*Indian Ocean sea Turtles*). Then the team installed a network of receiver stations on the island to collect and transmit the data from these tags to the researchers. This new open-source tracking system—smaller, more precise and cheaper than before—will allow scientists, protectors of marine species and even associations to track more turtles than before and at a lower cost. A win-win for science and for the sea turtle population!

The NExT project team counts scientists from Ifremer, the CNRS — Institut pluridisciplinaire Hubert Curien (IPHC), Kélonia and the Centre d'étude et de découverte des tortues marines (CEDTM). The IOT project is co-financed by the European Union as part of the 2014–2020 Interreg V Indian Ocean cooperation program, and it represents collaboration among several partners: Ifremer, the CNRS, the French Southern and Antarctic Lands, the departmental council of Mayotte, and the Seychelles Islands Foundation.

UNDERSTANDING
CLIMATE-OCEAN INTERACTIONS

DARWIN WAS WRONG ABOUT HOW ATOLLS FORM!

In 1842, after a trip to Polynesia and the eastern Indian Ocean, Charles Darwin decided that atolls must be the remains of collapsed volcanic structures. This theory is still widely taught and communicated by museums and on the internet, but new knowledge acquired by Ifremer researchers is calling it into question. Geological data from drilling and seismic studies, along with a better understanding of sea level fluctuations over time, tell an entirely different story that Ifremer and Rice University (USA) recount in a new publication.

It is now believed that the atolls formed 3.2 million years ago. At that time, the planet was experiencing a long stretch of stable climatic conditions that continued for at least 80,000 years. The sea level varied little if at all during this phase, and flat banks of sediment accumulated on the ocean's shoals.

During a second phase of development, 2.5 million years ago, these flat-topped banks transformed as the climate changed, the ice caps grew and shrank, and sea levels rose and fell. Sometimes underwater, sometimes exposed, these landforms eroded bit by bit. Rain fell on them and dissolved their carbonate, which shaped new bowl-like structures with a central depression surrounded by higher edges.

ATOLLS IN THE MALDIVES © Tamas Kauffmann

Starting during the Mid-Brunhes Transition, around 400,000 years ago, these embryonic atolls underwent a new transformation. The sea level changed more frequently, and by as much as 125–135 m. Each time the pre-atolls were submerged, when the environmental conditions were right, corals made their home on the high edges of the landforms and created rings around deep lagoons, giving atolls their characteristic shape.

The atolls continue to evolve under our current climate changes, which render their future uncertain. Some believe that warmer waters coupled with faster sea level rise will be fatal to the atolls, while others believe that they will be able to adapt.

Droxler AW, Jorry SJ. 2021. The origin of modern atolls: Challenging Darwin's deeply ingrained theory. *Annual Review of Marine Science* 13:21.1-21.37, https://doi.org/10.1146/annurev-marine-122414-034137. https://www.annualreviews.org/doi/10.1146/annurev-marine-122414-034137

IS CLIMATE CHANGE SHRINKING SARDINES AND ANCHOVIES?

Sardines and anchovies, key elements of the ocean food chain, are some of the most heavily fished creatures in the world. Their populations are relatively abundant around mainland France today, but fishermen and scientists have been noticing a decrease in their size and weight over the past ten years. The length of Mediterranean sardines has shrunk from 13 cm to 10 cm, while their weight has dropped by two-thirds. Several projects led by Ifremer show that this phenomenon could be linked to climate change.

SHRINKING BY CENTIMETERS AND GRAMS: SARDINES HAVE BEEN GETTING SMALLER FOR 10 YEARS, A CONSEQUENCE OF GLOBAL WARMING © Tanaka Juuyoh

In the Bay of Biscay, teams studied the waters' warming and observed that it would have no negative impact on the abundance of anchovy populations until 2050, but that it could be affecting the growth of individual fish. Warmer water leads to earlier plankton production, which benefits anchovies earlier in the year—as soon as winter ends. However, these plankton could be less abundant and of a different composition, which would affect the size of the fish.

Other studies were carried out in the Mediterranean to figure out why sardines were becoming smaller and thinner. An analysis of fish stomach contents revealed that the size of the plankton ingested had decreased since 2008.

Furthermore, experiments performed on captive fish showed that the smaller the plankton were, the more energy the sardines expended while feeding. The scientists also found that sardines caught today are much younger than those caught ten years ago. This may be due to the precocious death of adult sardines following reproduction. Since they are smaller and in worse physical condition when they reproduce, they may be using up too much of their energy, leaving them unable to survive the winter.

This new information about these small pelagic fish spurred scientists and industry professionals to seek solutions to ward off the repercussions of these changes on fisheries and the downstream activities of processing and distribution. DEFIPEL, a project launched in October 2019, continues in this vein with scientists (ecologists, fisheries experts, economists) and industry actors (fishermen, processors, managers of fisheries and maritime areas) working together on three seafronts (the English Channel, the Bay of Biscay and the Mediterranean).

TIDES INFLUENCE METHANE EMISSIONS IN THE ARCTIC

Gas hydrates are a fascinating natural phenomenon. These tiny molecules—often methane—are trapped in "cages" of water in their solid state, but when the temperature or pressure changes, they transform into their liquid and gaseous states and dissolve into ocean water or the atmosphere. Methane is very flammable, which lends gas hydrates the moniker of "ice that burns." Our understanding of these phenomena has progressed with new knowledge of the tides' influence on the intensity and periodicity of gas emissions in the Arctic Ocean. This discovery, made by a team of marine geosciences researchers from Ifremer and the University of Tromsø, was published in the prestigious scientific journal *Nature Communications*.

Gas hydrates are present in every ocean. There are, however, many challenges inherent to their study. Some see gas hydrates as a potential source of energy. Others are concerned that releasing these gases could acidify the ocean, with negative consequences for marine biodiversity and ecosystems. This could also increase the emission of greenhouse gases into the atmosphere, and methane is twenty five times as harmful in the atmosphere as CO2! Furthermore, the degradation of gas hydrates comes with geological risks. Destabilizing underwater sediments can lead to landslides and tsunamis.

Due to these risks, scientists keep a close eye on sites where gas hydrates have been detected. Researchers from Ifremer and their partners from the Arctic University of Norway and the Geological Survey of Norway have begun a mission on the western edge of Svalbard, near the Arctic Circle, an area known for its plentiful gas hydrates and its sensitivity to climate change.

Special piezometers (tools for measuring pressure) developed by Ifremer were deployed in sediments at a depth of 1,100 m and yielded valuable data suggesting a correlation between the tides and the intensity and periodicity of gas discharge.

Methane emissions effectively stop when the tide is high, but methane seeps into the water column at low tide. Additional investigations will be conducted to substantiate these first observations. If this hypothesis is supported, a rise in sea levels—an expected consequence of climate change—could partially counterbalance the effect of ocean warming on methane hydrates and slow the speed of gas emission.

The publication can be found on the website of the journal *Nature*.
https://www.nature.com/articles/s41467-020-18899-3

REMOTELY OPERATED SUBMERSIBLE VICTOR 6000
GRIPS A CHUNK OF GAS HYDRATE, THE MYSTERIOUS "ICE THAT BURNS."
© Ifremer

PREDICTING, PREVENTING, AND RESPONDING TO EXTREME WEATHER AND EARTHQUAKE EVENTS AND THEIR IMPACTS

MONITORING OF THE MAYOTTE VOLCANO CONTINUES

In May 2019, a new volcano 800 m tall was discovered 3,500 m underwater about 50 km east of Mayotte. Its presence explained the unusually frequent and intense earthquakes that the island had been experiencing for several months. Shortly after this discovery, a network for volcanic and seismic monitoring near Mayotte called REVOSIMA was created to coordinate the actions of the Institut de physique du globe de Paris (IPGP), the BRGM, the CNRS, Ifremer, the Institut du physique du globe de Strasbourg (IPGS), the Service hydrographique et océanographique de la Marine (SHOM) and the Université Clermont-Auvergne. In 2020, despite the difficulties caused by the pandemic, these observational missions continued in order to gather the necessary information to protect the population of Mayotte.

From May 4 to May 11, 2020, a first cruise on the *Gauss* (from the company Fugro) was directed remotely by Ifremer, the IPGP, the BRGM and the CNRS with the aim of observing the evolution of the submarine volcano's eruption. This cruise yielded surveys of the seabed and images of the water column over a surface area of about 1,500 km, east of the island of Mayotte. The data shows that the volcano's morphology has not changed significantly since August 2019, although the topography of the "volcano zone" has been altered in the northwest over a section of about five square kilometers. New lava flows could be behind these changes, which would suggest a continuation of the volcanic activity. Studies are ongoing.

From May 6 to May 19, 2020, another essential cruise took place thanks to the help of the French Navy and its overseas support and assistance ship *Champlain*. On board, a team of scientists from Ifremer, the IPGP and the CNRS located, repaired and redeployed the underwater seismological stations that had previously been placed in the area to complement the data stations on land.

This mission was crucial, since these devices' batteries were about to reach the end of their life. The data recovered, which spanned a period of several months, confirmed a decrease in both the frequency and the intensity of seismic activity.

A third cruise took place in October on R/V *Marion Dufresne* to perform the operations that had not been possible in May. The results are currently being studied.

TRACKING AND LIMITING THE IMPACTS OF HUMAN ACTIVITIES, POLLUTION, AND CHEMICAL, PHYSICAL AND BIOLOGICAL CONTAMINANTS

PESTICIDE CONTAMINATION IN MARINE ENVIRONMENTS

To date, 479 herbicides, insecticides and fungicides have been authorized for use in Europe. They are used to treat agricultural land, green spaces, sports fields and transport infrastructures. Once applied, all of these substances can reach the marine environment—the ultimate recipient of land contaminants—and affect the organisms that live there. To better understand the factors at play and protect the marine environment, Ifremer is working on several fronts.

In partnership with the French national research institute for agriculture (INRAE), Ifremer is carrying out a collective scientific research project (ESCO) on the impact of agrochemicals on biodiversity and ecosystems. The study aims to take stock of current knowledge on the subject and identify any gaps. Thanks to ever-improving modern tools and methods, scientists now know that pesticides are present in all marine environments, from coastlines (sometimes at very high concentrations) to the high seas (where trace amounts have been detected). Several studies provide evidence for the impact of these products on marine organisms' reproduction, development and immune systems. Nevertheless, there still remains much to learn about these molecules, what happens when they are combined and the cascading effects on different species and their environments.

THOUGH RARELY EXPOSED TO PESTICIDES, THE LA PALME LAGOON IN OCCITANIE IS SUFFERING FROM THE EFFECTS OF METOLACHLOR. REDUCING THE USE OF THIS SUBSTANCE IN OCCITANIE'S WATERSHEDS WOULD REDUCE THE RISKS TO THESE ECOSYSTEMS.
© IFREMER, D. MUNARON. © Ifremer / Dominique Munaron

Along the same lines, Ifremer shared the results of a pilot study evaluating the pesticide contamination levels of ten Mediterranean lagoons. These enclosed spaces are highly sensitive to this type of pollution. At three different points in the year, seventy two substances were measured by passive samplers that can detect even minute concentrations of these compounds in water. One of the main results of this work was the successful evaluation of risk as it relates to pesticide concentration, by defining a specific indicator for measurement. Though yet to be perfected, this method made it possible to determine and compare pesticide risk depending on the lagoon, the species present, and the time period or year. The new data highlights the importance of studying these pesticide mixtures and their effects on natural environments

AN UPDATE ON THE HEALTH OF FRANCE'S COASTS

On July 9, 2020, Ifremer held a press conference to present the latest update from its monitoring of France's coastal health. The in-person event was organized in Nantes with the Loire-Brittany water utility and was broadcast live. It was a great success, with over 120 mentions in the press and over 20,000 interactions on social media. Ifremer scientists explained what they are monitoring and why, and presented the changes they have observed over the past few years. They noted some encouraging examples of resilience while being careful to indicate the elements that demand continued vigilance.

For more than 30 years, Ifremer has been monitoring the health of France's coastal marine environments. Researchers' observations influence their understanding of these environments, which in turn informs public policy decisions and helps to improve the situation. The changes highlighted by their work are relatively positive. Chemical contamination of the environments observed has mostly dropped below regulatory thresholds. Instances of microalgae proliferation and eutrophication (a degradation of the aquatic environment) are decreasing along with microbiological contamination phenomena.

However, there are still some areas such as estuaries, the immediate surroundings of cities and large water treatment plants, and enclosed natural spaces where the situation remains concerning. All of these factors support the continuation of environmental improvement efforts, especially regarding water treatment processes.

This press conference enabled Ifremer scientists to discuss several key examples, such as the long regeneration process of the Thau lagoon. Armed with several decades' worth of data, researchers from Ifremer and the Université de Montpellier (Marbec mixed research unit) showed that it took thirty years after the installation of the first water treatment stations for the water in the Thau lagoon to return to a healthy ecological state.

Several innovative initiatives were also presented to the public. With the high-tech equipment used for its Veille-POP project, Ifremer has broadened its surveillance of persistent organic pollutants. Another example is the citizen science project Phenomer, which gives the public a means to alert scientists if they spot colored waters in Brittany or the Loire-Atlantique region. There are also other research projects under the umbrella of the "One Health" concept, which encourages the assessment of prevalent or emergent viruses discharged into the coastal environment.

The success of this press conference has inspired Ifremer to hold similar events in the future.

SAMPLING NEAR THE MOUTH OF THE LOIRE FOR A REPHY OBSERVATION STATION THAT WILL HELP MONITOR PHYTOPLANKTON NUMBERS AND MEASURE OTHER ASPECTS OF THE WATER COLUMN (TEMPERATURE, SALINITY, DISSOLVED OXYGEN AND TURBIDITY). © Ifremer

Sustainably managing marine resources for the well-being of human communities

— An ocean of solutions —

Ifremer researches, innovates and performs expert assessments to propose sustainable ways to feed, care for and produce energy for what will soon be nine billion humans on Earth.

ENSURING THE SUSTAINABILITY OF FISHING AND AQUACULTURE

BLUEFIN TUNA: LONG-HAUL TRAVELERS!

Bluefin tuna are known for their propensity for long voyages, but much about their ocean wanderings remains unknown to science. Ifremer and its partners have been working on a fish tagging campaign for two years in order to learn more about their migratory behavior and the environmental conditions along their path. This new knowledge will greatly serve the International Commission for the Conservation of Atlantic Tunas (ICCAT).

Native to the Atlantic Ocean and the Mediterranean Sea, bluefin tuna, which can weigh over 600 kg and live for more than forty years, are tireless swimmers. Their incessant migrations are motivated by two essential needs: feeding and reproduction. Unlike other species of tuna, which are tropical or subtropical, bluefin tuna tolerate the cold waters where they feed as well as the warm waters where they reproduce.

TUNA ARE TIRELESS SWIMMERS.
© Tom Puchner

In one of these reproduction zones, south of Malta, Ifremer took advantage of a fishing expedition to capture tuna and implant electronic trackers. This mission was performed aboard a fishing boat and featured a host of logistical challenges. In order to limit stress on the tuna, the fish (sometimes weighing over 200 kg) had to be hauled on board, tagged in a specific spot on their back and released back into the sea, all in a very short span of time.

The 2019 cruise delivered some instructive results. Five individuals were tagged and three of the tags stayed in place for more than ten months, bearing witness to the bluefins' travels. One of the fish crossed the Atlantic twice before making its way back to the Mediterranean!

