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FRANÇAISE

Liberté
Égalité
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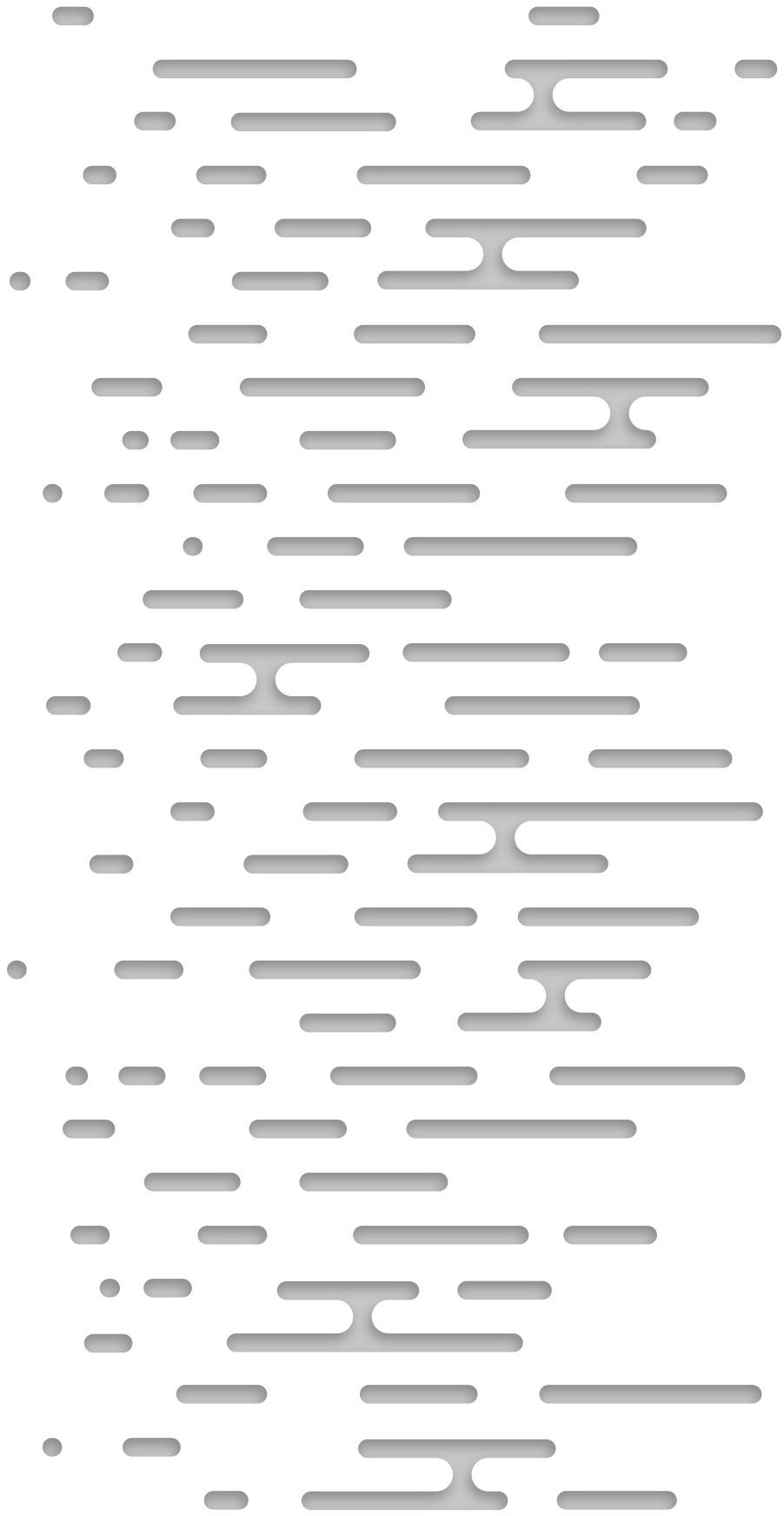
FLOTTE
OCÉANOGRAPHIQUE
FRANÇAISE
PAR L'IFREMER

A YEAR OF WORLD OCEAN SCIENCE

2020




A YEAR OF WORLD
OCEAN SCIENCE
2020

Cover image:
Crew members and scientists aboard R/V *Pourquoi Pas?* returning from the MoMARSAT cruise

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"We sail rough waters and make observations to understand how they play into carbon sequestration and climate change. We study calm seabeds and the submarine volcanoes just starting to break through them. We track living organisms at every scale and learn how they affect water quality and biogeochemistry in the world's oceans. We send our researchers out into the field to gather crucial data on-site. And we can do all of that thanks to the French Oceanographic Fleet. The FOF's vessels, vehicles, onboard instruments, and highly trained crews form an unparalleled oceanography tool for the scientific community. You won't find anything like it anywhere else in the world."

Nicolas Arnaud
Director of CNRS-INSU
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2020 was an unprecedented year on several fronts for the French Oceanographic Fleet, the flagship institution for environmental issues among all of France's Very Large Research Infrastructures.

François Houllier, Chief Executive Officer of Ifremer © Ifremer / E. Lenglemetz

The COVID-19 pandemic had a substantial and inescapable impact on fleet operations. All active cruises were suspended and their vessels recalled to port in mid-March of 2020. Nevertheless, the FOF proved resilient. MAYOBS13 was successfully carried out during the first lockdown in May, and other projects were gradually relaunched over the course of the summer, with strict protective health measures in place.

In the end, about 40% of the year's planned cruises were successfully completed. To the staff at the Oceanographic Fleet Division and Genavir, the university and institutional science personnel who went to sea, and all of our partners: thank you for your understanding, your commitment, and all of your hard work.

The effects of this pandemic will be felt for years to come. Not only is the crisis still ongoing, with protective measures to remain in place for many more months, but it also forced us to reorganize the entire schedule of oceanographic cruises.

2020 was also the first year of activity for Ifremer's new subsidiary Genavir, taking over operations from the Genavir Economic Interest Group. The CNRS transferred coastal-class vessels Téthys and Côtes de la Manche to Ifremer, and their crews were brought under the new company's umbrella. Ifremer and Genavir collectively received Green Marine Europe certification in 2020, a label that recognizes our commitment to responsible oceanography and energy efficiency as part of the maritime world's push toward a greener future.

In a showcase of the Oceanographic Fleet Division staff's creativity and resilience in the face of the pandemic, this past year also saw the convergence of two amazing technology projects: CORAL and DeepSea'nnovation.

CORAL (Constructive Offshore Robotics ALliance) began in 2016, jointly funded by the French government, the European Union, and the PACA Regional Council. With help from industry partners, the project has now wrapped up with the delivery of *UlyX*, a new autonomous underwater vehicle that can reach depths up to 6,000 m. Initial testing took place at the end of 2020 and will continue into 2021. When *UlyX* joins the fleet in 2022, it will fill a longstanding gap in the fleet's array of observational tools.

DeepSea'nnovation, developed during the first lockdown, was chosen to receive a grant from EquipEx+ as part of the Program for Investments in the Future. The Ifremer-led project also brings in teams from many other institutions, including the CNRS, the IPGP, and various universities. It aims to augment the scientific equipment on remotely operated submarine robots with high-quality sensors and sampling instruments for cutting-edge deep-sea research.

With these projects, the FOF will remain a leader in its field. In October 2020, the Ifremer Board of Directors also approved the fleet's plans for future upgrades and modernization. Development of these plans began in 2017, and proposals were discussed with the government in 2019 and 2020. The final version will steer the fleet's operations and investments through 2030. This is the first time the FOF has had such an ambitious and long-term road map to guide it.