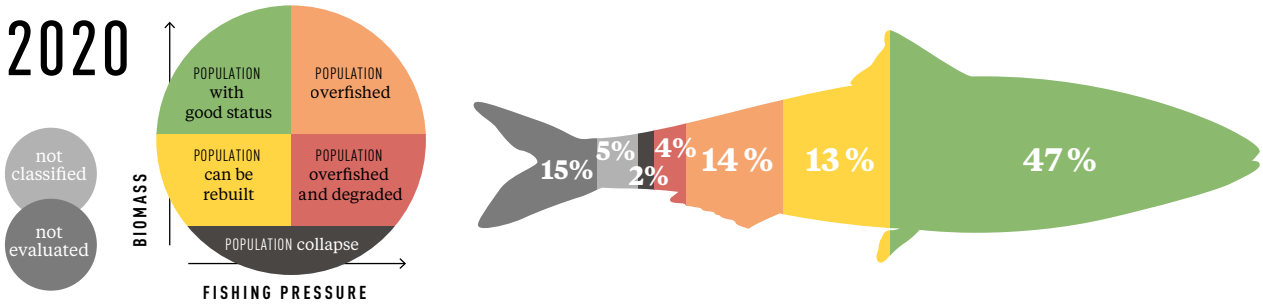
The quality of the information collected depends heavily on advancements made in electronic tagging. Within the research programs POPSTAR and FishNchip, Ifremer's scientists have made it their mission to develop smarter trackers that will make it possible not only to calculate trajectories using oceanographic models based on parameters like temperature, light and pressure, but also to obtain measurements of the fish's physiology, synchronized with its location. This is a first!

Involved in this operation: Ifremer (RDT, DOI and Marbec units); the Laboratoire d'Informatique, de Robotique et de Microélectronique de Montpellier (LIRMM); SATHOAN (a group of tuna producers) and the European Maritime and Fisheries Fund (EMFF).

CLOSE TO HALF OF THE FISH BIOMASS CAUGHT IN FRANCE COMES FROM SUSTAINABLY FISHED POPULATIONS

Every year, Ifremer participates in the evaluation of French fisheries populations and to do so, it operates the Fisheries Information System (SIH) which consolidates national data on the subject. The report on the information collected in 2019 and analyzed this year is generally positive. It shows that the ecological status of fish populations exploited in France is clearly improving. In 2020, 49% of the fish biomass caught came from populations with a "good ecological status"—that is, populations with a long-lasting equilibrium between reproduction and the portion of the population removed by fishing.

These results are encouraging when considering the fact that this figure was no higher than 15% twenty years ago. However, it must be noted that the goal of 100% of fished populations reaching good ecological status by 2020—the aim of European regulations—is still out of reach.



STATUS OF FISH POPULATIONS EXPLOITED IN MAINLAND FRANCE IN 2020 (SHARE OF CATCH BY VOLUME). © Jérémy Barrault / Ifremer

Science has greatly contributed to this positive trend for fish populations. New knowledge in biology and ecology has made it possible to enlighten fish population managers and provide support for their decisions. Over the past twenty years, Ifremer researchers have expanded the scope of fisheries evaluations by taking twice as many fish species into account and reducing the proportion of populations that are unclassified. It is now possible to predict the evolution of the main fish populations exploited based on different management scenarios and, importantly, to determine the level of fishing intensity that is compatible with the Sustainable Development Goals. Our scientists are continuing their efforts by turning to genetics, as one example, to fine-tune new methods for counting fish.

This information on fisheries populations is crucial for shaping fishing policies, establishing quotas that correspond to the available resources and broadening adoption of more selective fishing tools. In the 1990s and 2000s, scientists raised the alarm and spurred public powers to tackle the overexploitation of bluefin tuna in the Mediterranean and the collapse of hake populations in the Bay of Biscay and the Celtic Sea. These two species' populations are today evaluated respectively as "rebuilding" and "good status," to the benefit of the fishing sector.

Of course, 2019's diagnosis shows that there is still a long road ahead. The ecological status of several species, such as the cod and whiting populations in the North Sea and the Celtic Sea, remains worrying. The situation is also troubling in the Mediterranean.

SCIENCE OUTREACH ABOUT SUSTAINABLE FISHING

Through its new science outreach project, "Débattre sans se battre" (Debating without fighting), Ifremer intends to help sharpen younger generations' critical thinking. In an environment overflowing with information that can be shared instantly with audiences of any size, often without any real fact-checking, it's more and more important to ensure that children learn to separate the wheat from the chaff. With this aim, Ifremer and its partner Les Petits Débrouillards (a community network promoting scientific culture as part of public education) have designed an initial series of lessons for high schoolers that focuses on sustainable fishing practices.

The lesson series has two main objectives: first, to familiarize young people with speaking in public on topics relevant to society, and second, to teach them to unmask misinformation by drawing inspiration from the scientific method. It includes several sessions on debate techniques, and others on evaluating media to find reliable sources of information. Laboratory visits and discussions with Ifremer researchers are also planned so students can understand the long road between the formulation of a hypothesis and its scientific validation. The culmination of the lesson series is an organized debate in which each student participant must defend their point of view eloquently and with a well-structured argument.

A DISCUSSION BETWEEN STUDENTS AND SCIENTISTS AS PART OF THE NEW SCIENCE OUTREACH PROJECT "DÉBATTRE SANS SE BATTRE." THE OBJECTIVE: SHARPENING YOUNG PEOPLE'S CRITICAL MINDS USING SCIENTIFIC REASONING. © Ifremer / Jade Burdallet

For this first edition, Ifremer has given classes a ready-to-use dossier of educational information on sustainable fishing. Scientific evidence sheds light on some of the controversial questions that are often thrust into the media spotlight, such as: will there still be fish in the sea in 2050? How can we limit fishing activities' impacts on ecosystems?

Are the current quality labels satisfactory? High schoolers consider these issues and more when investigating and constructing their own positions in the debate on sustainable fishing.

FISH AND CLICK, A CROWDSOURCING PLATFORM FOR REPORTING FISHING WASTE

Reducing the amount of plastic in our oceans is one of the challenges on Ifremer's radar. Ifremer researchers are working specifically on the problem of waste from fishing, which is a significant source of this pollution.

In 2018, abandoned fishing equipment (nets, traps) represented 27% of the plastic waste found on beaches. This type of waste is also found in the sea, where waves and UV rays break it down into microplastics. Another problem is that even if this fishing equipment is abandoned, it continues to trap marine animals in a phenomenon called "ghost fishing."

As part of European project INdIGO, which focuses on the development of biodegradable fishing equipment, Ifremer has decided to create a map of this waste by appealing to the civic-mindedness of the population at large—fishermen (amateur and professional), beach strollers, swimmers and so on.

To do so, its researchers designed the app Fish and Click, which can be downloaded to a smartphone and used to report fishing waste.

WITH CROWDSOURCING APP FISH AND CLICK, YOU CAN REPORT DISCARDED FISHING EQUIPMENT AND TAKE ACTION AGAINST PLASTIC POLLUTION IN OUR OCEANS. © Ifremer / Geraldine Guillevic

It's very simple. Users sign in to the platform and fill in the location, date and type of equipment found, then attach a photo. Of course, they are then encouraged to pick up the discarded equipment and dispose of it in a trash can or at a beachside waste collection point.

The data collected enables researchers to map out fishing waste and take stock of the situation in Brittany and Normandy. Over a longer term, this information will be helpful for measuring changes in fishing waste pollution and determining whether the use of biodegradable materials reduces it.

The Interreg INdIGO project is directed by the Université de Bretagne Sud and involves institutions on both sides of the Channel: Ifremer, the University of Plymouth, the University of Portsmouth, the Centre for Environment, Fisheries and Aquaculture Science (Cefas), Synergie Mer et Littoral (Smel) as well as four private partners: NaturePlast, Filt, Irma and Marine South East.

KEEPING SHELLFISH **HEALTHY**

BUILDING AN ON-SITE IMAGING SYSTEM TO DETECT MARINE BIOTOXINS

Harmful algal blooms, also called HABs, are sporadic natural phenomena that can have serious consequences for the environment, human health and economic activities that depend on water quality. HABs are caused by the excessive growth of microalgae, some of which produce toxins. These toxins can accumulate and become concentrated, particularly in shellfish, which makes them unsuitable for consumption. Toxic blooms of diatoms from the genus *Pseudo-nitzschia*, which emit a neurotoxin known as domoic acid (DA), are more and more worrying since their frequency and intensity has increased over the past few years on our coasts. And yet, despite the threats inherent in these HABs, there is no automated sensor on the market that can detect the presence of DA in seawater.

Researchers have been working for several years to design such a device using optical technology called surface plasmon resonance (SPR). This technology would make it possible to detect various types of molecules at very low concentrations, in real time and without performing any prior marking. Ifremer has created and field-tested a first prototype that appears promising. Continuing their efforts, the researchers have fine-tuned a new and improved biosensor that facilitates automated SPR imaging (SPRi) and meets all requirements for sensitivity, compactness and cost-effectiveness.

THE NEW SPRI SENSOR DEVELOPED BY IFREMER IS DESIGNED TO DETECT BIOTOXINS LIKE DOMOIC ACID IN THE OCEAN. © Ifremer

This new sensor also makes it possible to conduct multiplexed analyses (that is, analyses with multiple simultaneous targets). Its performance, first studied in the laboratory, has now been successfully tested in a mesocosm (in this case, an enclosed aquatic environment reproducing the conditions of the natural environment), which represents noteworthy progress toward *in situ* detection of marine biotoxins (as in the European project JERICO-NEXT).
This prototype is currently being adapted for other applications such as the field detection of metallic ions in the deep seas (the SURIMI project, ANR-18-CE04-0010).

Prado Enora, Colas Florent, Laurent Sebastien, Tardivel Morgan, Evrard Justine, Forest Bertrand, Bocher Alan, Rouxel Justin (2020). Toward a SPR imaging in situ system to detect marine biotoxin. *Proceedings Volume 11361, Biophotonics in Point-of-Care*; 113610J (2020)

PORTRAIT OF AURÉLIE BOISNOIR, FRANCE'S WINNER OF THE 2020 RISING TALENTS PRIZE FROM THE L'ORÉAL-UNESCO FOR WOMEN IN SCIENCE PROGRAM

AURELIE BOISNOIR © FONDATION L'ORÉAL

A postdoctoral researcher at Ifremer's Antilles station in Martinique, Aurélie Boisnoir studies toxic benthic dinoflagellates. In 2020, she was selected as a Rising Talent in France by the L'Oréal-UNESCO For Women in Science program. This prestigious award was given to only 35 young scientists this year out of nearly 700 candidates. Here, we explore her career path so far, her work and her ambitions for the future.

WHAT LED YOU TO BECOME A RESEARCHER IN MARINE BIOLOGY?

First, I did a university degree in Environment and Earth Sciences in Guadeloupe. Then, I left to do a master's degree at Université Pierre et Marie Curie in Paris. At that point, I chose marine biology and oceanography as my main areas of interest. It was also during this master's degree that I learned about the issue of toxic microalgae.

As for my interest in academic research, that grew slowly over time. I don't think that that's something you can plan. I had always liked lab work, starting when I was an undergraduate. My professors had a wealth of interesting knowledge. Then, I found a subject that I was fascinated by and that I wanted to make the subject of a doctorate.

WHAT ABOUT TOXIC MICROALGAE CAUGHT YOUR ATTENTION?

During my master's degree, a lecturer offered me an internship on toxic benthic dinoflagellates, since there was a study to be done in the French Antilles and I was familiar with Martinique and Guadeloupe. The internship focused on the distribution of microalgae involved in types of food poisoning such as ciguatera, which is widespread in the Caribbean and which can cause many different digestive, neurological and cardiovascular symptoms. These microalgae were formerly restricted to the tropics but can now be found in temperate regions too. This project caught my attention right away. It was a marine biology issue that required an interest in several other scientific disciplines and that had health-related and economic repercussions. The cross-disciplinary nature of this project and its associated challenges really interested me. I thought that I could bring something to the table. After that, I had the great fortune of meeting Gwenaël Bilien, Nicolas Chomérat and Jean Pierre Allenou, which is what led me to this postdoc at Ifremer after a work experience in the United States.

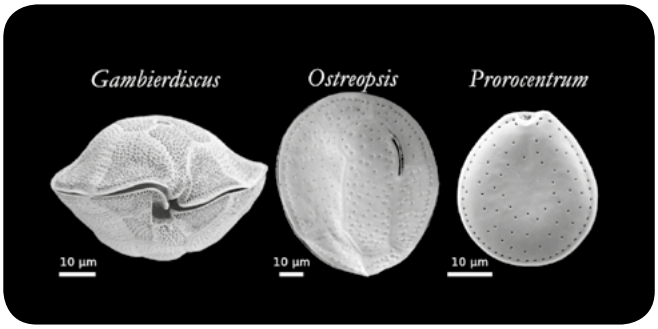
WHAT DOES YOUR RESEARCH CONSIST OF NOW?

The objective is to describe the genetics of each of the different species of benthic dinoflagellates present in the French Antilles and quantify their respective toxicities. Until now, these species were identified mainly through observation of their morphological traits, but we realized that these criteria weren't sufficiently reliable for telling species apart from each other. That's why we use genetic tools now. We have already distinguished several species belonging to the genera *Gambierdiscus* and *Fukuyoa*, and there are others belonging to the genera *Ostreopsis* and *Prorocentrum* that we're trying to identify. This diversity could contribute to the clinical picture of ciguatera and explain the variety of symptoms observed in people who have been poisoned after consuming seafood contaminated by these toxic algae. In Martinique, doctors have recorded 175 different symptoms! We are working closely with the university hospital center in Martinique on this public health dimension.

DID YOU HIGHLIGHT THIS RESEARCH WHEN YOU SUBMITTED YOUR CANDIDACY FOR THE L'ORÉAL-UNESCO AWARD?

Yes. Applicants had to submit a portfolio of our current research and our future projects, since those are the ones that the award would fund if we won. I laid out my current work on toxic benthic dinoflagellates and presented my prizewinning project, which consists of continuing and expanding Maria A. Faust's work. Dr. Faust has done a tremendous amount of work on the taxonomy of toxic microalgae, but using morphological criteria. The goal is to conduct new investigations and reinterpret her results in light of the genetic tools that we now have available. This award is a great source of pride for me, and also for everyone at Ifremer who encouraged me to apply, such as the teams in Concarneau and Martinique. Without their encouragement, I probably wouldn't have gone for it.

Benthic dinoflagellates are microscopic algae that need to attach to a structure (dead coral, macroalgae, marine phanerogams, plastic debris) in order to grow. When highly concentrated, these microalgae can detach from those structures and float in the water column. Ecosystem degradation, water temperature increases and coastal eutrophication all contribute to the appearance of benthic dinoflagellate blooms. Some species synthesize toxins that accumulate within marine organisms. Since the toxins are temperature-resistant (deep-freezing, freeze-drying, high-heat cooking and smoking have no effect on them), they expose the human population to potential health risks.



MICROALGAE STUDIED BY AURELIE BOISNOIR
© Ifremer

EVALUATING THE CHALLENGES OF EXPLOITING MINERAL RESOURCES

Prospective studies on the energy transition all focus on the enormous quantity of metals that will be needed to build a zero-carbon future. Wind turbines, solar power plants and electric vehicles all require immense amounts of bauxite, cobalt, copper, manganese and other metals. It is in this context that the mineral resources in the ocean's depths are attracting renewed interest, and Ifremer has been solicited by the French Ministry of Ecology to watch over the work being done.

Over 3,000 m deep in the middle of the Atlantic and Pacific Oceans, the seabed is rich in two types of desirable mineral resources: sulfur deposited by hydrothermal vents, and polymetallic nodules (containing manganese, copper, nickel and cobalt) that can be found on the surface of abyssal plains. The International Seabed Authority (ISA), which has jurisdiction over these areas, has assigned different zones to a small group of countries, including France, for exploration. Their efforts are represented by a high volume of scientific cruises and studies, technological developments and reflections on the legal framework for the potential future exploitation of these resources.

As a leading figure in France's exploratory campaigns, as well as the associated studies and developments, Ifremer is keeping a watchful eye on this international activity. Through its monitoring and analysis work, it keeps the Ministry abreast of new information. Ifremer's surveillance enables it to take stock of the situation.

Although important advances have been made in the development of seafloor exploration equipment, exploitation technologies are not yet fully mature. It is not yet certain whether it would be profitable to use them. It is also difficult to obtain a precise assessment of the impacts that mineral extraction could have on deep-sea ecosystems. Biological processes in abyssal environments proceed very slowly due to the extremely low temperatures (close to 0°C) and limited energy flows. Abyssal species' resilience to disruptions would therefore appear to be poor. Studies performed by Ifremer in 2020 on species of hydrothermal vent shrimp and deep-sea worms indicate the great fragility of these environments.

Ifremer is especially attentive to the potential effects on deep-sea species, since it wishes to promote a sustainable and environmentally friendly approach to the exploitation of these mineral resources.

ZINC SULFIDE, COPPER SULFIDE AND GOLD CARPET THIS HYDROTHERMAL VENT IN THE LAU BASIN (SOUTHWEST PACIFIC – TONGA ISLANDS). © Ifremer

INNOVATING TO CREATE A RESPONSIBLE, DERISKED, SUSTAINABLE AND DIGITAL OFFSHORE INDUSTRY

INTERVIEW WITH JEAN-MARC DANIEL ON THE CREATION OF THE FIRST CARNOT INSTITUTE DEDICATED TO THE OCEAN: MERS (MARINE ENGINEERING RESEARCH FOR SUSTAINABLE, SAFE AND SMART SEAS)

JEAN-MARC DANIEL, HEAD OF THE PHYSICAL RESOURCES AND DEEP-SEA ECOSYSTEMS (REM) DEPARTMENT © IFREMER / AMBRE BODÉNÈS

Carnot institutes are public research structures certified by the Ministry for Research. They are dedicated to the development of research partnerships with companies and other socioeconomic actors.

WHAT ARE THE FUNDAMENTAL GOALS OF THE MERS CARNOT INSTITUTE FOR IFREMER?

First of all, the Carnot label recognizes Ifremer's ability to work with different types and sizes of companies. This positioning is crucial, since the development of partnerships with economic actors is part of the Institute's overarching strategy. MERS is intended to facilitate interactions between researchers and companies on all subjects within its scope, as well as at the scale of Ifremer itself. However, we do not seek to promote any and all types of marine engineering. The MERS Carnot institute's objective is to guide companies toward greater awareness of their activities' impacts on the marine environment.

This is what makes it so unique. It aims to connect ecosystem health to the progression of ocean industry.

HOW MANY PARTNERS AND RESEARCH TEAMS ARE INVOLVED WITH MERS?

This Carnot institute includes Ifremer, École centrale de Nantes, the CNRS and the universities of Nantes, Bretagne Sud and Bretagne Occidentale. To build this institute, we first turned to existing collaborations between Ifremer and École centrale de Nantes. We had already had the opportunity to benefit from our complementary skills on sustainable engineering projects. Through MERS, we can continue on this path with some new teams; there are now thirteen units and laboratories within this structure, working on the promotion of sustainable maritime activities that protect the ocean's health. All together, we can offer a wide range of skills in geology, geophysics, geochemistry, biology, ecology, physical oceanography, hydrodynamics, marine structural engineering, digital modeling and more.

WHAT COMPANIES AND INDUSTRY SECTORS DOES MERS TARGET?

This Carnot institute is relevant to a broad swathe of markets: the naval and offshore industries, marine renewable energies, fishing and aquaculture, and the nautical industry. Through this structure, we can assist industry actors with almost all stages of their projects, from concept development and prototype design to experiments in a lab environment and at sea. This enables us to interact with companies of all sizes, from start-ups to multinationals. It's very important for us to be able to help small companies make progress in these domains, since they don't always have the means to do it alone.

WHAT ARE YOUR CURRENT AND FUTURE PROJECTS?

MERS is currently in high demand for subjects related to the technological development and environmental footprint of marine renewable energies. We're also working on projects for optimizing ships' energy consumption, which the École centrale de Nantes is overseeing. At Ifremer, we are assisting Equinor, a Norwegian company that wants to know more about the potential impacts of its underwater mining activities on certain ecosystems.

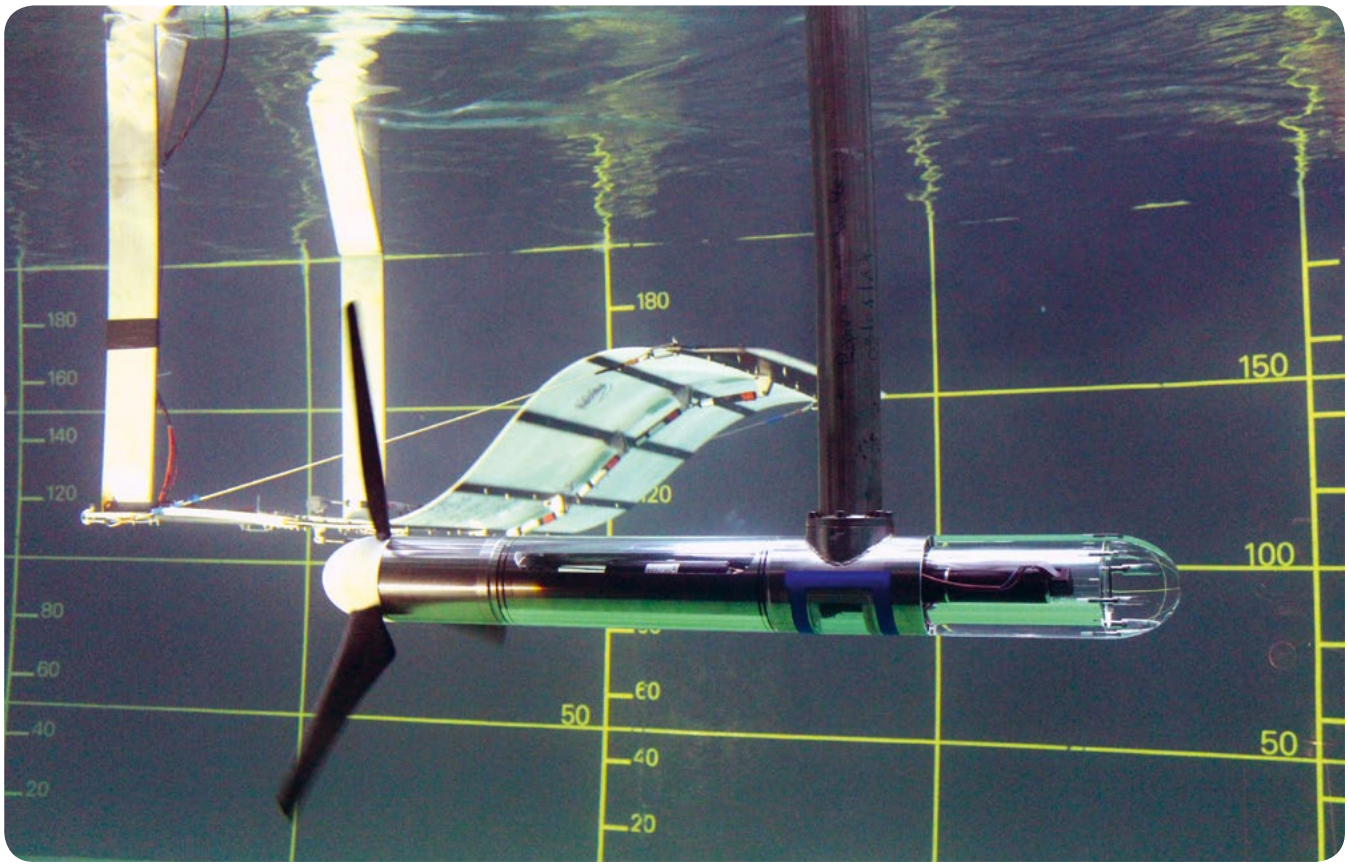
We are also collaborating with Total on a buoy project that will assess the ecological status of the ocean's upper layers. This system of buoys, installed near the company's platforms, would make it possible to gather environmental data before and during exploitation. Environmental monitoring is a subject that we are particularly invested in, since it's essential for protecting the ocean's health.

https://www.instituts-carnot.eu/recherche-partenariale-def

INSTITUT CARNOT MERS

SUPPORTING AND ACCELERATING INDUSTRIAL DEVELOPMENT AND DEPLOYMENT OF MARINE RENEWABLE ENERGIES

The energy transition is underway, and marine renewable energy (MRE), which has been little explored so far, could represent great potential. However, there are a number of scientific, technical, economic and social obstacles to overcome in order to make the most of MRE. And facilitating the growth of the offshore renewable energy sector in Europe is exactly what MARINERG-i aims to do. This research consortium, of which Ifremer is a member, seeks to create a network of experts and experimental infrastructures in order to better serve the development of MRE. Offshore wind energy, tidal energy and wave energy are targeted in particular.



THE EUROPEAN RESEARCH CONSORTIUM MARINERG-I, OF WHICH IFREMER IS A MEMBER, SUPPORTS THE GROWTH OF THE OFFSHORE RENEWABLE ENERGY SECTOR
© Ifremer / Grégory Germain

MARINERG-i was born from the success of the European projects MaRINET (FP7) and MaRINET2 (H2020), which brought together a scientific community with rich and varied skills and knowledge in disciplines relevant to MRE: hydrodynamics, aerodynamics, fluid-structure interaction, materials sciences, electrical engineering, naval architecture, sensor development, oceanography, and social and environmental sciences. These two projects also spurred the creation of a community of testing infrastructures that MARINERG-i now benefits from. The French research structure THeoREM, created to coordinate the hydrodynamics and mechanics testing facilities used by Ifremer, the École centrale de Nantes and the Université Gustave Eiffel, is one of the entities involved.

MARINERG-i has several organizational duties such as streamlining practices and setting common standards for quality and performance. It also serves as an advisor when national and European authorities need insight on MRE. Furthermore, MARINERG-i has a science program that matches requests from users (industry actors and academics) with expertise from members and recommendations from European programs. Four priorities have been retained: characterization of the resource and of sea conditions; improved performances in energy extraction processes; related materials and infrastructures; and increased testing capacity. In the future, this infrastructure, which is currently in the deployment phase, should include partners from a dozen EU countries: Ireland (coordinator), France, Spain, Portugal, Belgium, the United Kingdom, Italy, Norway, the Netherlands, Sweden, Denmark and Germany.

ELASTONICS, A FLOATING STRUCTURE THAT CORRALS TIDAL ENERGY TO MAKE RENEWABLE ENERGY PRODUCTION MORE EFFICIENT AND PROTECT OFFSHORE INSTALLATIONS

From February 24 until March 6, 2020, scientists from the École supérieure de physique et de chimie industrielles (ESPCI Paris – PSL) took up residence at Ifremer's test tank in Plouzané. With the team from the Laboratoire Comportement des Structures en mer (LCSM), they tested a floating device meant to focus tidal energy, which could have useful applications in energy production as well as in the protection of offshore structures.

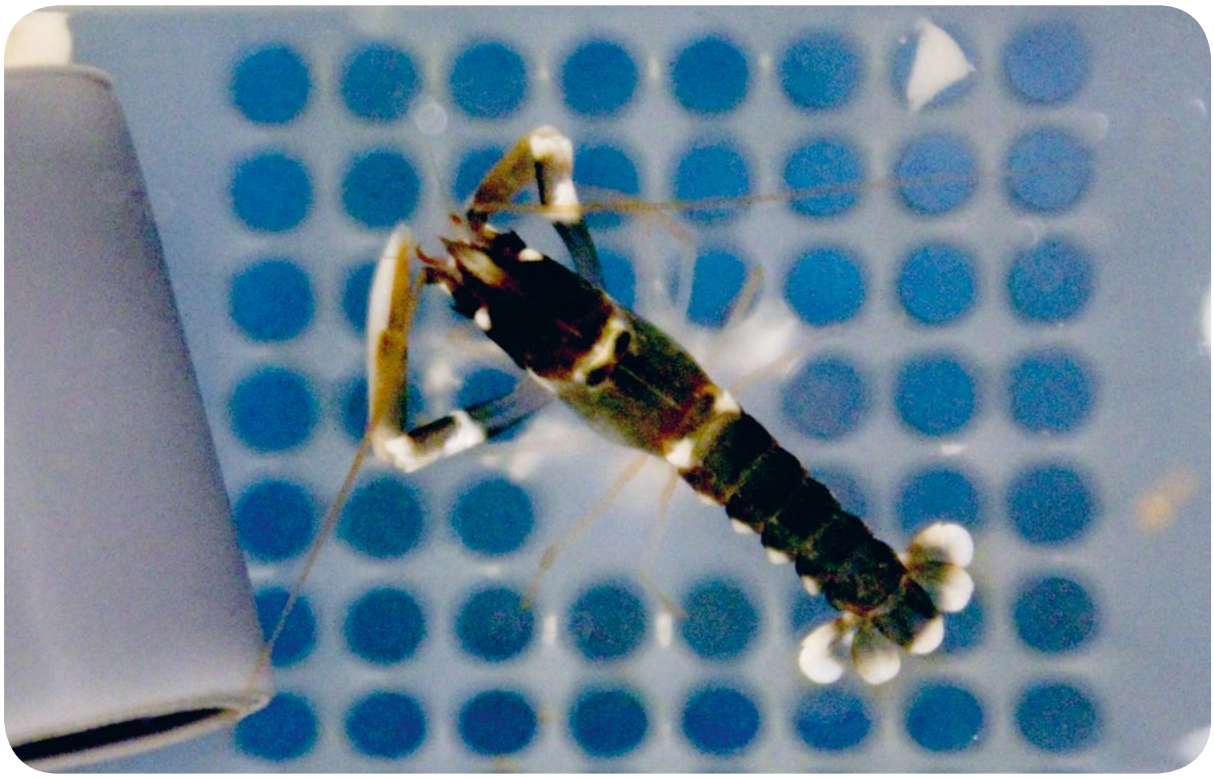
The ESPCI researchers were initially interested in studying how waves from sea swells behaved under sea ice. During an experiment in an aquarium, they discovered that their experimental device could, if made from the right materials in the right shape, redirect or concentrate swell energy. They were aware of the potential applications of this technology—it could direct tidal energy at energy conversion systems or deflect it from offshore installations. With this knowledge, they applied for a patent, got in touch with Lutech (a SATT, or company accelerating technology transfer) and partnered with Ifremer to make the most of this discovery.

Larger-scale tests could then be conducted in the Plouzané test tank with a new prototype of the floating structure. Measuring over 16 m long and almost 5 m wide, it was made of flexible plates of composite materials whose design and mechanical properties were deliberately kept simple. The test plates were tethered to one end of the test tank and subjected to different intensities of wave energy to simulate their behavior in a real-life scenario, in which they would be anchored to the seafloor and would sometimes have to withstand very strong waves.

The first series of tests made it possible to study the plates' behavior at this larger scale (with eight cameras filming their movements) and determine whether the wave propagation speed corresponded to the researchers' expectations. The first results were, in fact, as predicted by the digital models that had been fine-tuned since the beginning of the project. Another series of tests will aim to show that it is possible to control and focus the direction of the waves by adding a thick viewing lens to the plates.

EUROPEAN LOBSTERS UNAFFECTED BY MAGNETIC FIELDS GENERATED BY SUBMARINE ELECTRIC CABLES

The development of offshore wind power in France raises the pressing question of its potential impacts on marine ecosystems. Laypeople and scientists are concerned about possible effects from the magnetic fields emitted by the submarine electric cables used with offshore wind turbines. Anxious to shed light on the subject, France Énergies Marines and Ifremer, in collaboration with Norway's Institute of Marine Research, undertook an innovative experiment on European lobsters.



NO ILL EFFECTS DETECTED IN JUVENILE LOBSTERS SUBJECTED TO THE MAGNETIC FIELD AROUND SUBSEA CABLES © Institute of Marine Research

There were several reasons behind the choice of this species. European lobsters have both economic and ecological importance. They tend to take shelter in the corridors housing submarine cables. Furthermore, it has been shown that similar species (spiny lobsters and crayfish) are sensitive to changes in magnetic fields.