François Houllier

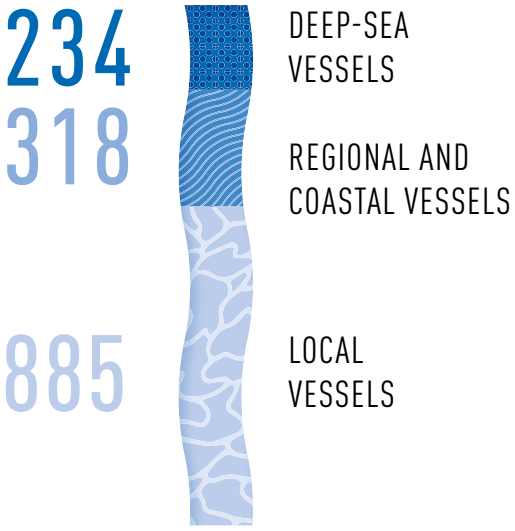
2020 by the numbers

Whether down in the abyss or up where the ocean meets the air, the French Oceanographic Fleet helps us respond more effectively to today's key challenges in marine science and technology.

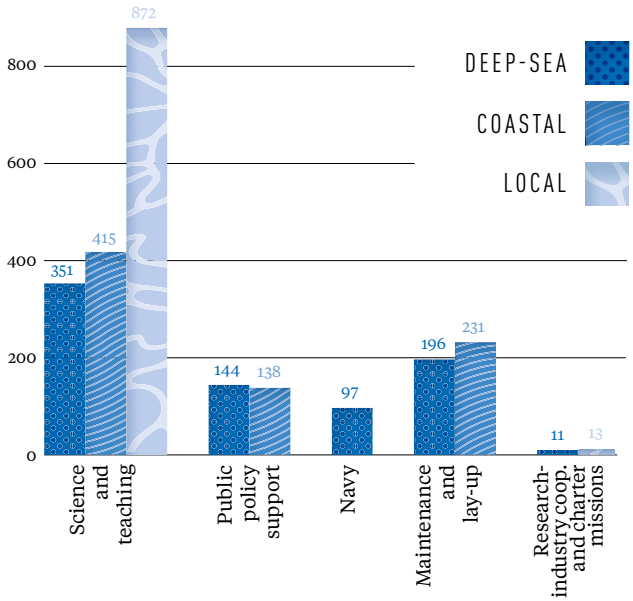
It serves the French and European scientific communities and contributes to excellence in both basic and applied research. It performs surveys and public service projects on behalf of the government, and its crews are highly sought after for collaborations with both business and government.

2020 BY THE NUMBERS

NET SCIENCE **ACTIVITY DAYS**

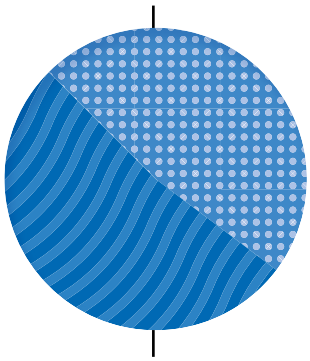


NUMBER OF **ACTIVITY DAYS**



962 PERSONNEL ABOARD (INCLUDING GENAVIR TECHNICAL TEAMS)

460
On coastal and regional vessels

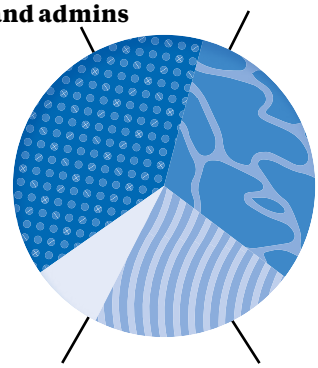


502
On deep-sea vessels

843 PERSONNEL FROM THE MINISTRY OF HIGHER EDUCATION AND RESEARCH (ESR)

330
Engineers, technicians and admins

262
Researchers



64
Doctoral student

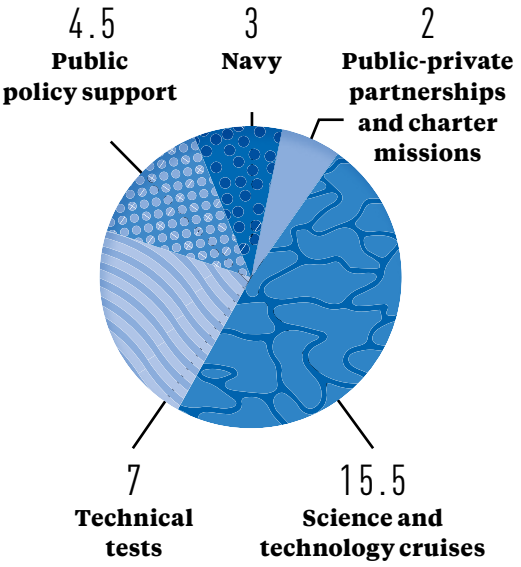
187
Students

304 MISSIONS ON **LOCAL-CLASS VESSELS**

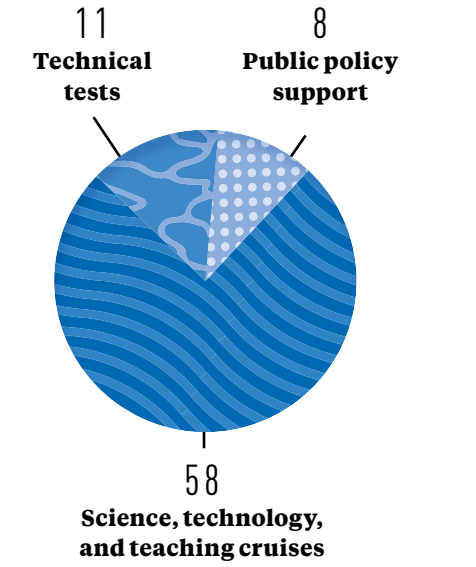
including 229
evaluated by Local Assessment Committees

109 MISSIONS

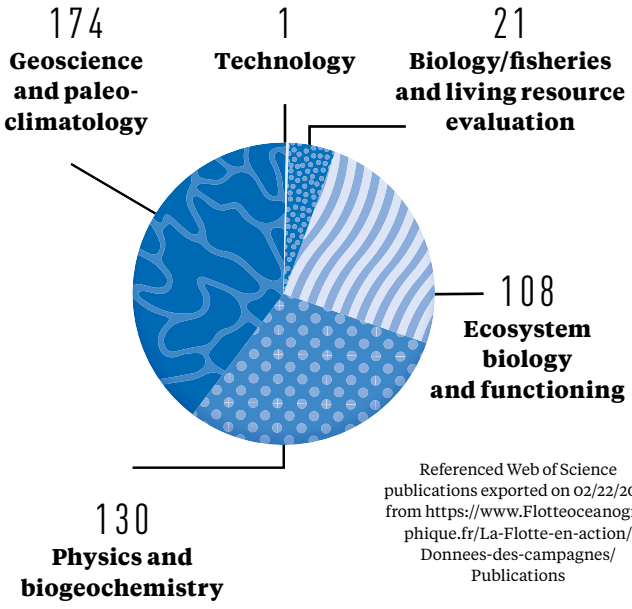
32 MISSIONS ON DEEP-SEA VESSELS



77 MISSIONS ON COASTAL AND REGIONAL VESSELS

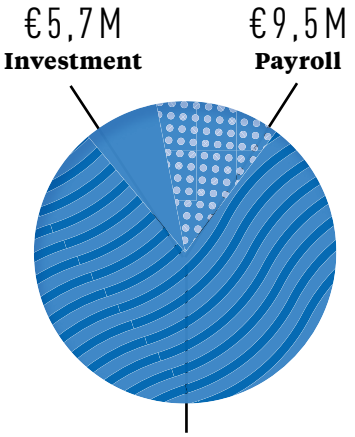


434 PUBLICATIONS



Referenced Web of Science publications exported on 02/22/2021 from https://www.Flotteoceanographique.fr/La-Flotte-en-action/Donnees-des-campagnes/Publications

€70.3M IN PAYMENT APPROPRIATIONS



(including Genavir payments for business management of naval assets)

Overcoming the health crisis

2020 was a turbulent year for the French Oceanographic Fleet, operated by The government-mandated lockdown in mid-March put scientific cruises on pause, with the fleet's vessels of all classes kept at port for months on end. But cruises were rescheduled, and new health protocols were implemented to keep crews and scientists safe. Gradually, operations resumed. Local-class vessels started setting sail in May, and other vessels followed suit over the course of the summer.