The experiment was performed at the Institute of Marine Research on juvenile lobsters that had hatched three weeks prior and were therefore at a sensitive stage of their life cycle. Thanks to an apparatus designed by the Brittany-based SMB MAPPEM Geophysics, the researchers were able to generate a magnetic field that resembled the ones that have been measured near high-power cable interconnections. During the first phase of experiments, the scientists sought to determine whether the lobsters were attracted to, repelled by or indifferent to the magnetic field. Then, over a period of seven days, they studied the effect of this magnetic field on the mortality and natural behavior of the animal, especially its ability to seek shelter.

The results were reassuring in several respects. First of all, no deaths were observed in the group of juvenile lobsters during the experiment. Next, an analysis of the video recordings clearly showed that the animals were neither attracted nor repelled by the magnetic field, and that their exploratory behavior in search of shelter did not change at the magnetic field intensities tested.

This experiment was part of the collaborative R&D project SPECIES (Submarine PowEr Cables Interactions with Environment & associated Surveys, 2016-2020), which focused on interactions between submarine electric cables and marine organisms living on the seafloor. Coordinated by France Énergies Marines and under the scientific leadership of Ifremer, SPECIES brings together a consortium of nine academic and private partners with complementary skills and contributions.

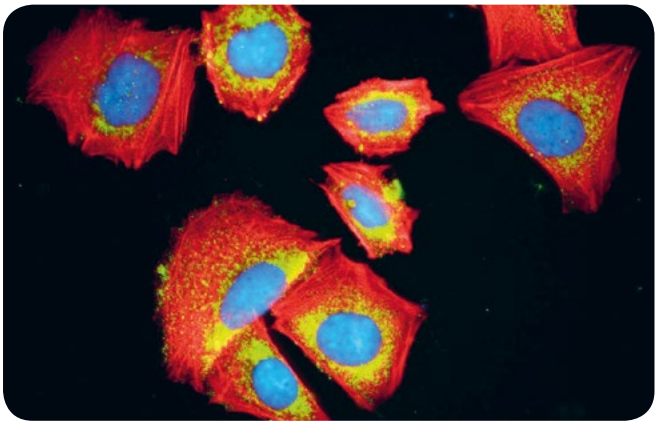
View the scientific publication here:
https://doi.org/10.1016/j.aquatox.2019.105401

SPECIES project:
https://www.france-energies-marines.org/R-D/Projets-en-cours/SPECIES

DEVELOPING MARINE BIOTECHNOLOGIES

USING MARINE BACTERIA TO HELP CURE CANCER

Over its years of deep-sea exploration, Ifremer has discovered many new bacteria and created a unique strain bank. Researchers have extracted from this unusual collection several bacteria that can produce molecules that are in high demand in the health, cosmetics and food sectors. An Ifremer researcher, Sylvia Colliec-Jouault, and a professor from the Université de Nantes, Dominique Heymann, have successfully shown that some of these molecules have the potential to fight cancer. This discovery led to a family of patent applications. One of these patents will soon be granted in Europe. In order to demonstrate the value of this patent, the MAPACA (Marine polysaccharides and cancer) project was launched. This is the first mature project led by Ifremer in partnership with Ouest Valorisation, a company accelerating technology transfer that specializes in this type of activity.



CANCEROUS CELLS FROM AN OSTEOSARCOMA: MARINE POLYSACCHARIDES SEEM TO HAVE POTENTIAL IN THE FIGHT AGAINST THIS TYPE OF CANCER. TESTS ARE BEING PERFORMED AS PART OF THE MAPACA PROJECT © Ifremer

Initial research showed that some submarine bacteria, such as *Alteromonas infernus* and *Vibrio diabolicus*, can be cultivated via fermentation and produce exopolysaccharides that resemble molecules called glycosaminoglycans, or GAGs. By subjecting these exopolysaccharides to a specific treatment (depolymerization and re-sulfation), the researchers obtained GAG mimetics that could be used in tissue engineering and cancerology.

To check their hypotheses, they conducted an experiment on animals using a particular type of cancer (osteosarcoma) that causes metastases to form in the lungs. They observed that their product limited the formation of these metastases in animals treated with a GAGmimetic derivative. The potential of a molecule like this one, which can stop the spread of cancerous cells within an organism, is clearly immense. However, since the process of industrial development is so expensive, the researchers wanted to test the molecule's efficacy in the treatment of other cancers. This was the goal of the MAPACA project. The funds raised enabled the two researchers to continue their experiments and determine whether their product could be useful in treating breast cancer, lung cancer, prostate cancer and melanoma. To determine whether the product leads to any adverse side effects, a toxicity study is also planned. This eighteen-month research program includes an initial *in vitro* test phase (on cell cultures) followed by a series of experiments on animals. Should these experiments succeed, Ouest Valorisation will continue to support Ifremer in the promotion of this molecule within the pharmaceutical industry.

The patent family covers the anti-metastatic properties of the molecules studied. The patents are the joint property of Ifremer, the Université de Nantes, the university hospital center of Nantes and the Institut national de la santé et de la recherche médicale (Inserm). The MAPACA project is co-directed by Dominique Heymann and Sylvia Colliec-Jouault.

ERC DYNAMIC: USING MARINE PHAGES AS AN ALTERNATIVE TO ANTIBIOTICS

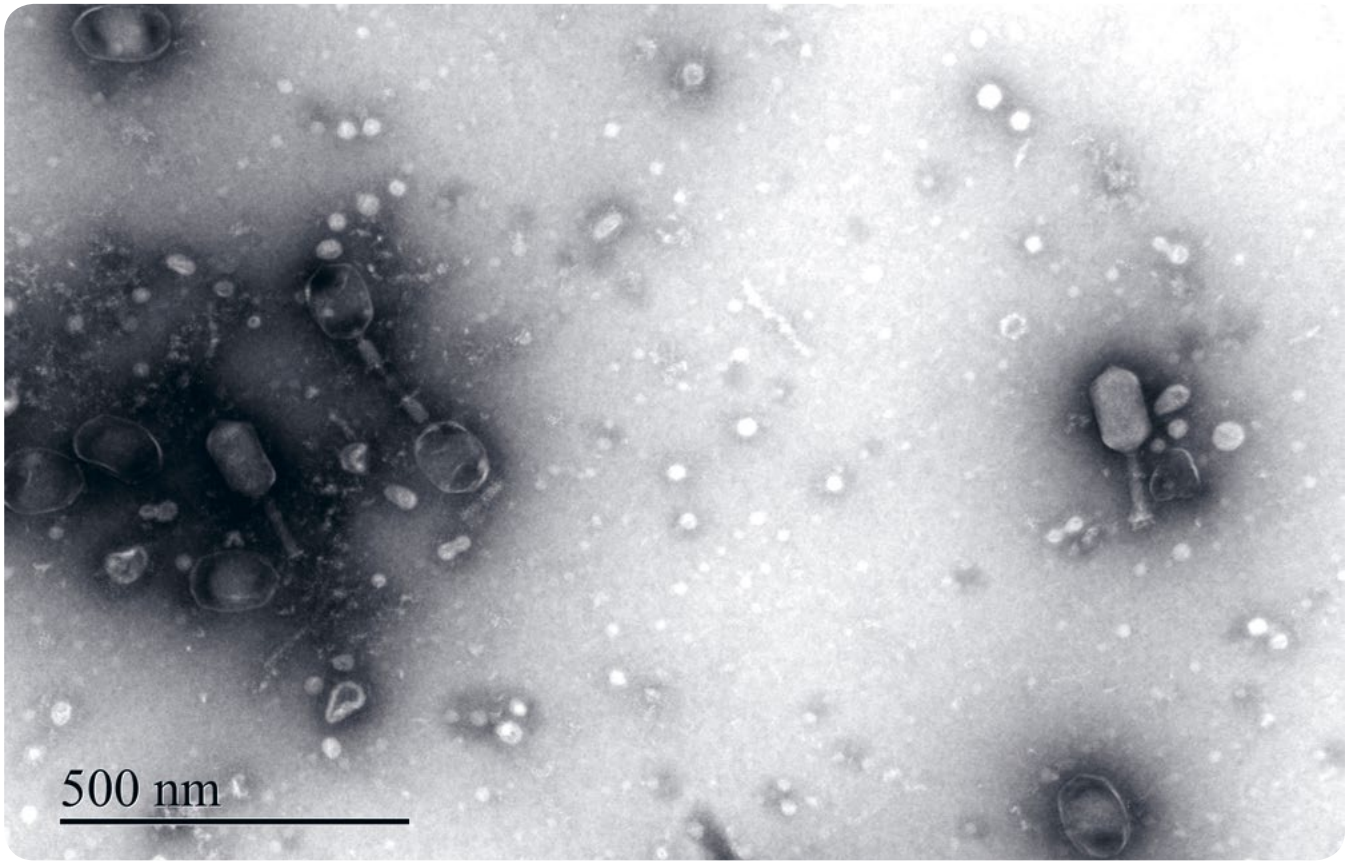
For several years, growing antibiotic resistance has been a cause for concern within the healthcare community. This trend is especially worrisome because fewer and fewer new molecules that can fight pathogenic bacteria are being produced. This predicament, which could have serious consequences, tends to provoke two types of responses. The first is to restrict the use of antibiotics so that they remain effective for as long as possible. The second is to seek other alternatives. The DYNAMIC project (A mechanistic approach to understand microbiome-viriome dynamics in nature) takes this second path by studying phages—viruses that prey on bacteria—in marine environments.

Phages attack only specific bacteria, sparing other organisms such as animals, plants and seaweed. DYNAMIC seeks to address several questions about phages. What links phages to disease-causing bacteria? How do bacteria resist phages and how do

phages learn to counter-attack (a process called co-evolution)? The DYNAMIC team is approaching antibiotic resistance as more than a clinical issue; for them, it has environmental, agricultural and aquacultural ramifications. If a person is infected by multidrug-resistant bacteria, those bacteria necessarily came from the surrounding environment. Farmed oysters were chosen as the research specimens since marine bacteria, particularly *Vibrio* bacteria, infect this type of mollusk. By studying the interactions between phages and the bacteria associated with oyster mortality, the scientists could improve our understanding of these ancient relationships.

In time, this knowledge will make it possible to determine whether phages can or cannot be used as an alternative to antibiotics in aquaculture, and it will shed light on information acquired from other ecosystems such as pig farms or the digestive system of an individual animal.

In 2020, Frédérique Le Roux, an Ifremer researcher in molecular microbiology at the Roscoff Marine Station (CNRS/Sorbonne Université) won a €2.5 million Advanced Grant from the ERC (European Research Council) to finance the DYNAMIC project. This award was a great honor for this researcher, her team and Ifremer.



OBSERVED WITH AN ELECTRON MICROSCOPE, THESE PHAGES, WHICH PREY ON BACTERIA IN THE MARINE ENVIRONMENT, COULD SOMEDAY BE A PROMISING ALTERNATIVE TO ANTIBIOTICS. © Ifremer - Station Biologique de Roscoff - CNRS Sorbonne Université / Sophie Le Panse - Damien Piel

Creating and sharing a digital ocean

An ocean of data and services

As in all fields, the digital transition is affecting marine and maritime activities as well as our professional practices. Managing the increasing amount of data on the ocean and transforming it into services for people, companies and the scientific community is a major challenge when sharing ocean knowledge, as is promoting economic growth in a way that is sustainable for the marine environment. The mass of available data also serves as a foundation for models that test hypotheses, imagine the past and predict the future.

IFREMER'S EXCEPTIONAL INVESTMENT PLAN (EIP)

INTERVIEW WITH PATRICK VINCENT ON THE MAIN PRIORITIES OF THE EIP

PATRICK VINCENT, DEPUTY CHIEF EXECUTIVE OFFICER AT IFREMER © IFREMER

WHAT IS THE EXCEPTIONAL INVESTMENT PLAN FOR?

The objective is to invest 49 million euros in research and innovation over a ten-year period, which would be a first for the Institute at this scale. These funds come from the January 2020 sale of Ifremer's shares of the company Collecte Localisation Satellites (CLS). The budget will be divided up among seven top-priority scientific projects that we have built up over time, aiming to broaden and accelerate the implementation of Ifremer's 2030 strategic plan and the 2019–2023 Statement of Objectives. Through these seven projects, we want to reinforce infrastructures and skills, provide support for scientific and technological developments, speed up transitions, create assets for the future and strengthen our strategic partnerships.

WHICH SCIENTIFIC PROJECTS WILL BENEFIT FROM THIS PLAN?

We chose to focus on a small number of big projects that were difficult to finance through the usual channels. These projects fall into three groups. The first group has to do with the deployment of innovative infrastructures and equipment for marine observation. We intend to invest in two new seafloor observatories, continue our Argo float program, and keep working on underwater vehicles.

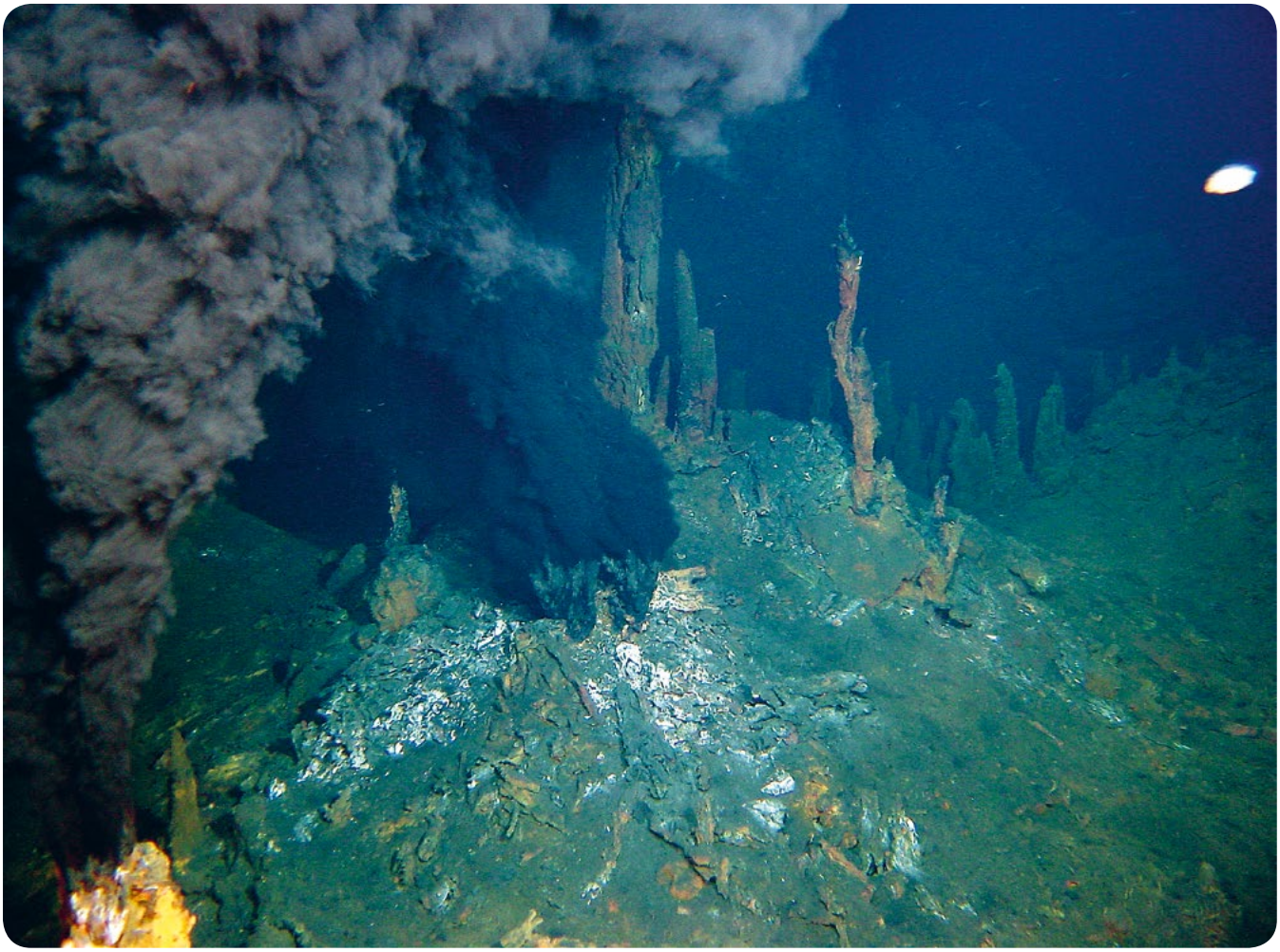
The second focuses on strengthening the Institute's innovation policy, especially as regards digital technology. Finally, the third group seeks to foster the development of sustainable marine sciences by creating five interdisciplinary Research Chair positions dedicated to these subjects.

WHICH ACTIVITIES FOCUS SPECIFICALLY ON INNOVATION AND DIGITAL TECHNOLOGY?

We want to boost the Digital Ocean project, which already has a solid foundation. The new funding will help speed up the development of scientific information systems and increase our involvement in collaborative projects, like the one we have underway now on variability and uncertainty in the dynamics of the upper oceanic layer (with Inria and the Imperial College of London) and the European project for building a digital twin of the ocean. What's more, we will support the creation of a nano-satellite network for the IoT (Internet of Things), whose global connectivity, simplicity and reliability will facilitate the development of marine and maritime services that use satellite data. To do so, we have already invested in the company Kinéis, an affiliate of the Centre national d'études spatiales (CNES) and CLS. Finally, another part of the funding will be set aside to ramp up the InOcean initiative through concrete actions inspired by the Institute's innovation strategy. In 2020, for example, we bought a stake in the start-up Forssea, which develops remotely operated autonomous vehicles and smart cameras for the maritime sector.

WHAT PLACE DO PARTNERSHIPS HOLD IN THIS DEVELOPMENT AND INVESTMENT STRATEGY?

As mentioned in our 2030 strategic plan, Ifremer cannot reach our ambitious goals without assistance from French and international partners who share our aims. We already work with partners on infrastructures such as the Argo network and the EMSO-Azores seafloor observatory. So it's natural to continue in this spirit of openness to external partners. This initiative has been lauded, in fact, by Ifremer's Board and by the Ministry of Higher Education, Research and Innovation as one of the strong points within Ifremer's approach. In this vein, the Exceptional Investment Plan seeks to accelerate innovation by strengthening our relationships and creating new collaborations with companies.



SCIENTISTS ARE ALWAYS KEEPING AN EYE ON THE LUCKY STRIKE HYDROTHERMAL VENTS THANKS TO EMSO-AZORES, ONE OF VERY FEW SEAFLOOR OBSERVATORIES IN THE WORLD. © Ifremer

DESIGNING AND OPERATING OPEN RESEARCH INFRASTRUCTURES

THE EMSO-AZORES SEAFLOOR OBSERVATORY TURNS TEN

EMSO-Azores (European Multidisciplinary Seafloor and water column Observatory), deployed near an active submarine volcano in the middle of the Atlantic Ocean in 2010, celebrated its tenth year of loyal service this year. There are only four scientific observatories of this type in the world; this one continuously records a stream of data on volcanic activity and hydrothermal vent fields at a site called Lucky Strike.

Researchers have been using this data for ten years to make incredible progress on our understanding of these deep seabeds, about which much is still unknown.

Located 1,700 m underwater, EMSO-Azores features two observational "nodes." The first one is for large-scale geophysical studies and houses the associated measuring equipment (seismometer, pressure gauge, etc.). The second focuses on hydrothermal structures—geological landforms with tall chimneys that spit out fluids rich in heavy metals at temperatures over 300°C.

Though it may seem hostile, this environment is in fact host to a thriving ecosystem that the cameras and sensors of EMSO-Azores observe in the hopes of better understanding the complex dynamics between fauna and physicochemical factors. All of the data is sent to a buoy at surface level that transmits it to the Ifremer center in Brest by satellite every six hours.

Each year, an oceanographic cruise called MoMAR-SAT visits the observatory to perform maintenance and collect additional data. The 2020 edition took place in October aboard the Pourquoi Pas?, with COVID-19 protective measures in force. This cruise made use of the remotely operated underwater vehicle Victor 6000 to make 3D video recordings of the area and take samples of fluids, rocks, and animals. To celebrate the tenth anniversary of EMSO-Azores, the scientists also published a list of ten success stories made possible thanks to this observatory

The EMSO-Azores seafloor observatory is supported by France and Portugal.

THEOREM PROGRAM MODERNIZES IFREMER'S TEST TANKS

Created in 2017, the THeoREM research network pools the testing facilities of Ifremer, the École centrale de Nantes and the Université Gustave Eiffel for the purposes of hydrodynamic, mechanical and hyperbaric tests on materials and structures used in marine environments. THeoREM's strength is that it offers an array of equipment and skills that can support all phases of project development, from concept testing up to industrialization. As the subject of increasing demand from the marine renewable energy (MRE) industry, THeoREM is updating its facilities to ensure that they are well-adapted for this sector. For Ifremer, this means that some test tanks and flumes will be modernized with funding from two state-regional contracts (the IjinMor project in Brittany and MARCO in Hauts-de-France).

First on the list for renovation are the facilities at Ifremer's Centre de Bretagne in Plouzané. The deep basin, also called the ocean engineering basin, will be updated with a "snake" wave generator that performs much better than its predecessor. The device can generate higher waves, take into account the directional spread, and produce more consistent sea swell, as is needed to test MRE technology. It provides a more realistic simulation of the environmental conditions and of the efforts required of marine structures.

The test flume in Plouzané, which complements the ocean basin, will be updated with the same objective. The installation of a multi-purpose wave generator will enable scientists to reproduce phenomena that occur at shallow and moderate depths. For example, they will be able to study the risks associated with wave breaking or the effects of sea swell on submarine cables in coastal areas.

More investments will be made in the test basin at the Boulogne-sur-Mer center. This infrastructure, dedicated to the study of interactions between sea swell, currents, and structures in complex environmental conditions, will be upgraded so that it can maintain its superior level of performance. A modular floor plate that can allow for wall-mounted equipment and adjustable mooring points will be installed. A new measurement system (using three-component laser velocimetry) will also be developed to better quantify turbulence both upstream and in the wake of the devices tested. These upgrades will be exceedingly useful for studying structures' behavior in ocean environments.

HYDRODYNAMIC TESTS BEING PERFORMED IN THE TANK AT IFREMER'S CENTRE DE BRETAGNE, WHICH HAS BEEN MADE AVAILABLE FOR TESTING THEOREM PROJECTS AT EVERY STAGE OF DEVELOPMENT, FROM PROOF OF CONCEPT THROUGH INDUSTRIALIZATION.
© Ifremer / Olivier Dugornay

OBSERVING THE OCEAN: DESIGNING, DEPLOYING AND PILOTING SENSORS AND MEASUREMENT SYSTEMS

NEW AUTONOMOUS ROBOTS TAKE OCEAN OBSERVATION TO THE NEXT LEVEL

Co-led by Ifremer and Sorbonne Université, the NAOS project (Novel Argo Ocean observing System), which held its wrap-up meeting on September 17, 2020, was a great success. Thanks to eight million euros in funding granted by the Agence nationale de la recherche between 2011 and 2020, the project produced, for both France and Europe, a new generation of autonomous Argo floats ready to tackle future challenges in ocean observation.

The international program Argo, a collaboration among thirty countries, relies on a network of 4,000 profiling floats (small autonomous robots) that measure the temperature and salinity of all of the planet's oceans, from surface level down to 2,000 m underwater. This is the first worldwide, on-site, real-time ocean observation network, and the data it yields is an essential complement to satellite measurements. Argo makes it possible to observe, understand and predict climate evolution and characterize the impact of climate change on marine ecosystems and the ocean's physical and chemical properties.

NAOS has facilitated the development of smarter, more durable Argo floats—a real boon to the project. The new models can accommodate more sensors (especially for marine biogeochemistry) and reach the most inaccessible zones of the ocean, such as the greatest depths (4,000 m) and the polar regions. Their usefulness was clearly demonstrated in three pilot experiments: monitoring the biological status of the Mediterranean Sea, studying phytoplankton under Arctic polar ice, and observing deep ocean dynamics in the Atlantic Ocean. Floats that can "hibernate" under the ice and measure the oxygenation of deep layers of the ocean were tested in real-life conditions and passed with flying colors.

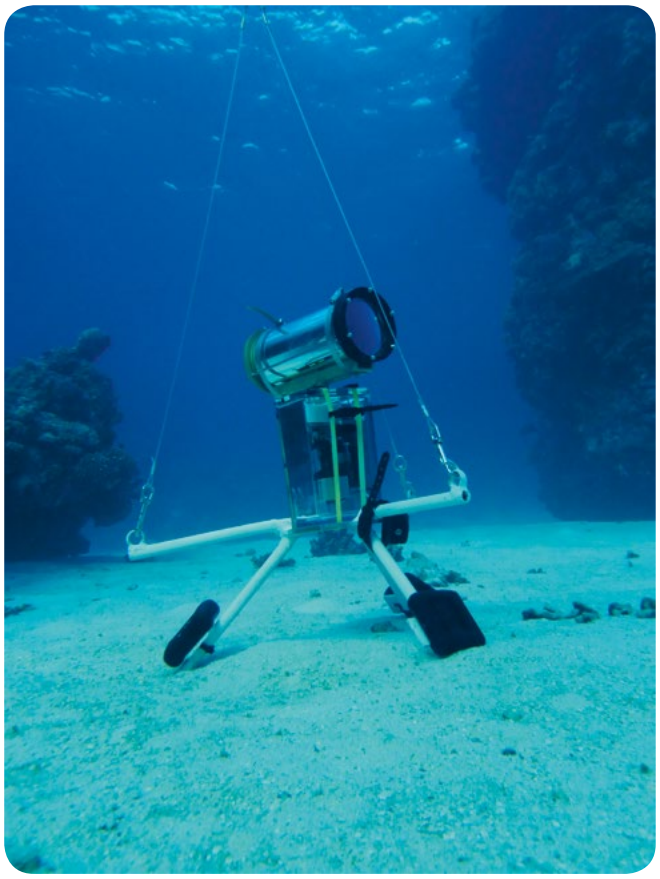
NEW AUTONOMOUS ARGO FLOATS, NOW SMARTER AND MORE DURABLE, DEVELOPED AS PART OF THE NAOS PROJECT (NOVEL ARGO OCEAN OBSERVING SYSTEM) CO-LED BY IFREMER AND SORBONNE UNIVERSITÉ
© Ifremer / Kevin Balem

Furthermore, NAOS was helpful for forging ties with industry actors. The SMB that produced and marketed the Argo floats that were manufactured in France, NKE Instrumentation, experienced tremendous growth over the course of the program and strengthened its position on the international stage.

NAOS may have come to an end, but France intends to continue its efforts by contributing to the new operational phase of the Argo program (2020-2030) which aims to extend its range to the abyssal ocean (Deep Argo) and to biogeochemistry (BGC-Argo). These objectives are closely linked to the strong scientific interest in studying climate change and the ocean's evolutions.

CUTTING-EDGE VIDEO METHODOLOGY FOR OBSERVING FISH IN THEIR NATURAL HABITATS

Coastal areas play an important role for ecosystems and fisheries resources. They serve as nurseries, refuges and feeding sites for many species, including those that live in the open ocean. As the human population grows, human activity intensifies and climate change continues, these areas are subjected to strong pressures and transformations that Ifremer's researchers seek to characterize. To do so, they first need to compensate for the lack of quantitative data on these coastal habitats and their ichthyofauna (fish life within an aquatic ecosystem). This is the goal of the new unbaited underwater video observation methods (unbaited in that they do not use food to attract animals) that Ifremer is developing.



PEERING INSIDE COASTAL ECOSYSTEMS WITHOUT DISTURBING THE FISH—THAT'S WHAT THE STAVIRO SYSTEM, SET UP IN THE NATURAL PARK OF THE CORAL SEA IN NEW CALEDONIA, DOES BEST. © Bastien Preuss

Respectively named STAVIRO and MICADO, these approaches have proved their worth in New Caledonia, the Indian Ocean, and the Mediterranean Sea. Their great advantage is that they are easy to deploy in all kinds of habitats and can cover wide areas while minimally disturbing the fish. They use submarine video stations equipped with high-definition rotating cameras and data-processing capabilities that stretch from image acquisition through analysis. The data is fleshed out by stereo-video transects that provide measurements of fish size.

These methodologies, which were used during three cruises in 2019, produced valuable results in 2020. In the Mediterranean, the zone around Cap Sicié, and the Côte Bleue Marine Park, researchers were able to assess habitat and population changes (number, species and size of fish) that have occurred since the missions conducted there in 2011 and 2012. They also worked on Atlantic coastal areas (around Concarneau and the Glénan islands) where this type of data is in short supply.

The results obtained thus far demonstrate the value of these methodologies for ichthyofauna and coastal habitat observation. Without harming the ecosystem, they fulfill currently unmet needs for data collection.

The *Now You See Me* project, led by research unit Écologie et Modèles pour l'Halieutique (EMH), aims to understand the relationships between coastal fish and their habitats using data from unbaited underwater video recordings.

SAILING EXPEDITION OCEANSCIENTIFIC COLLECTS CONTAMINANTS IN THE MEDITERRANEAN

As he has done each year since 2006, skipper Yvan Griboval, president of the OceanoScientific Association, set sail to collect oceanographic data. Aboard the large catamaran *Amaala Explorer*, he navigated into the Mediterranean this year to sample chemical contaminants. On October 28, 2020, he delivered his cargo to the port of La Seyne-sur-Mer in the presence of the president of the Provence-Alpes-Côte d'Azur region and handed it off to the Ifremer scientists in charge of analyzing the samples and data collected.

The partnership between Ifremer and OceanoScientific meets a twofold goal, serving to collect data and also to raise public awareness about the urgent need to preserve our oceans.

IFREMER SCIENTISTS RECEIVE CHEMICAL CONTAMINANT SAMPLES COLLECTED IN THE MEDITERRANEAN BY AN OCEANOSCIENTIFIC TEAM DURING THEIR 2020 MISSION. LEFT TO RIGHT: YVAN GRIBOVAL, SKIPPER; VINCENT RIGAUD, DIRECTOR OF IFREMER'S CENTRE MÉDITERRANÉE; LINN SEKUND, BIOLOGIST; AND BRENDAN JACK, PARTNER.
© Ifremer / Erick Buffier

The two entities worked closely together to prepare for the 2020 cruise. Ifremer helped to plan out the itinerary through its Environnement Ressource Provence Azur Corse and Biogéochimie des Contaminants Métalliques laboratories, in order to identify the best places to take samples. Furthermore, the Institute lent the Association its passive sampling devices, an innovative way to take samples.

Kitted out in this manner, the catamaran tracked organic and metallic contaminants present in the water throughout a 2,800-km journey with stops in Monaco, Porto-Cervo (Italy), Barcelona (Spain), and La Seyne-sur-Mer (France).

The researchers were especially interested in the areas surrounding the three biggest deltas in the western Mediterranean: the Tiber (Italy), the Ebro (Spain) and the Rhône (France), since each river ferries contaminants from large cities into the sea. Nine other sampling locations filled out the dataset.

This treasure trove of data will allow scientists to measure the organic contaminants (hydrocarbons, polychlorobiphenyls [PCBs], tributyltins [TBTs], pesticides) and heavy metals (lead, cadmium, nickel, mercury) present in these samples. The analyses will be very useful for understanding the big picture of chemical contamination in the Mediterranean, especially because there is not yet much data available on the subject.