The teams at Genavir, the CNRS-INSU Technical Division, and the Oceanographic Fleet Division demonstrated exceptional responsiveness and commitment during this crisis. The fleet's executive committee also rose to the challenge: they met ten times in 2020, including six special meetings. Thanks to all these efforts, disruption of fleet operations was kept to a minimum, and 40% of the projects originally planned for the year were successfully completed.

LOGBOOK FROM AN UNUSUAL YEAR

Running the French Oceanographic Fleet in 2020 was a complex endeavor. A look back at a year full of surprises:

JANUARY-FEBRUARY: BOLD PLANS

At the start of the year, the cruise schedule itself was as ambitious as the scientific goals it served. Research vessels deployed across the globe. R/V *L'Atalante* went to the Antilles for EUREC4A, an international initiative to observe and understand ocean-atmosphere interaction and its role in climate change. After that, it moved to the Pacific for another international project, HIPER. R/V *Marion Dufresne* combined its annual OBSAUSTRAL cruise (OISO, OHA-SIS-BIO, and NIVMER projects) with the ACCLIMATE-2 coring expedition. After a technical stop, R/V *Pourquoi Pas?* arrived in the central Mediterranean for PERLE3, a project focusing on the dispersion of Levantine Intermediate Water and changes in its physical and biogeochemical features. R/V *Thalassa* and the coastal-class vessels likewise took to sea with a packed schedule, after technical stops for R/V *Téthys 2*, R/V *Côtes de la Manche*, and R/V *Thalia*. Our European collaborations also continued: the project ABRIC1 sent HROV *Ariane* out on the Spanish R/V *Sarmiento de Gamboa*.

MARCH 16: CRUISES HALTED AND VESSELS RECALLED TO PORT

Amidst the worsening global health crisis, the Oceanographic Fleet Division and fleet operator Genavir decided in February to limit entries into certain countries and prioritize the use of French ports, even if it meant longer transit times for the science teams on board. When the lockdown was announced on March 16, all vessels were immediately recalled to port in France for the safety of their crews, scientists, and operational personnel. Projects were suspended and return trips arranged. Coastal and local vessels went into lay-up, and deep-sea vessels headed straight for France.

The *Pourquoi Pas?* had been on its way to Greece for PERLE3, and arrived in Toulon on March 19. The *Thalassa* had been wrapping up its annual PIRATA FR30 cruise, and reached Brest on March 31. The *L'Atalante* also made its way to Brest, arriving on April 14 after passing through the Panama Canal and crossing the Atlantic Ocean.

MARCH-JULY: REARRANGING ITINERARIES

As the Oceanographic Fleet Division prepared to resume operations, the priority was to ensure that as much scientific work as possible could be accomplished in the time remaining. They hoped for a quick return to normal starting in May. The Naval Operations Division assembled a new calendar, rescheduling the impacted cruises to the best of their ability. Nevertheless, it quickly became clear that strict protective health measures would need to be put in place and maintained for the long term. The FOF implemented the same protocols already adopted by Genavir and Louis Dreyfus Austral Seas (LDAS), aiming to prevent infections aboard ship. Routine PCR tests and mandatory two-week quarantines before boarding became the new norm for everyone using the French Oceanographic Fleet, and the new guidelines were followed diligently. MoMARSAT was among a few deep-sea cruises able to relaunch in August. Another one was SHOMAN, for the Navy's Service hydrographique et océanographique de la marine (SHOM). Day trips by local vessels also started up again, following strict protocols from the CNRS.

AUGUST-DECEMBER: NEARLY 40% OF PLANNED SCIENTIFIC WORK ACCOMPLISHED IN 2020

Genavir closely monitored the ongoing health crisis and adapted its protocols and methods as the changing situation allowed. At-home quarantines and streamlined PCR testing times allowed for more flexibility in clearing personnel to board ship. Changes were also made to allow the resumption of coastal cruise operations, which are usually relatively short trips on small, cramped vessels. Complementing these collective efforts were extensive discussions with mission heads and countless schedule adjustments. In the end, the Naval Operations Division was able to reschedule almost 50% of the deep-sea work and 35% of the coastal work planned at the start of the year.

The division prioritized fisheries projects and other missions of public interest, along with critical science cruises aimed at retrieving data and equipment.

SCIENCE TEAM FOR MAYOBS15, PART OF THE VOLCANIC AND SEISMIC MONITORING SYSTEM AT MAYOTTE © Ifremer

Quite a few projects were carried out: MoMARSAT and FOCUS X1 on the *Pourquoi Pas?*; HYDROMOMAR, CGFS and EVHOE on the *Thalassa*; TONGA RECUP on the *Alis*; and MAYOBS on the *Marion Dufresne*. R/V *Pourquoi Pas?* even had time to take on SEALEX, a cruise reviewed, approved, and mobilized in the space of just two weeks. The vessel then moved on to the Indian Ocean for a set of large-scale projects that will start in early 2021. Meanwhile, no fewer than five vessels began technical stops in preparation for heading back out to sea in 2021.

Operations were scheduled late into the year in an effort to help scientists accomplish as much of their planned work as possible, despite the risk of bad weather. A few cruises did have to be canceled at the last second due to adverse conditions. Nonetheless, it must be seen as a great accomplishment that, despite the many difficulties, nearly 40% of planned scientific work was completed in 2020.

SETTING SAIL
DURING THE PANDEMIC

PROJECT RESISTE: ADAPTATION AND FLEXIBILITY

INTERVIEW WITH LAURE SIMPLET OF IFREMER'S LABORATOIRE GÉODYNAMIQUE ET ENREGISTREMENT SÉDIMENTAIRE, GEOLOGICAL ENGINEER FOR CONTINENTAL SHELF MAPPING AND MINERAL RESOURCES AND IFREMER COORDINATOR FOR MINING CODE TECHNICAL EXPERTISE AND ADVICE

© Ifremer/O.Dugornay

WHAT DOES THE RESISTE PROJECT AIM TO DO?

The goal is to observe how well a site recovers from the disturbance of underwater sand and gravel mining. We chose Pilier, near the Loire estuary, where mining operations only recently ended at the end of 2017. The idea is to monitor the area frequently in spring and fall for three consecutive years, then again ten years after mining stopped. This will help us get a better grasp on mechanisms of ecosystem resilience following the removal of an anthropogenic pressure.

WHAT HAPPENED WHEN THE LOCKDOWN WAS ANNOUNCED?

Our very first cruise, set for spring 2020, was canceled and couldn't be rescheduled. So we started by asking ourselves whether this cancellation jeopardized the entire program. After discussing it with the team members, we felt we could still fulfill our scientific objectives without those initial measurements, as long as the other cruises could take place normally.

WAS THE OCTOBER CRUISE ABLE TO HAPPEN ON TIME?

It had to be reworked. All the schedules got changed; that's an enormous amount of work, considering how complicated it was to deal with all the high-priority and government missions. In the end, the vessel we'd intended to use for our cruise wasn't available for the full time. The Oceanographic Fleet Division proposed we do our work on two different vessels instead: R/V *Thalia* for mapping (soundings) and R/V *Antea* for periodic measurements (sediment cores, benthic fauna samples, and hydro-sedimentary measurements). We were supposed to do the work in that order, starting off with detections based on acoustic data (bathymetry and seabed reflectivity), but we had to reverse things to fit the vessel availability. Luckily, the gravel mining company gave us digital bathymetric terrain models and acoustic imaging mosaics. That helped us plan out the data we needed to collect and get our measurements done even though we hadn't yet had a chance to take our own acoustic readings.

DID THE HEALTH CRISIS CAUSE ANY OTHER DISRUPTIONS?

The change in schedule meant we had to rethink parts of our plans. We had to double-check that the tides during our new time slots wouldn't interfere with our planned swathes, for example. We also made sure that if we had to, we would be able to remain at sea longer and continue our measurements, so as not to lose too much time to port access delays and bad weather. The FOF made that possible by providing us with an extra sailor on the *Thalia*, even though we hadn't requested it. The pandemic imposed a lot of constraints on our return to work, but everyone was incredibly adaptable and flexible in dealing with them.

HOW DID YOU HANDLE HEALTH PROTOCOLS AND PREVENTION MEASURES?

There again, we had to adapt. A few different options were laid in front of us in October. The first was to do our work during the day and isolate in a hotel at night. The second was to quarantine for several days ahead of time and remain aboard the vessel after that, but teams would rather not quarantine for projects like ours, where the time out at sea is fairly short. The last option, and the one we chose, was to have everyone provide negative results from a PCR test performed no more than four days before departure. That let the cruises go on largely as normal. Mandatory PCR tests came with their own difficulties, though. More than once, we ended up waiting impatiently for a team member's test results so that we could get under way. Then, of course, on the ship we wore masks, washed our hands regularly, and took all the other "traditional" preventive measures.

WAS THE PROJECT SUCCESSFUL, IN THE END?

The hydro-sediment dynamics component had to account for the loss of equipment and adjust its data acquisition strategy on the fly. But we did succeed in collecting 100% of our intended data for the geoscience component. Plus, thanks to a particularly intense day's work, we were able to make up for some weather problems and accomplish 80–90% of our goals for the biology component. So we're very satisfied overall. We really had to adapt anew every single day this year, and make decisions as the situation continued to evolve. I think the success of our project comes from the fact that we kept communicating amongst ourselves as a team, and also kept up communication with the Oceanographic Fleet Division. More than anything else, we succeeded because of the amazing flexibility shown by everyone involved. The crews were very mindful of our concerns about our objectives. They agreed to do some extra work and change their own plans to address the issues we brought up.

SUSPENSION OF THE HIPER CRUISE

INTERVIEW WITH CAPTAIN GILLES FERRAND

© Genavir

HOW WAS THE HIPER CRUISE GOING WHEN THE LOCKDOWN WAS ANNOUNCED?

HIPER is an enormous project studying the effects of the 2016 earthquake in Pedernales, Ecuador. It's incredibly resource-intensive: the project mobilizes 200 tons of equipment and an international team of scientists from Germany, France, and Italy. A huge number of devices have to be put into operation, which is a lot of work for us. When the lockdown was announced, the equipment had been deployed and we'd already started taking measurements. The weather was beautiful. The conditions were perfect. Then, shortly after the government's announcement, Ifremer CEO François Houllier told us that all cruises were being suspended and vessels had to return to France. Given how much time and how many resources had gone into getting HIPER underway, we were a bit surprised. It was a huge disappointment for the project head, because we'd only been able to take a tiny portion of the intended measurements.

WHAT DECISIONS DID YOU MAKE BEFORE HEADING FOR PANAMA?

It would have been out of the question to abandon the forty ocean-bottom seismometers we'd already placed, so we spent four days retrieving them before leaving for Panama. Morale was low at that point. It wasn't just that the project had been suspended. Some of the personnel were concerned for their loved ones, and there were even fears that the canal might be closed, which is something that never happens. The pandemic was already making its effects known—the pilot and mooring crew who boarded to maneuver our vessel through the canal were all wearing masks, gloves, and visors. We ourselves had to dip into the stock of masks on board, left over from the avian flu outbreak, and we rearranged our foot traffic to avoid contact. We were able to refuel and resupply with fresh food while we were at anchor, and then we set sail for France.

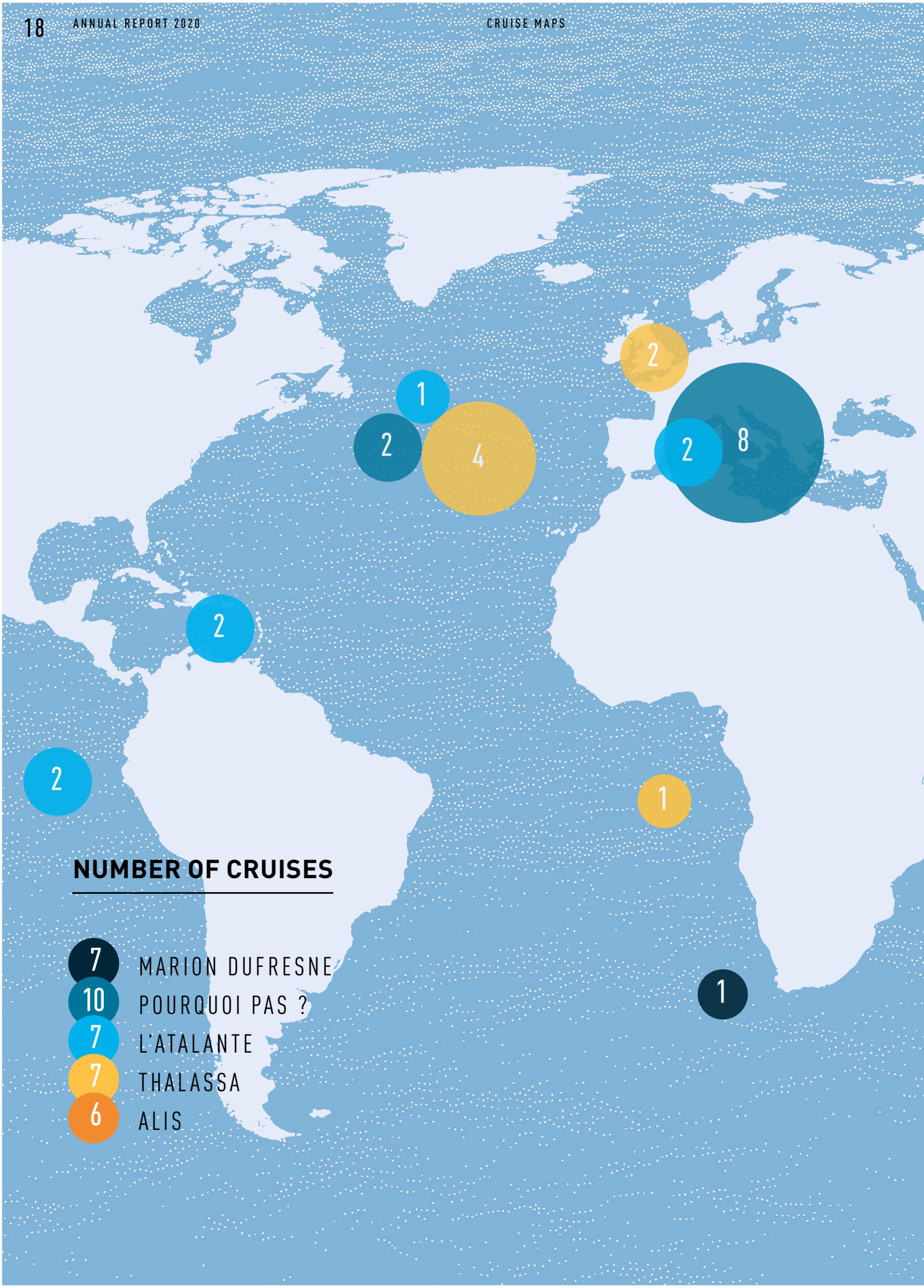
HOW DID THE ATLANTIC CROSSING GO?

We were very careful for the first week, since the virus could have gotten aboard despite all our precautions. Our course was going to take us near the French West Indies, so that was my Plan B—putting ashore those who were ill, if anyone was. Luckily that wasn't necessary. When we started crossing the Atlantic it was a bit strange, because we're not used to having the scientists on board for that part of the voyage. But they were very pragmatic about the whole thing. They used the onboard computers and satellite connection to download the data they needed in order to work. We sailed south of the Azores to avoid a depression, and finally, on April 5, Easter Sunday, we came in sight of Brest. The next day we started unloading people and equipment. We had to help some of the German and Italian researchers figure out how to get home, since transportation in France had become quite complicated.