DESIGNING OPEN INFORMATION SYSTEMS

MAKING COASTAL AND MARINE WATER MONITORING DATA ACCESSIBLE TO ALL

Surval was developed in the early 2000s as a portal where amateurs and professionals could easily view and download data from French coastal water monitoring efforts. The first three data sets put online using this tool were from the networks REMI (microbiological monitoring of shellfish production areas), REPHY (monitoring of phytoplankton and phycotoxins), and ROCCH (monitoring of chemical contaminants).

More data sets were added later as more monitoring projects were conducted and their scope expanded. Little by little, data on marine waters supplemented the data on coastal waters. In 2020, Ifremer resolved to make all of this data available to the greater public—some 13 million items instead of the 1.7 million previously available through Surval. This challenge came with its share of technical obstacles, but the project should be accomplished by the end of the first quarter of 2021.

Digital management of the data from French coastal and marine water monitoring efforts relies on several different tools. First, the database Quadrige was created to meet the needs of authorities that wanted a national classification system. It centralizes all data collected by Ifremer and other entities for projects that fall under the European Water Framework Directive (coastal focus). To date, only one community of about 550 people uses it directly. Surval was created so that it would be easier for the public to access this data. The portal automatically processes the data and publishes it online.

Along with the mapping tool Sextant, which was also developed by Ifremer, Surval makes it simple to find the data in the form of maps and graphics on a website. Design engineers, public servants, academics, researchers, members of environmental associations and curious members of the public can learn more about their topic of interest in just a few clicks. Since this data is available under an Etalab v. 2.0 Open License, it can be freely reused as long as the source is credited.

MAKING MODELS TO UNDERSTAND AND PREDICT THE OCEAN OF THE FUTURE

CROCO, AN OCEAN MODEL THAT BRINGS SCIENTIFIC COMMUNITIES TOGETHER: INTERVIEW WITH SWEN JULLIEN.

SWEN JULLIEN, RESEARCHER AT THE LABORATOIRE D'OCÉANOGRAPHIE PHYSIQUE ET SPATIALE (LOPS, IFREMER MIXED RESEARCH UNIT – CNRS – UNIVERSITÉ DE BRETAGNE OCCIDENTALE)
© Ifremer / Stéphane Lesbats

WHAT ARE CROCO'S GOALS?

CROCO (Coastal and Regional Ocean COmmunity model) is a digital model of the ocean that a whole community of researchers and developers are working on. Two objectives led to the creation of this community in the 2010s. The first objective was to perform some of the research and digital development necessary to resolve fine ocean scales, especially in coastal and shoreline areas, and to address some of the related multidisciplinary questions.

The second objective was to pool and share progress made on this subject within a tool that could model complex systems realistically.

WHAT DOES IT ALLOW YOU TO MODEL?

CROCO is first and foremost a model that solves fluid dynamics equations for fluids with the fundamental physical properties of the ocean: current, temperature, and salinity. Basically, it's a mathematical representation of ocean dynamics. Users can deploy CROCO to simulate a given area by plugging in the characteristics of the area (coastline, depth, tide, wind, etc.). The model solves equations and digitally recreates the ocean dynamics in this zone. CROCO can handle a scale as large as a region (several dozen kilometers) or as small as a single local coast (several dozen meters). The core of the model can be coupled with other models to integrate information on biogeochemistry, sediments, waves, and atmosphere.

WHAT ARE ITS APPLICATIONS?

There are many! CROCO can be used to model air-sea interactions and the ocean's response to extreme events such as tropical storms or cyclones. It can also be used to characterize the oceanographic conditions of an area such as the Bay of Brest or a zone where offshore wind turbines are installed. One of its features is that it can simulate internal waves (waves that propagate at the interface between two masses of water with different densities), which improves our understanding of, for example, what happens where the Mediterranean and the Atlantic meet in the Strait of Gibraltar. CROCO is useful as well for modeling coastline dynamics, such as the rip currents that form along the Landes coast in France or the significant erosion of beaches in Vietnam. The modeling system has even been used to reproduce larval drift around hydrothermal vents and the migration of small open-sea fish off the coast of Senegal.

HOW MANY TEAMS ARE INVOLVED WITH CROCO?

On the administration side, CROCO has four funding partners (Ifremer, the IRD, the CNRS, SHOM) and some teams from Inria. There are thirteen research units throughout France—mainland and overseas—participating in this project. However, our scientific collaboration stretches much farther than that. We have partners in Los Angeles, since CROCO was partially based on the ROMS model that was created there. We also work with researchers and developers from other centers and universities in the United States as well as in South Africa, Germany, Chile, Colombia, Spain, Mexico, Peru, Senegal and Vietnam. One of CROCO's strengths is that it reconciles all actors' expectations and adapts to each one's computational resources. This model can be used everywhere.

WHAT CHANGES ARE UNDERWAY?

One of our main objectives is to remain at the cutting edge of innovation in digital modeling. For CROCO's developers, this means constantly working to improve. Collaborative projects with targeted funding are often launched to create and integrate new features. And every two years or so, a new, stable version is released. We provide training so that all users can learn to manipulate the model. Right now, we're working on jointly developing some aspects of the model with the team from NEMO, the European ocean modeling framework.

Inria (National Institute for Research in Digital Science and Technology)
IRD (National Research Institute for Sustainable Development)
CNRS (Centre national de la recherche scientifique)
SHOM (French Navy's Service hydrographique et océanographique de la Marine)

PROVIDING INFORMATION ABOUT THE MARINE ENVIRONMENT AND ITS USES

"MARINE ENVIRONMENT—INDIAN AND SOUTHERN OCEANS" PORTAL LAUNCHED

To make data on French maritime areas more accessible and reusable, the Ministry of the Ecological Transition, along with the Office français de la biodiversité and Ifremer, set up SIMM (Système d'information sur le milieu marin). This marine information system centralizes public data from different sources and makes it available to all through an easy-to-use web portal. A new addition, called SIMM-OIA, focuses specifically on the Indian and Southern Oceans.

SIMM's ambition is to cover as widely as possible all topics of study in the marine world, from ecosystems to uses, while sharing information about actions taken by the authorities in favor of sustainable management of these issues. Consequently, it is just as useful for members of the public seeking information as it is for the European bodies responsible for protecting marine environments. The web portal makes it easy to access data through themed sections giving the status of the environment, actions being taken to protect and restore ecosystems, and key figures relating to the topic.

The regional site for the Indian and Southern Oceans, which has just come online, aims to boost the visibility of local data acquired by associations, research bodies, public authorities and other organizations. Ifremer contributed greatly to its development by helping the developer collect data and aiding the contractor in creating the portal and its content. The Institute collected, published and secured many sets of regional data. It also wrote much of the content while managing the different validation levels of the various entities and partners in charge of these subjects. This portal includes some brand-new features, like direct access to data through products adapted to certain themes (benthic habitats, the European Water Framework Directive, scientific missions performed at sea, etc.).

INTERVIEW WITH ÉMILIE LEBLOND ON THE FISHERIES INFORMATION SYSTEM (SIH), A COMPREHENSIVE SYSTEM THAT MANAGES FRENCH FISHERIES DATA

ÉMILIE LEBLOND, NATIONAL COORDINATOR OF THE FISHERIES INFORMATION SYSTEM AT IFREMER © IFREMER

WHAT IS THE FISHERIES INFORMATION SYSTEM?

The Fisheries Information System (SIH) collects, classifies, processes and publishes a wide range of data on French fishing, specifically data from professional fishing vessels. One of its strong points is that it collects information from all fleets and covers all of the seafronts of mainland France and the overseas departments (the Antilles, French Guiana, Martinique, Mayotte, and Réunion). The extremely diverse data sets are pooled in Ifremer's Harmonie database, which is noteworthy for the fact that it uses a common repository, making it possible to conduct integrated and multidisciplinary analyses. Various tools are used to process the data and verify its quality. The data is then made available to users through a web platform. So the SIH isn't just a database. It's an infrastructure that manages the whole chain of operations from data acquisition to publication using standardized methodologies and procedures.

WHO ARE ITS USERS ?

The SIH can be used by anyone who requests access, although some data is restricted. The system is meant to inform the creation of public policies and aid experts working to evaluate and diagnose resource statuses. It is also useful for fisheries research.

WHAT KINDS OF DATA ARE COLLECTED?

They fall under four main categories: ecosystems, resources, ships and their catch, and the sector's socioeconomic status. The data comes from different sources as well. Some of it is sent to us by the government entities that administer and oversee fishing activities. This is how we obtain the list of ships and their satellite positions, as well as the catch reports that professional fishermen have to fill out. FranceAgriMer sends us data on fish market sales. This is part of the daily stream of data that feeds into the Harmonie database. More data is transmitted to us by a network of land-based and sea-based observers. Finally, we add data from scientific cruises studying fish, conducted aboard ships from the French Oceanographic Fleet.

WHAT DOES THE NETWORK OF OBSERVERS DO?

The network is composed of Ifremer staff and external service providers who have been trained for this type of study and observation work. They follow protocols developed and tested by our statisticians, engineers, and researchers. Their work makes it possible to fill in the gaps regarding ships' activity, which is sometimes not well recorded by supervisory entities, especially in the overseas territories.

It can also provide information on the fishing vessels used and the socioeconomic status of the fishermen. Some observation is performed aboard the boats, so that the entire catch can be recorded, including the subset thrown back into the sea. A good understanding of the demographics of the catch is key for evaluating resource status.

HOW DO YOU STANDARDIZE SUCH DISPARATE DATA?

Not only does the SIH play an important role as a classifier of data, it features a whole host of tools for managing automatic importation and checking data quality. To quantify a catch, data sets from several sources must be cross-compared (fishermen's reports, sales at fish markets, information collected by observers on land or aboard boats) to ensure that they are consistent and to make the most out of each source's strengths. Other tools can be used to aggregate and format data, extrapolate on the basis of samples, retrieve extracts or create map-based visuals.

In 2020, due to the pandemic, we had new problems to face. The lockdown interrupted some of our data flows and data collection processes. We have to estimate the ensuing loss of information and work on new methodologies that will help fill in the gaps and better weather this type of disruption in the future. We have also updated our website so that it is easier to access the data.

Guiding and supporting research

HUMAN RESOURCES AND LABOR RELATIONS

The year 2020 was thoroughly affected by the need to manage the COVID-19 health crisis. Ifremer adapted to this unprecedented situation by keeping in regular contact with its employees and strengthening labor relations efforts.

This is how, for example, the activity continuity and return-to-activity plans were co-constructed with staff representatives before they were submitted for feedback from the committees representing the staff. Furthermore, the psychological support platform that had been set up in December of 2019—managed by an independent group of experts in psychological health at work—remained available to employees throughout this period. The consultants also created a webinar to give employees advice and tools for grappling with the unusual situation of the first lockdown in both their professional and personal lives. Another webinar for managers, focusing on managing teams remotely, was organized as well. Finally, the HR department and the CSSCT-C (Central Commission on Health, Safety and Working Conditions) worked together to conduct a survey during the last quarter of 2020 that examined employees' experiences during the lockdown.

Despite the ongoing health crisis, HR remained busy by recruiting over video calls, holding individual interviews in the same manner, and developing remote and e-learning training courses. In 2020, half of all transdisciplinary training courses were held either partially or fully remotely.

As of December 31, 2020, Ifremer counted 1,516 employees, of whom 684 were researchers and engineers. The proportion of women within the Institute stayed relatively stable: 47.23% of the total workforce. Involvement at all levels made it possible to organize recruiting committees, which in turn hired 57 external candidates.

Skill development remained a high priority for Ifremer. The Institute spent 2.2% of total payroll on training this year. Despite the ongoing public health crisis, 575 employees took a training course as part of the skill development program. The priority activity of providing training for supervisors of doctoral students continued in 2020. Close to half of these supervisors took a training course that covered, among other things, scientific integrity.

The Institute maintained its commitment to providing work-study (alternance) opportunities by recruiting almost 50 new employees for apprenticeships and professional training.

Concerning labor relations, work on a new version of the employment agreement began in 2020. The Institute and the unions started this work by signing an agreement on the method for determining topics to address, modalities, and the schedule for the subsequent negotiations (the initiation of which was planned for the beginning of 2021).

In 2020, a new agreement on the exercise of the right to organize was also signed with the two representative unions, along with an agreement on the modalities of organization and the process for electing employee representatives to Ifremer's Board.

Another important labor relations agreement, signed on June 22, 2020, focused on remote work. Several weeks prior, an agreement on adaptation measures for time off and time savings accounts during the COVID-19 pandemic had been signed with the unions.

SOCIAL RESPONSIBILITY AND THE INSTITUTE

In 2020, the Institute committed to the development of a corporate social responsibility (CSR) strategy in alignment with the Sustainable Development Goals, France's roadmap for the 2030 Agenda, and the actions performed under the umbrella of the UN Decade of Ocean Science for Sustainable Development. To this effect, five strategic priorities were defined and approved by the steering committee:

- promoting the viewpoint that our oceans are a common good that we share
- limiting the environmental impact of oceanographic cruises
- creating shared value
- reducing Ifremer's overall environmental footprint
- upholding Ifremer's role as a responsible employer.

These five priorities are now being broken down into operational specifics.

The full strategy will be presented to the Board in early 2021. Ifremer's adoption of these CSR standards was the result of close collaboration with the CNES, IFPEN, CIRAD, the IRSN and now the ONF. These synergies provided support for Ifremer's choices and gave rise to opportunities to develop shared ambitions in the realm of more sustainable mobility, responsible digital practices, sustainable and responsible purchasing practices, and so on.

More specifically, Ifremer is undertaking its own internal actions such as the organization of two sessions raising employee awareness of the CSR strategy, held during Sustainable Development Week, and the rollout of a far-reaching waste reduction program in collaboration with the Interreg project Preventing Plastic Pollution. Through its "implementation of exemplary plastic reduction practices in the workplace" component, the project has helped raise awareness among the Plouzané employees and set up optimized plastic processing flows to recover as much plastic as possible.

ETHICS, PROFESSIONAL **CONDUCT** AND SCIENTIFIC INTEGRITY

INTERVIEW WITH MARIANNE ALUNNO-BRUSCIA ON IFREMER'S DUTY TO SERVE AS AN EXAMPLE.

MARIANNE ALUNNO-BRUSCIA, DELEGATE FOR PROFESSIONAL CONDUCT AND SCIENTIFIC INTEGRITY © Ifremer

WHAT DOES YOUR JOB ENTAIL? WHAT ARE YOUR DUTIES?

Ifremer has pledged, in its Statement of Objectives as well as the 2030 strategic plan, to serve as the leading public-facing expert in marine sciences and technologies for its three supervising ministries. Consequently, our Institute has certain duties in terms of scientific integrity and ethics. We must be a role model for the scientific community and for society at large, since they trust and believe in our research, expertise and innovation.

Like other research bodies in France and Europe, Ifremer decided to designate a delegate for scientific integrity, ethics and deontology. My work consists of leading discussions and encouraging further progress on scientific integrity and ethics issues as they relate to Ifremer's activities, and on the principles governing the behavior of individuals within our institute, in all their diversity and complexity. There are three main subjects that I cover.

In terms of scientific integrity and professional conduct, I will continue, in collaboration with Doriane Ibarra, the training course that we started for researchers. We will extend it to other scientific staff at Ifremer. I will encourage the use of our existing tools and update them if necessary. These are Ifremer's charters on professional conduct, doctoral research, expertise and expert opinions. We also have recommended criteria for the signature of publications, a no-conflict-of-interest statement, and a procedure for receiving and handling reports of breaches of scientific integrity.

In terms of ethics, Ifremer has been a member of the joint ethics consulting committee, which also includes INRAE, CIRAD and the IRD, since 2016. This committee examines and produces reports on ethics issues related to research activities in the domains of food, agriculture, the ocean, the environment, and sustainable development, especially as concern the relationship between science and society. As part of the secretariat of this committee, which is composed of members from these four organizations, my job is to facilitate the committee's work and communicate about it within Ifremer and outside of our institute. What's more, a mechanism to certify the ethics standards of research projects is being developed within the national environmental research alliance AllEnvi. We intend to use it at Ifremer, with modifications if necessary.