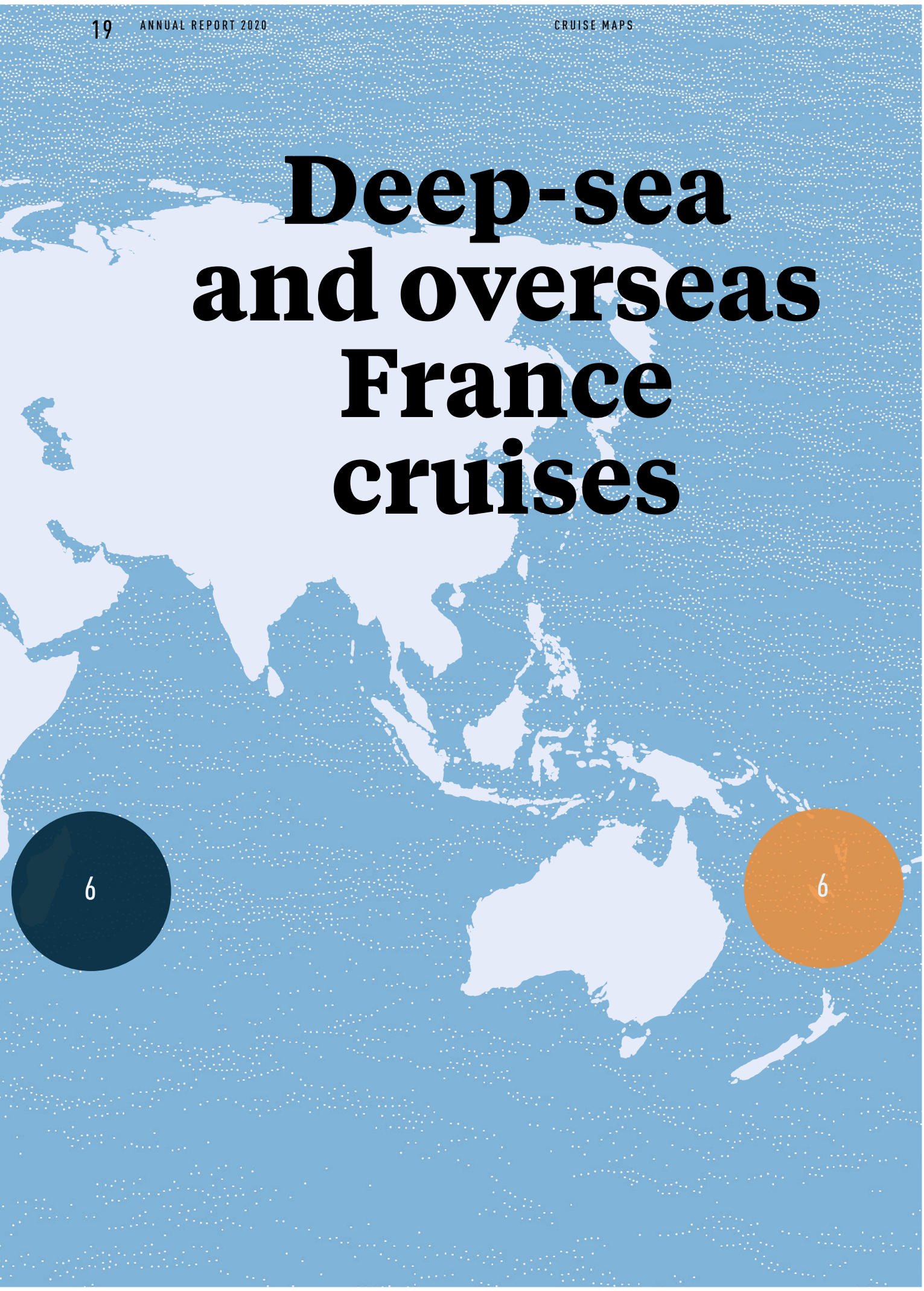
WHAT WERE THE BIGGEST CHANGES ONCE OPERATIONS RESUMED?

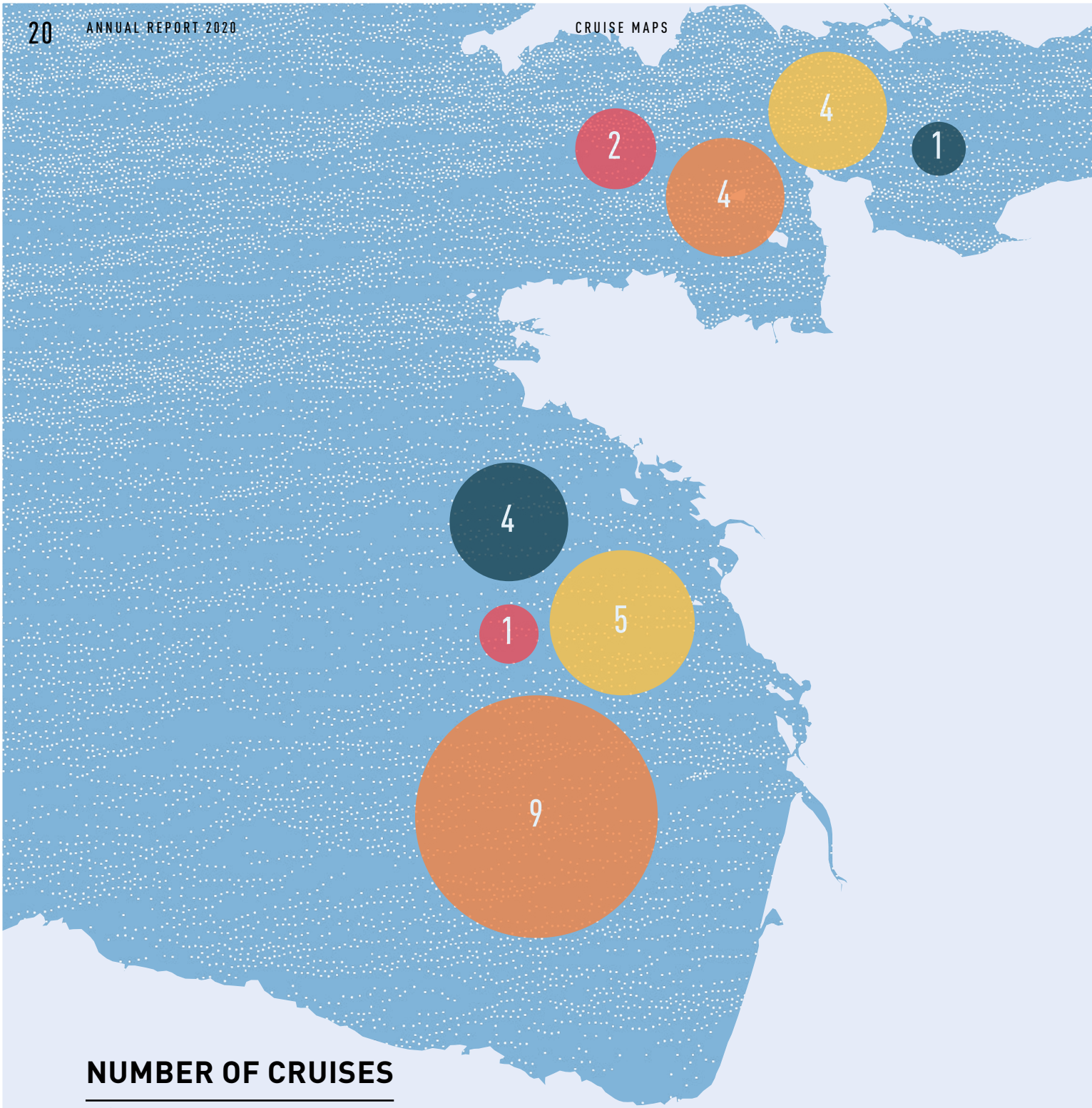
We immediately put protective guidelines in place. Sailors don't cross paths during crew changes now, for example. Orders are given in writing and supplemented by phone calls. Genavir also implemented a new boarding protocol that mandates a quarantine period and two PCR tests ahead of time. Once aboard, we continue to take precautions for one week. If no one is sick, then the ship is declared COVID-free and we can stop using masks. At the moment, we're also required to only embark science teams at French ports, which sometimes means they're spending a longer time aboard the vessel than usual. We were the first crew to leave in August with R/V *L'Atalante*. The new protocol means we can get back to roaming the oceans and carry out the rescheduled scientific projects. We're constantly adapting.