In terms of public health and environmental alerts, I will oversee the implementation of the procedure for recording whistleblower reports by creating a register that maintains the confidentiality of the identities of whistleblowers and the persons accused (as required by the Blandin law).

WHAT LED TO THIS CHANGE IN YOUR CAREER PATH?

After my doctoral and post-doctoral work abroad (in Canada and the Netherlands), I built my research career by focusing on scientific skills and expertise that were related to moral values: intellectual honesty, responsibility, and loyalty. These values are doubly imperative—for the individual and for the institution—in the human relationships within teams and in the significance and responsibility of our research activities. I believe that it is important to develop and promote these values, which are the common ground of our Institute's various activities. Our ways of working may be called into question by society, or by the authorities that we provide answers to. My new challenge is to rethink our habitual ways of doing things in order to be ever more exemplary, while drawing on my research experience.

QUALITY MANAGEMENT SYSTEM

After an audit that involved teams from five sites in mainland France and two in overseas France, our ISO 9001 certification was maintained. The auditors did not note any instances of regulatory non-compliance. They gave some suggestions for progress that were immediately studied by our national quality coordination team; the actions retained were ported into Gaia, the tool that manages improvement actions within Ifremer's quality management system. Work is being continued to harmonize the quality system's indicators with those of the Statement of Objectives, so that the quality policy can integrate elements that measure goal achievement. The year 2020 also saw the retirement of our national quality coordinator, whose successor will be the national coordinator for both quality and safety starting on February 1, 2021.

BUDGETARY AND FINANCIAL DATA

The main significant accounting and financial data for the 2020 financial year is the following:

Pre-tax income	**€61.397M**
Self-financing capacity	**€15.079M**
Working capital	**€114.301M**
Cash flow	**€122.050M**

FUNDS:

The Institute's overall income was €293.663 million during the 2020 financial year:

- Public subsidies (for public service responsibilities and operating expenses, from the national government and other public entities) amounted to €205.140 million.
- Direct income from activity amounted to €88.52 million. This income was boosted by exceptional revenue from the sales of CLS shares. After having supported the development of CLS for over thirty years in its use of satellite data to serve the planet, Ifremer and Ardian sold their shares of the company. The funds corresponding to the income from this sale of shares were reinvested, in part, in Ifremer's scientific and technological priorities as part of the Exceptional Investment Plan. Another segment of these funds was invested in the company Kinéis, through which Ifremer will participate, in 2022, in the deployment of the first nanosatellite constellation intended to develop the Internet of Things around the world.

In addition, the Institute posted €7.29 million in investment grants intended to fund Ifremer projects. These mainly concern real estate operations and investment projects (facilities) financed through various national-regional contracts (CPER) with support from structural European funds (ERDF).

EXPENDITURE

The Institute's overall expenses totaled €232.26 million during the 2020 financial year :

- Expenses directly related to activity amounted to €127.54 million.
- Payroll costs were €104.71 million. Ifremer's workforce represents 1,549 FTE positions.

Investment spending totaled €26.106 million over the 2020 financial year.

ASSETS

Total assets amounted to €408.328 million at the end of 2020. Key figures:

- Cash flow of €122.05 million
- €57.08 million in accounts receivable (€46.80 million held for public entities) and €10.28 million in accounts payable
- Net fixed assets valued at €687.16 million

BUDGET APPROPRIATION

- Commitment authority (CA) reached €243.80 million in 2020.
- €229.45 million in payment appropriations (PA) were used.
- Investment spending totaled €276.68 million.
- Thus the budget balance shows a surplus of €47.22 million for 2020.

CONCLUSION

The Institute's financial situation is good. The Institute has a very large amount of working capital (€114 million). This working capital should be considered in light of the Institute's major investment plan, presented to the Board in October 2020. That plan gave an overview of the Institute's medium-term investment capacity beyond the ongoing investment capacity, which must be maintained (and self-funded) for smaller operations. There are three main parts to this major investment plan.

MEDIUM-TERM PLANNING FOR THE FLEET

The fleet's medium-term plan (see page 24 and the annual report of the French Oceanographic Fleet) addresses, first of all, a recommendation from the Audit Office following its examination of Ifremer's 2009–2017 financial statements (recommendation no. 8), and second of all, a commitment within Ifremer's 2019-2023 Statement of Objectives (action no. 23).

The main objectives are the following:

- Preservation of capacity to perform deep-water projects in all three major oceans, including major refits for the *L'Atalante* and the *Pourquoi Pas*?
- Advancement of deep-sea exploration capacities through the construction of a new hybrid ROV that can operate at depths of 6,000 m
- Concentration of coastal and regional fleet resources into five vessels, down from six
- Improvement of the fleet's environmental performance.

REAL ESTATE INVESTMENT PLAN

This plan identifies the sites in need of significant investment by 2030.

In Plouzané: The technical installations and workshops used for engineering sciences, along with the analytical and experimental platforms used for chemistry and biology, must be redimensioned. Isolated structures will be phased out and a new, modular building for experiments will be added.

In Nantes: A building complex for experiments will be created to foster the development of scientific and technical activities, with a separation between technical/experimental activities and office work. The two main buildings at this site (S and T) will be renovated or reconstructed to accommodate the project.

In Sète-Palavas-Montpellier: The Celimer project will be taken as an opportunity to better structure analyses and experiments at these sites. Palavas will be turned into a multi-use structure for hosting experiments while Sète will become the new hub for the analytical platforms and the research teams that use them.

THE EXCEPTIONAL INVESTMENT PLAN

The EIP (see page 51, interview with P. Vincent) has two objectives:

- To **reinvest** part of our resources in our scientific priorities, in order to broaden and accelerate the implementation of the Institute's 2030 strategic plan and its Statement of Objectives
- To dedicate these resources to **research and innovation** with the twofold goal of creating assets and strengthening strategic partnerships

Appendices

YEAR-END FINANCIAL STATEMENT BEFORE ALLOCATION OF EARNINGS

BALANCE SHEET – ASSETS	2020 GROSS	AMORTIZATIONS & DEPRECIATIONS	2020 NET	2019 NET
FIXED ASSETS				
INTANGIBLE ASSETS	**54,429,267.56**	**39,144,849.83**	**15,284,417.73**	**17,030,782.22**
TANGIBLE FIXED ASSETS	**617,690,905.42**	**418,399,061.52**	**199,291,843.90**	**209,330,647.06**
Land	8,732,585.29	1,890,009.23	6,842,576.06	6,704,054.06
Buildings	125,973,143.98	85,350,683.98	40,622,460.00	40,966,563.00
Technical facilities, equipment and tools	397,515,394.43	299,266,945.43	98,248,449.00	90,828,154.00
Collections	872,856.49	0.00	872,856.49	872,856.49
Historical and cultural property	0.00	0.00	0.00	0.00
Other tangible fixed assets	36,556,181.88	31,891,422.88	4,664,759.00	1,959,226.00
Fixed assets under concession	0.00	0.00	0.00	0.00
Tangible fixed assets in progress	622,426.08	0.00	622,426.08	8,417,473.72
Advances and prepayments made on orders	47,418,317.27	0.00	47,418,317.27	59,582,319.79
Fixed assets subject to rights	0.00	0.00	0.00	0.00
Tangible fixed assets (living organisms)	0.00	0.00	0.00	0.00
FINANCIAL ASSETS	**15,046,139.81**	**342,194.61**	**14,703,945.20**	**11,082,446.63**
TOTAL FIXED ASSETS	**687,166,312.79**	**457,886,105.96**	**229,280,206.83**	**237,443,875.91**
CURRENT ASSETS				
STOCKS	**0.00**	**0.00**	**0.00**	**0.00**
ACCOUNTS RECEIVABLE	**57,087,691.61**	**90,332.62**	**56,997,358.99**	**52,160,376.96**
Accounts receivable on public entities (national government, other public entities), international bodies and the European Commission	46,803,720.82	0.00	46,803,720.82	41,008,378.22
Customer and related accounts receivable	3,967,865.29	90,332.62	3,877,532.67	6,153,075.84
Accounts receivable on tax owed (income from earmarked taxes)	0.00	0.00	0.00	0.00
Advances and prepayments made on orders	190,519.17	0.00	190,519.17	4,550,896.36
Accounts receivable corresponding to operations on behalf of third parties (intervention plans)	0.00	0.00	0.00	0.00
Accounts receivable on other debtors	6,125,586.33	0.00	6,125,586.33	448,026.54
PREPAID EXPENSES	**0.00**	**0.00**	**0.00**	**0.00**
TOTAL CURRENT ASSETS	**57,087,691.61**	**90,332.62**	**56,997,358.99**	**52,160,376.96**
CASH FLOW				
Investment securities	0.00	0.00	0.00	0.00
Cash	122,050,683.29	0.00	122,050,683.29	68,436,421.51
Other	0.00	0.00	0.00	0.00
TOTAL CASH FLOW	**122,050,683.29**	**0.00**	**122,050,683.29**	**68,436,421.51**
Accrual and deferral accounts	0.00	0.00	0.00	0.00
Unrealized foreign exchange gains	0.00	0.00	0.00	0.00
OVERALL TOTAL	**866,304,687.69**	**457,976,438.58**	**408,328,249.11**	**358,040,674.38**

YEAR-END FINANCIAL STATEMENT BEFORE ALLOCATION OF EARNINGS

BALANCE SHEET – LIABILITIES	2020	2019
LIABLE EQUITY CAPITAL		
FUNDING RECEIVED	**160,142,355.04**	**172,706,577.85**
Asset funding by the State	108,071,920.43	120,151,978.77
Asset funding by third parties	37,200,255.63	36,969,676.10
Own funds from foundations	0.00	0.00
Reevaluation differences	14,870,178.98	15,584,922.98
RESERVES	**63,164,159.37**	**36,225,405.75**
RETAINED EARNINGS	**19,104,507.72**	**22,919,179.90**
FINANCIAL YEAR RESULT	**61,397,916.22**	**26,224,009.62**
REGULATED PROVISIONS	**0.00**	**0.00**
TOTAL LIABLE EQUITY CAPITAL	**303,808,938.35**	**258,075,173.12**
PROVISIONS FOR CONTINGENCIES AND EXPENSES		
Provisions for contingencies	2,954,700.04	4,564,035.28
Provisions for expenses	36,728,110.67	38,714,762.58
TOTAL PROVISIONS FOR CONTINGENCIES AND EXPENSES	**39,682,810.71**	**43,278,797.86**
FINANCIAL LIABILITIES		
Bond loans	0.00	0.00
Loans taken out from financial institutions	0.00	0.00
Financial debts and other loans	0.00	3,448.41
TOTAL FINANCIAL LIABILITIES	**0.00**	**3,448.41**
NON-FINANCIAL LIABILITIES		
Trade accounts payable and related accounts	7,874,012.45	11,893,348.26
Tax and social security payable	27,773,972.63	19,571,933.42
Advances and prepayments received	26,393,163.13	22,149,167.98
Accounts payable corresponding to operations on behalf of third parties (intervention plans)	10,873.74	10,873.74
Other non-financial liabilities	2,154,615.98	2,515,195.24
Deferred income	629,862.12	272,078.20
TOTAL NON-FINANCIAL LIABILITIES	**64,836,500.05**	**56,412,596.84**
CASH FLOW		
Other elements of passive cash flow	0.00	270,658.15
TOTAL CASH FLOW	**0.00**	**270,658.15**
Accrual and deferral accounts	0.00	0.00
Unrealized foreign exchange losses	0.00	0.00
OVERALL TOTAL	**408,328,249.11**	**358,040,674.38**

FINANCIAL RESULTS

EXPENSES	2020	2019

OPERATING COSTS

PURCHASES	**0.00**	**0.00**
CONSUMPTION OF GOODS AND SUPPLIES, PERFORMANCE OF WORK AND DIRECT CONSUMPTION OF SERVICES BY THE ORGANIZATION FOR ITS ACTIVITIES AS WELL AS EXPENSES RELATED TO CHANGE IN STOCK	**93,550,076.08**	**86,935,498.07**
SALARIES AND BENEFITS	**95,306,302.94**	**96,954,841.17**
Salaries, appointments and miscellaneous payments	65,256,136.17	66,681,368.42
Social contributions	25,903,313.59	25,138,279.42
Employees' profit sharing	0.00	0.00
Other staff expenses	4,146,853.18	5,135,193.33
OTHER OPERATING COSTS	**16,197,845.08**	**11,158,230.35**
AMORTIZATION, DEPRECIATION, PROVISIONS AND NET BOOK VALUE OF ASSETS SOLD	**26,339,002.79**	**19,612,381.17**
TOTAL OPERATING COSTS	**231,393,226.89**	**214,660,950.76**

INTERVENTION COSTS

FOR INTERVENTION ON OWN BEHALF	**5,000.00**	**55,453.08**
Transfers to households	0.00	0.00
Transfers to companies	0.00	0.00
Transfers to local or regional authorities	0.00	0.00
Transfers to other authorities	5,000.00	55,453.08
CHARGES DUE TO EXERCISE OF THE INSTITUTE'S GUARANTEE	**0.00**	**0.00**
DEPRECIATION AND PROVISIONS FOR LOSS IN VALUE	**0.00**	**0.00**
TOTAL INTERVENTION COSTS	**5,000.00**	**55,453.08**
TOTAL OPERATING AND INTERVENTION COSTS	**231,398,226.89**	**214,716,403.84**

FINANCIAL EXPENSES

Interest fees	119.08	1,440.33
Net loss from sale of securities	0.00	0.00
Exchange losses	20,812.49	18,146.69
Other financial charges	0.00	0.00
Amortization, depreciation and financial provisions	249,093.05	2,649.50
TOTAL FINANCIAL EXPENSES	**270,024.62**	**22,236.52**
CORPORATE INCOME TAXES	**597,638.00**	**59,441.00**
FINANCIAL RESULTS (PROFIT)	**61,397,916.22**	**26,224,009.62**
TOTAL EXPENSES	**293,663,805.73**	**241,022,090.98**

FINANCIAL RESULTS

OPERATING INCOME

INCOME	2020	2019
INCOME WITHOUT DIRECT CONSIDERATION (OR SUBSIDIES, GRANTS AND SIMILAR INCOME)	**205,140,169.48**	**208,099,063.96**
Subsidies for public service responsibilities	173,359,654.00	168,051,185.00
Operating subsidies from the State and other public entities	31,773,015.48	40,043,878.96
Subsidies from the State and other public entities specifically earmarked to cover certain intervention costs	0.00	0.00
Donations and bequests	7,500.00	4,000.00
Income from earmarked taxes	0.00	0.00
INCOME WITH DIRECT CONSIDERATION (OR DIRECT INCOME FROM ACTIVITY)	**68,217,557.08**	**16,466,315.97**
Sale of goods or services	13,303,651.20	15,143,993.54
Gains from sales of assets	52,712,407.92	19,262.24
Other management income	2,201,497.96	1,303,060.19
Inventories and capitalized production	0.00	0.00
OTHER	**19,934,843.19**	**16,310,925.47**
Write-off of amortizations, depreciations and provisions (operating income)	6,997,236.60	3,625,867.37
Write-off of financing related to an asset	12,937,606.59	12,685,058.10
TOTAL OPERATING INCOME	**293,292,569.75**	**240,876,305.40**

FINANCIAL INCOME

INCOME FROM SHARES AND LOANS	**8,988.90**	**122,141.96**
Net income from sale of financial fixed assets	0.00	0.00
Interest on non-fixed receivables	0.00	8,972.02
Income from investment securities and cash flow	0.00	0.00
Income from sale of securities	0.00	0.00
Exchange gains	12,268.11	14,671.60
Other financial income	0.00	0.00
Write-off of amortizations, depreciations and financial provisions	349,978.97	0.00
TOTAL FINANCIAL INCOME		
	371,235.98	145,785.58
FINANCIAL RESULTS (LOSS)	**0.00**	**0.00**
TOTAL INCOME	**293,663,805.73**	**241,022,090.98**

BOARD AS OF DECEMBER 31, 2020

CHAIRMAN

François Houllier, Chief Executive Officer

REPRESENTATIVES OF THE STATE

MINISTRY OF HIGHER EDUCATION, RESEARCH AND INNOVATION
Lise Fechner, representative
Didier Marquer, alternate

MINISTRY OF THE SEA
Thierry Courtine, representative
Marie Feucher, alternate

MINISTRY OVERSEEING SEA FISHERIES AND AQUACULTURE
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Laureline Gauthier, alternate

MINISTRY OF EUROPE AND FOREIGN AFFAIRS
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Isabelle Thirion, representative
Colin Thomas, alternate

MINISTRY OF THE ECOLOGICAL TRANSITION
Fabienne Ricard, representative
Isabelle Terrier, alternate

MEMBERS CHOSEN FOR EXPERTISE IN THE INSTITUTE'S AREAS OF FOCUS

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Julien Lamothe
Frédéric Moncany de Saint-Aignan

MEMBERS OVERSEEING LIVING RESOURCES

Elsa Cortijo
Valérie Verdier

REPRESENTATIVES ELECTED BY IFREMER PERSONNEL

CFDT Catherine Treguier
Loîc Le Dean
Marie-Anne Cambon Bonavita
Abdellah Benabdelmouna

CGT Éric Abadie
Carla Scalabrin
Jean-Michel Schramm

CONSULTING MEMBERS

GOVERNMENT COMMISSIONER
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SECRETARY GENERAL FOR THE SEA
Denis Robin
Patrick Augier, alternate

GENERAL COMPTROLLER FOR FINANCE AND ECONOMY
Philippe Debet

MINISTRY OF OVERSEAS TERRITORIES
Camille Servetto

CHAIRMAN OF IFREMER'S SCIENCE COUNCIL
Patrick Landais

IFREMER HEAD ACCOUNTANT
Didier Jaouen

SCIENCE COUNCIL
AS OF DECEMBER 31, 2020

CHAIRMAN OF IFREMER'S SCIENCE COUNCIL

Patrick Landais

MEMBERS APPOINTED BY DECREE

Denis Allemand
Anne Beauval
Gérard Blanchard
Chris Bowler
Pascale Braconnot
Annie Cudennec
Jean-François Ghiglione
Anne-Marie Gué
Gonéri Le Cozannet
Edwige Quillet
Hervé Roquet
Frédérique Viard

MEMBERS REPRESENTING IFREMER PERSONNEL

Jean-François Pepin
Alternate: Marie-Anne Cambon Bonavita
Caroline Montagnani
Alternate: Christophe Desbois
Julien Normand
Alternate: Ricardo Da Silva Jacinto

PERMANENT GUEST MEMBERS

Nicolas Arnaud
Didier Gascuel
François Lallier
Frédéric Menard
Sylvie Rebuffat

SECRETARIAT

Anne Renault, Scientific Director of Ifremer

JOINT ETHICS COMMITTEE

For handling matters of social ethics in research, the Institute is a member of an independent joint ethics consulting committee with INRAE, CIRAD and the IRD. This committee gives Ifremer a framework for reflecting on its scientific activities and their potential consequences.

CHAIRMAN

Axel Kahn

VICE CHAIR

Michel Badré

GENAVIR SASU GOVERNING BOARD

As outlined in the company's statutes, the governing board of Genavir SASU held a meeting to authorize the chairman and chief executive officer of the company to make and implement the decisions necessary for its proper functioning. These decisions primarily concerned the company's initial launch phase and the crewing practices used in the highly unusual context of the pandemic, which led to the need to establish directives and strong measures for staffing vessels and to adapt to the French Oceanographic Fleet's revised schedule.

CHAIRMAN

Patrick Vincent

CHIEF EXECUTIVE OFFICER

Éric Derrien

ORGANIZATIONAL CHART AS OF MARCH 1, 2021

SECURITY AND DEFENSE OFFICIAL
Antoine Dosdat

DELEGATE FOR PROFESSIONAL CONDUCT AND SCIENTIFIC INTEGRITY
Marianne Alunno-Bruscia

DELEGATE FOR DATA PROTECTION (GDPR) SD-CSR
Jean-Marc Sinquin

NATIONAL QUALITY AND SAFETY COORDINATOR
Marie-Laure Chao

François Houllier
CHAIRMAN & CHIEF EXECUTIVE OFFICER

Patrick Vincent
DEPUTY CHIEF EXECUTIVE OFFICER

HEAD OF ACCOUNTING
Didier Jaouen

Genavir
Éric Derrien (CEO)

INSTITUT CARNOT MERS
Jean-Marc Daniel (director)

5 CENTERS IN THE THREE MAJOR OCEANS

CHANNEL – NORTH SEA
Dominique Godefroy

BRITTANY
Valérie Mazauric

ATLANTIC
Pierre Labrosse

MEDITERRANEAN
Vincent Rigaud

PACIFIC
Patrick Vidal

SCIENTIFIC DIRECTOR
Anne Renault

COORDINATOR FOR EXPERTISE IN SUPPORT OF PUBLIC POLICY
Léa Marty

DIRECTOR OF PARTNERSHIPS AND INNOVATION
Romain Charraudeau

DEPARTMENT OF BIOLOGICAL RESOURCES AND ENVIRONMENT
Tristan Renault
• 16 units

DEPARTMENT OF PHYSICAL RESOURCES AND SEAFLOOR ECOSYSTEMS
Jean-Marc Daniel
• 3 units

DEPARTMENT OF OCEANOGRAPHY AND ECOSYSTEM DYNAMICS
Philippe Riou
• 3 units
and 1 subdivision

DEPARTMENT OF RESEARCH INFRASTRUCTURES AND INFORMATION SYSTEMS
Gilbert Maudire • 6 units and subdivisions

OCEANOGRAPHIC FLEET DIVISION
Olivier Lefort • 2 units and 1 subdivision

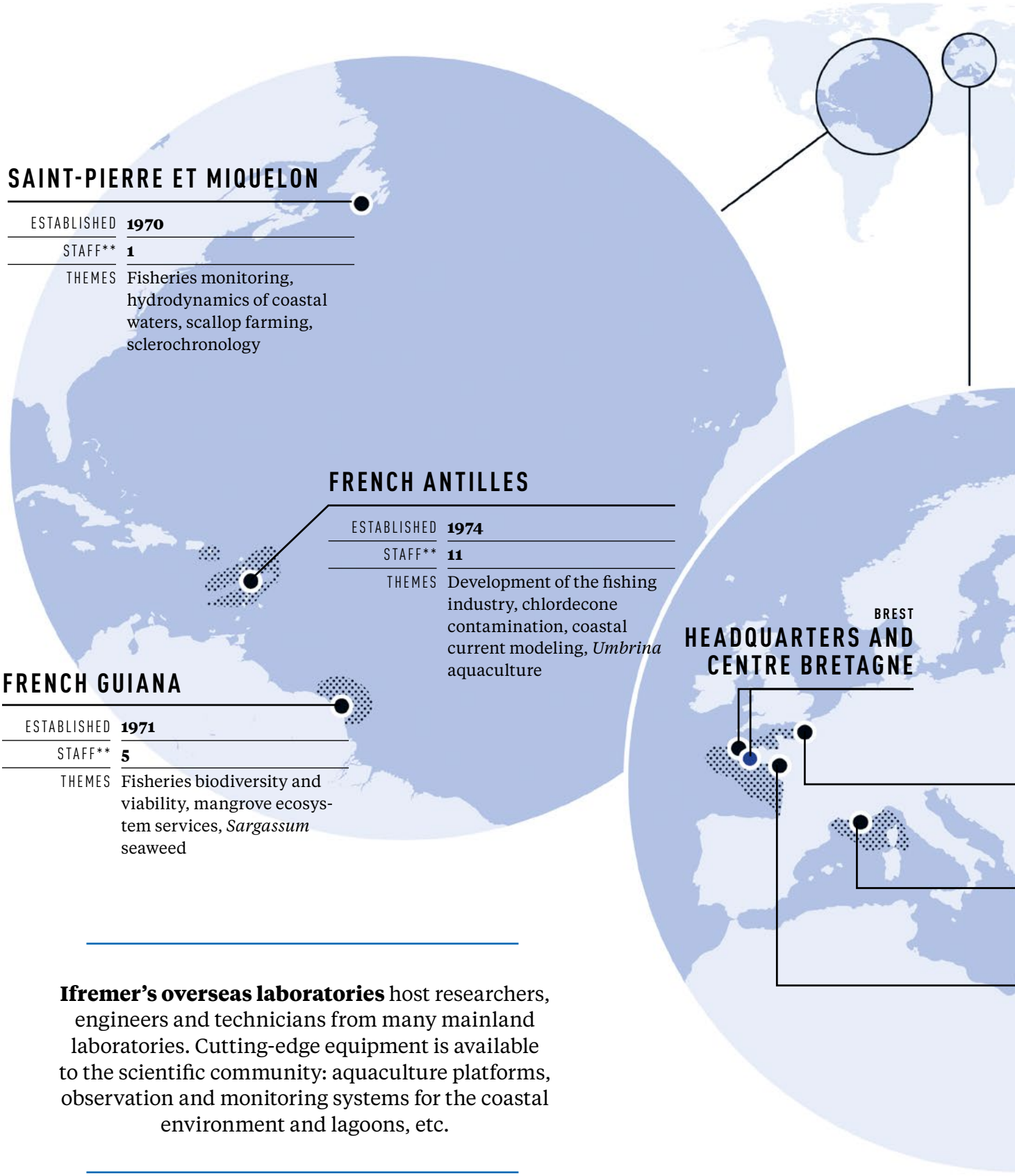
EUROPEAN AND INTERNATIONAL AFFAIRS DIVISION
Natalia Martin Palenzuela

COMMUNICATION AND INSTITUTIONAL RELATIONS DIVISION
Sofia Nadir

HUMAN RESOURCES DIVISION
Stéphane Bergeret

ADMINISTRATIVE, LEGAL AND FINANCIAL DIVISION
Laurent Couret

IFREMER'S PRESENCE IN



SAINT-PIERRE ET MIQUELON

ESTABLISHED	**1970**
STAFF**	**1**
THEMES	Fisheries monitoring, hydrodynamics of coastal waters, scallop farming, sclerochronology

FRENCH ANTILLES

ESTABLISHED	**1974**
STAFF**	**11**
THEMES	Development of the fishing industry, chlordecone contamination, coastal current modeling, *Umbrina* aquaculture

FRENCH GUIANA

ESTABLISHED	**1971**
STAFF**	**5**
THEMES	Fisheries biodiversity and viability, mangrove ecosystem services, *Sargassum* seaweed

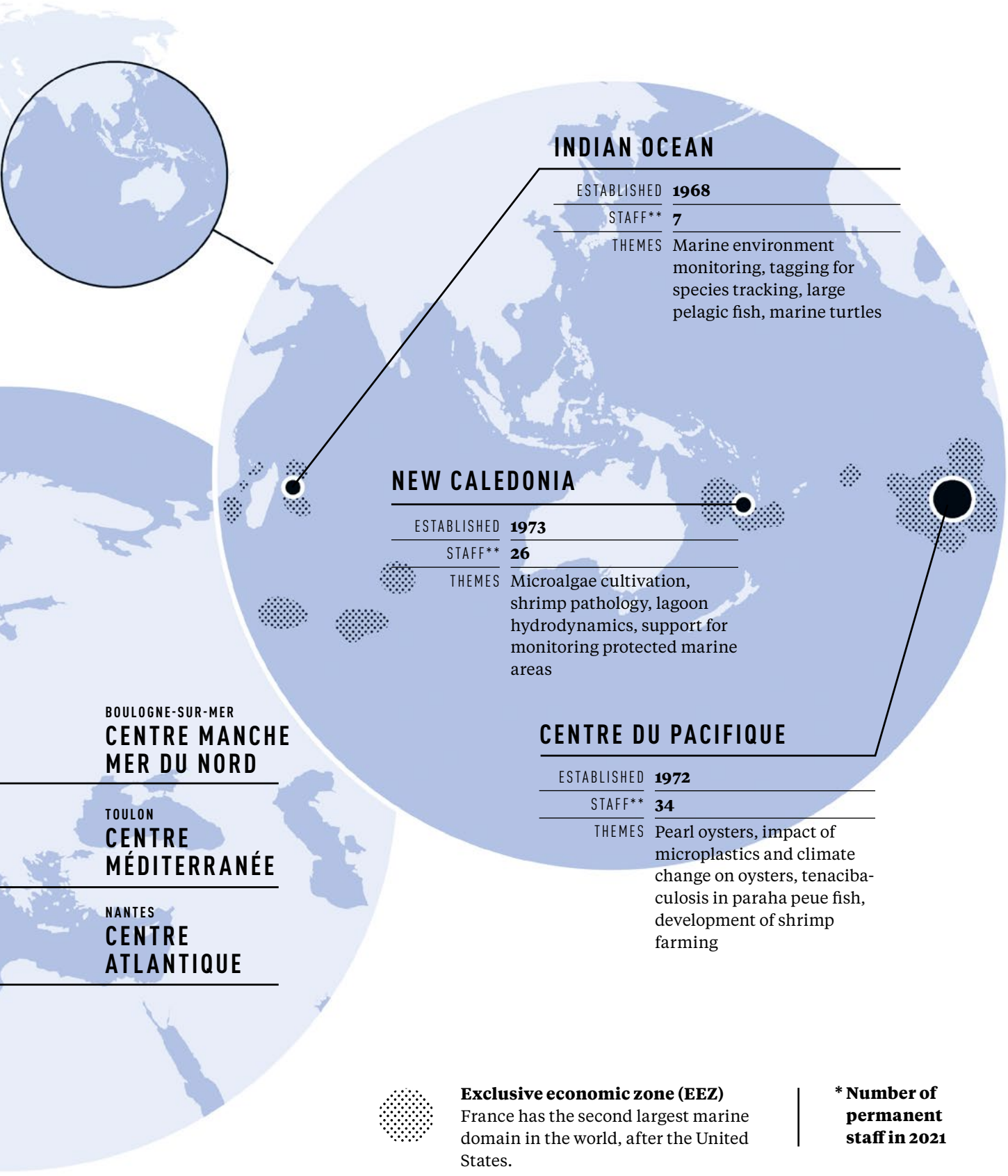
BREST

HEADQUARTERS AND CENTRE BRETAGNE

Ifremer's overseas laboratories host researchers, engineers and technicians from many mainland laboratories. Cutting-edge equipment is available to the scientific community: aquaculture platforms, observation and monitoring systems for the coastal environment and lagoons, etc.

THE THREE MAJOR OCEANS

— ATLANTIC, INDIAN, PACIFIC —



INDIAN OCEAN

ESTABLISHED	**1968**
STAFF**	**7**
THEMES	Marine environment monitoring, tagging for species tracking, large pelagic fish, marine turtles

NEW CALEDONIA

ESTABLISHED	**1973**
STAFF**	**26**
THEMES	Microalgae cultivation, shrimp pathology, lagoon hydrodynamics, support for monitoring protected marine areas

CENTRE DU PACIFIQUE

ESTABLISHED	**1972**
STAFF**	**34**
THEMES	Pearl oysters, impact of microplastics and climate change on oysters, tenaciba-culosis in paraha peue fish, development of shrimp farming

BOULOGNE-SUR-MER
CENTRE MANCHE MER DU NORD

TOULON
CENTRE MÉDITERRANÉE

NANTES
CENTRE ATLANTIQUE

Exclusive economic zone (EEZ)
France has the second largest marine domain in the world, after the United States.

*** Number of permanent staff in 2021**

Ifremer

Centre Bretagne
ZI de la Pointe du Diable
CS 10070
29280 Plouzané

02 98 22 40 40
https://wwz.ifremer.fr/

Our thanks to everyone who contributed
to the creation of this annual report.

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Jérémy Barrault

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Média Graphic

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