Cruise maps


2
1
2
4
2
8
2
2
1
1
NUMBER OF CRUISES
7 MARION DUFRESNE
10 POURQUOI PAS ?
7 L'ATALANTE
7 THALASSA
6 ALIS

Deep-sea and overseas France cruises

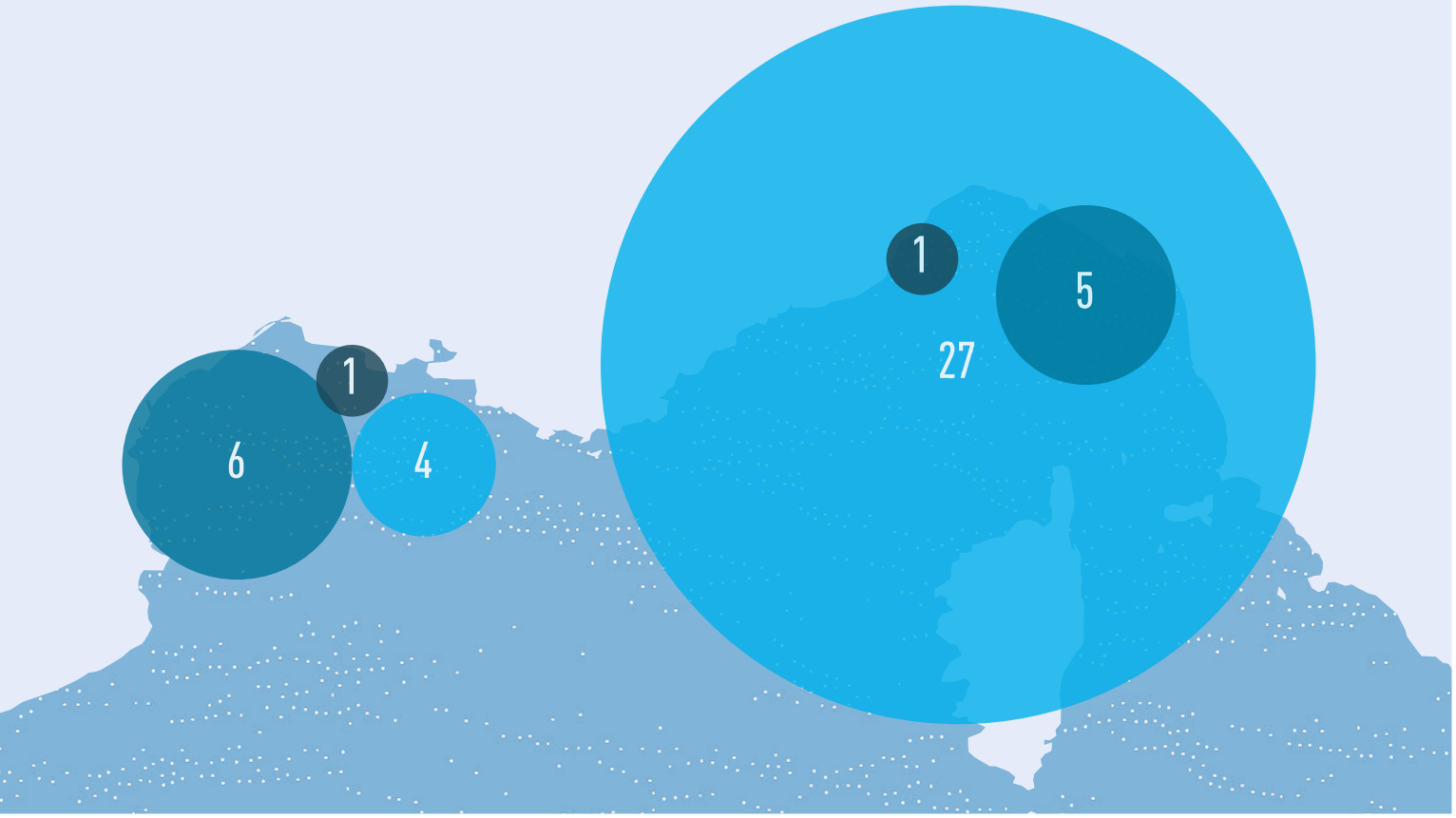




NUMBER OF CRUISES

- 7 ANTÉA
- 11 L'EUROPE
- 31 TETHYS
- 9 THALIA
- 13 CÔTES DE LA MANCHE
- 3 HALIOTIS

Mainland France coastal cruises



Ocean exploration: pushing science forward

UNDERSTANDING DEEP-SEA ECOSYSTEMS

10 YEARS OF MOMARSAT

INTERVIEW WITH PIERRE-MARIE SARRADIN, HEAD OF IFREMER'S DEEP-SEA ECOSYSTEMS STUDIES UNIT AND LEADER OR CO-LEADER OF THE MAJORITY OF MOMARSAT CRUISES

© Ifremer

SO HOW DID THIS ADVENTURE START?

The idea first emerged in 1998. There was an appetite in the scientific community at the time to move beyond ocean cruises of only two or three weeks per year, which could only provide an extremely limited view of how an ecosystem functioned. Advances in technology had us envisioning a permanent infrastructure capable of taking continuous measurements. It took ten years, but we managed to design such a project and get it accepted. In 2010 we set up an autonomous seabed observatory on the Lucky Strike hydrothermal vent field, 1,700 m below the surface off the coast of the Azores. That was the first MoMARSAT cruise. The observatory comprises two nodes deployed on and around a fossil lava lake.

One node investigates issues of seismology and geodesy, specifically dealing with the deformation of the ocean floor. The other node lets us observe a large hydrothermal vent colonized by abundant fauna. We've been monitoring this site since it was discovered in 1994.

Thanks to this facility, called EMSO-Azores, we can study the links between the biosphere, hydrosphere, and geosphere. We're gaining a better understanding of hydrothermal circulation and its impact on the populations of living organisms in this field.

WHAT DO THE MOMARSAT CRUISES DO?

They're primarily for annual maintenance. We bring the vast majority of the devices back to the surface, change the power modules, and clean, recalibrate, and/or replace the sensors. We also retrieve all the data; the observatory has a satellite transmission system, but not all the information can be sent to the surface from the sea floor. The cruises are also used to explore the site further, perform more advanced research, and collect samples. The agenda is more or less the same every year: as soon as we arrive, we retrieve the nodes. Then, while a team of technicians takes care of the maintenance, we do our scientific work.

WHAT DISCOVERIES HAVE BEEN MADE THANKS TO THIS OBSERVATORY AND THESE CRUISES?

We've gotten some amazing results. For example, these days we understand a lot more about the relationship between magmatic heat, faults, and the hydrothermal system. We've modeled how currents and topography affect the dispersion of particles and larval organisms. Studying the temporal dynamics of the fauna has shown how stable these communities are over the course of a decade and helped us better describe the species distribution. A recent study even demonstrated the existence of biological rhythms in one of the seabed species for the first time

WHICH FRENCH OCEANOGRAPHIC FLEET VESSELS HAVE YOU MADE USE OF?

Over the years, we've worked with R/V *Thalassa*, R/V *L'Atalante*, and R/V *Pourquoi Pas?*, along with submersibles *Nautile* and *Victor 6000*. R/V *Pourquoi Pas?* is best suited for our purposes, because its massive work deck can hold the nodes, the transmission buoy, and a submersible all at the same time. It's also a spacious vessel with a generously-appointed laboratory that can accommodate a forty-person science team.

HYDROTHERMAL MUSSEL BED (BATHYMODIOLUS AZORICUS) FEATURING A NUMBER OF CRABS LIVING AROUND THE HYDROTHERMAL VENTS © Ifremer

WHAT ARE SOME OF YOUR FAVORITE MEMORIES FROM THESE CRUISES?

> One of the most vivid is from 2010, when we got the observatory running for the first time. There are also the connections we've made with each other along the way. We're bound and determined to get together almost every year, and that's really helped us develop a multidisciplinary approach to the work. There's always some kind of passionate discussion going on. We've really come to trust each other, especially when it comes to establishing cruise priorities. There are a lot of stories to be told about the weather, when we've had to hunker down and get away from the site until a storm blows over. One year a wave of flu went through the ship. Almost half the people on board got sick, and the infirmary ran out of painkillers. There have also been some extraordinary experiments, of course, like the time we took samples of hydrothermal mussels every 2 hours and 4 minutes for 24 hours straight. That was one of the most complicated dives I've ever had to organize. The 2020 cruise might be a memorable one as well. It ended up being a success despite the health crisis, but we had to board at Toulon, isolate in a hotel, and take two PCR tests beforehand, plus spend a week on board wearing masks at all times.

WHAT COMES NEXT FOR THIS PROJECT?

> We've been starting to think about next steps, both in terms of science and in terms of organization. We'd like to reduce the required maintenance so that the cruises can be shorter and cheaper, which will make them easier to sustain long-term.

Mathilde Cannat, CNRS Director of Marine Geoscience Research and member of the Institut de physique du globe de Paris (IPGP), created the MoMARSAT project along with Pierre-Marie Sarradin. The project is a collaboration among a multitude of teams from France and other countries: Ifremer/REM/RDT, GET, LIENSs, University of the Azores, MIO, LEMAR, and LOPS. Technical coordination is managed by the Ifremer Technical Research and Development unit (RDT) (J. Blandin followed by J. Legrand, L. Gautier starting in 2021).

The EMSO-Azores observatory is run and financed by Ifremer and the CNRS as part of the EMSO-ERIC research infrastructure network. The project also receives national and international funding (LabexMER, ISblue, ANR, H2020).

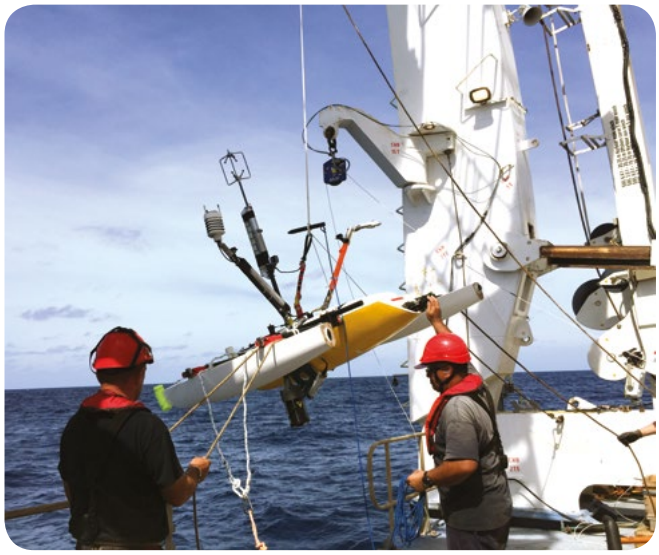
IDENTIFYING CLIMATE-REGULATING PROCESSES

EUREC4A: INVESTIGATING UNKNOWN VARIABLES IN THE CLIMATE EQUATION

Between January 20 and February 20, 2020, the fleet participated in a large-scale airborne and maritime campaign near the Caribbean island of Barbados. A multitude of researchers from many different countries came together to complete EUREC4A (Elucidating the role of clouds-circulation coupling in climate), a field study of trade-wind cumuli and ocean mesoscale eddies. Scientists hope that studying these air-sea interactions will improve our understanding of the pace and intensity of climate change.

Shallow clouds, the kind seen in fine weather, are ubiquitous in the tropics. Climatologists have found that these clouds have a significant influence on climate. An important step in clarifying precisely how global warming works, then, will be to learn more about how these clouds form and what factors affect their properties. How will this cloud cover, with its vast cooling potential, evolve? Will it mitigate or amplify global warming's effects? A massive apparatus was mobilized to learn about the features and spatial organization of these clouds. Five research aircraft with state-of-the-art instruments took measurements at high and low altitudes, recording water content, droplet sizes, internal movement, vertical air motion, and more.

In parallel with the cloud research, scientists also investigated ocean mesoscale eddies—circulations typically less than 100 km wide. These eddies are very common in this region and are believed to function as reservoirs for CO2 and heat. However, many of the details of these air-sea interactions are still poorly understood, and they are only cursorily represented in climate models. With the help of four research vessels (including the R/V *L'Atalante* of the French Oceanographic Fleet) as well as a number of instrumented buoys, underwater gliders, and saildrones, the Barbados Cloud Observatory headed up an intensive study of these phenomena at small scales (1 m to 10 km).



CO-DIRECTED BY SANDRINE BONY OF THE CNRS AND BJORN STEVENS OF THE MAX PLANCK INSTITUTE, IN PARTNERSHIP WITH DAVID FARRELL OF THE CARIBBEAN INSTITUTE FOR METEOROLOGY AND HYDROLOGY, THE EUREC4A INITIATIVE STUDIED CLOUD FORMATION PROCESSES IN TROPICAL REGIONS. © EUREC4A-OA

The data gathered will strengthen our understanding of crucial climate processes. It will also help scientists evaluate how well weather and climate prediction models can forecast trade wind cumuli and air-sea interactions, and improve satellite detection of these processes.

EUREC4A is co-directed by Sandrine Bony of the CNRS and Bjorn Stevens of the Max Planck Institute, in partnership with David Farrell of the Caribbean Institute for Meteorology and Hydrology. This project is supported by the World Climate Research Programme. Participants included more than thirty institutions from eleven different countries. In France, thirteen labs and structures belonging to the CNRS or its partners were participants, collectively sending more than 100 people to the project site.

ACCLIMATE-2: RECONSTRUCTING THE OCEAN OF THE PAST

The ACCLIMATE-2 coring expedition aims to understand how the climate of the Southern Ocean has changed over the past 500,000 years. From February 9 to March 1, 2020, thirty scientists from eleven countries battled the Roaring Forties in R/V *Marion Dufresne* to procure valuable samples. Unlike the original ACCLIMATE cruise in 2016, researchers saw fair weather this time around, a boon as they carried out their work off the coast of South Africa.

The ACCLIMATE cruises take very long (40–70 m) marine sediment cores at depths ranging from 1,000 to 4,600 m. These cores can give scientists a picture of ocean circulation and climate at different points in time. Particle size, chemical composition, and microfossils extracted from these sediments can reveal a great deal of information, including the origins of water masses that moved through the area, the speed of deep currents at different times, and changes in water temperature. Scientists hope that by studying the sediment cores, they'll be able to make more robust climate prediction models.

The *Marion Dufresne* is the only research vessel in the world capable of collecting giant cores (length >60 m), and on ACCLIMATE-2 it once again lived up to its reputation. Researchers used the Calypso corer to collect eight long samples, including four that were 60 m long and in excellent condition. Initial analyses were performed immediately. These included measurements of the proportion of magnetic minerals in the samples, which can give information about variations in climate. The scientists also examined the color of the sediments to determine their age. Light-colored sediments indicate interglacial periods where waters were warmer and filled with carbonate. Dark green and blackish-brown hues show glacial periods. Some of these sediment cores contain details of the last 350,000 years of climate fluctuations in the Southern Ocean.

ON THE ACCLIMATE-2 CRUISE, THE CALYPSO CORER COLLECTED EIGHT LONG SEDIMENT CORES, INCLUDING FOUR THAT WERE 60 M LONG AND IN EXCELLENT CONDITION. © UB/Maria de la Fuente

The onboard analyses were just a preview of what's to come. Eight tons of sediment collected over the course of three weeks will provide material for many years of further research. Storage of the cores is shared by Brest and Norway, as part of a collaboration with the Norwegian Research Centre (NORCE) and the University of Cardiff in Wales.

ACCLIMATE-2 is a joint project of Ifremer's Marine Geosciences unit and the Laboratoire des Sciences du Climat et de l'Environnement (CNRS-CEA-University of Versailles Saint-Quentin-en-Yvelines). Scientists from the University of Perpignan, the University of Bordeaux, the University of Barcelona, the University of Rio de Janeiro, the Bjerkness Centre for Climate Research, the Norwegian Research Centre, and the University of Cardiff (United Kingdom) also participated in this project.

SEALEX: FOLLOWING ALEX'S UNDERWATER TRACKS

Researchers raced to put together SEALEX (SEarching for ALEX) to take advantage of a unique opportunity: the chance to observe as enormous quantities of sediment were dispersed into the ocean after being displaced by Storm Alex. They hoped the cruise would help them better understand this natural phenomenon and its repercussions.

The storm battered France, especially the Alpes-Maritimes department, from October 2 to 4, 2020. Its heavy rainfall caused the strongest flooding, landslides, and debris flows ever recorded in the Tinée, Vésubie, and Roya valleys. Initial estimates of the displaced volume exceeded even what was seen in the 1994 Var flood (18 million tons).

The massive scale of this event grabbed the attention of two marine geoscience researchers, who wanted to know what would happen to the enormous quantities of sediment ripped from the valleys and carried out to sea.

To help them answer that question, the FOF offered R/V *Pourquoi Pas?*. The project was reviewed, approved, and mobilized in record time. Crews, technicians, and scientists from France and Italy set sail for a nine-day expedition between the mouths of the Var and the Roya on November 1, 2020, just fifteen days after the project was first proposed. They worked in shifts to take a series of samples and soundings. Bathymetric and seismic surveys mapped submarine canyons and measured the thickness and structure of the sediment layers.

THE SEALEX CRUISE WAS QUICKLY PUT TOGETHER IN THE WAKE OF STORM ALEX BY GUEORGUI RATZOV, A LECTURER AT CÔTE D'AZUR UNIVERSITY, AND SÉBASTIEN MIGEON, A PROFESSOR AT SORBONNE UNIVERSITY.
© Université Côte d'Azur / M.O. Beslier

Researchers used grab samplers and a new device called a multitube corer to take regular sediment samples. The carefully selected sampling sites were located at depths of up to 2,500 m.

One of the highest-quality samples could allow for analysis of sedimentary deposits from multiple notable events: the 1887 earthquake, the 1979 landslide near Nice airport, and the Roya flooding from Storm Alex. All of the samples are being protected from oxidation and kept in cold storage to avoid altering their organic content. Description and analysis were begun during the voyage, but more in-depth studies will be conducted on land.

SEALEX was arranged by Gueorgui Ratzov, a lecturer at Côte d'Azur University, and Sébastien Migeon, a professor at Sorbonne University. It drew twenty-four scientists from those two universities as well as from the Consorzio Nazionale Interuniversitario per le Scienze del Mare (CoNISMa), the CNRS, the IRD, the University of Genoa, and Sapienza University of Rome.

STUDYING MARINE BIODIVERSITY

KANADEEP: BIODIVERSITY ON PACIFIC SEAMOUNTS

INTERVIEW WITH SARAH SAMADI, PROFESSOR AT THE MUSÉUM NATIONAL D'HISTOIRE NATURELLE AND HEAD OF THE "EXPLORATION, SPECIES, AND EVOLUTION" TEAM AT THE MIXED RESEARCH UNIT INSTITUT DE SYSTÉMATIQUE, ÉVOLUTION, BIODIVERSITÉ (ISYEB)

© MNHN

WHY ARE THE NEW CALEDONIA SEABEDS SO FASCINATING FROM A BIODIVERSITY STANDPOINT?

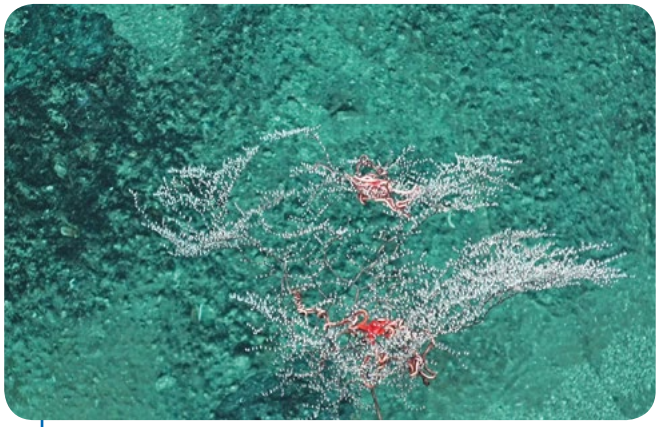
We don't know much about the deep ocean environment, generally speaking. There are surprises waiting for us all over the planet. But New Caledonia especially is right in the sweet spot for biodiversity, especially marine biodiversity. When we're exploring that part of the world, we know we're going to dive into a rich environment and discover something new.

New Caledonia is also a place that's aware of what a treasure its oceans are. They want to learn more about these areas so they can take better care of them. There's a lot of information already out there—maps, biodiversity data—that we can use to keep pushing forward. So we're continuing to work on discovering new species, but we're also starting to study ecosystem functioning, which you can't do everywhere yet.

HOW DID THE KANADEEP PROJECT GET STARTED?

Almost forty years ago, the Muséum national d'histoire naturelle (MNHN), the National Research Institute (IRD), and the Office de la recherche scientifique et technique outre-mer (ORSTOM) created a wildlife exploration program to learn more about deep-sea habitats around tropical islands. When New Caledonia decided to protect its marine space, we took stock of the information we had and identified a number of gaps in our knowledge. We proposed KANADEEP to help fill those gaps.

The first KANADEEP trip took place in 2017 on the French Oceanographic Fleet's R/V *Alis*. We dredged and trawled in areas that had already been explored, as a supplement to existing samples from those places. Two years later, a second cruise was arranged, this time with increased resources. The FOF gave us R/V *L'Atalante* and the *Victor 6000* submersible. That equipment let us descend up to 3,000 m below the surface, as opposed to the *Alis*'s 1,000 m. We also got a lot of pictures of the fauna *in situ*, whereas before we'd mostly only learned about them from specimens brought back to the surface by the dredges and trawls. At the end of 2020 we also took R/V *Alis* out for KANARECUP to retrieve the particle traps we'd set up the previous year. The data we've gathered will teach us more about how food particles and larvae settle on the seabed and nourish these ecosystems.



CNIDARIAN (METALLOGORGIA MELANOTRICHOS) AND BRITTLE STAR SAMPLES FROM KANADEEP, A COLLABORATION BETWEEN THE MNHN AND IFREMER © MNHN / IFREMER

WHAT HAVE YOU FOUND OUT?

We've been able to describe several thousand New Caledonian species during these expeditions. The first KANADEEP cruise saw some interesting discoveries that became the subjects of several publications. The pandemic has kept us from really digging into the data from the second trip, but the images and samples are very promising. Because the *L'Atalante* is so big, we were able to bring a larger team with a wider range of specializations, and we could investigate taxonomic groups that we hadn't done much work on before. We're going to add data on sponges, corals, and gorgonian corals to our existing findings on fish, mollusks, and crustaceans. These "architectural" organisms are less well understood, but they are crucial, because they form habitats for other species.

WHAT DO YOU THINK OF THE PLANS UNDER DISCUSSION FOR MODERNIZING THE RESEARCH VESSELS THAT HEAD TO THIS PART OF THE PACIFIC?

They're vital to our work. We've been working with R/V *Alis* for a long time. That vessel has its virtues, but it also has limits. We're waiting for a medium-sized ship that we can use to go out more often and do more while we're there, without having to resort to large vessels like R/V *Pourquoi Pas?* and R/V *L'Atalante*. There are several different features we'd like to see: a larger capacity, for one, so we can bring more people, and also the ability to dredge and trawl without sacrificing the ability to send imaging systems down to the sea floor. The biggest limitation with the *Alis* is that it can only accommodate six scientists at a time.

The more specialists we have on board, the better the samples we can collect and the richer the results of the cruise will be.

WHAT COMES NEXT? ARE YOU GOING TO CONTINUE EXPLORING?

Yes, we intend to continue our work in New Caledonia as well as in Papua New Guinea, another intriguing site that we've been exploring since 2010. The pandemic has introduced some logistical constraints that we'll have to adapt to, but we've established extremely fruitful partnerships with international specialists and New Caledonian geologists, and we'd like to see those continue. We're hoping to keep things going along the same lines as they have been and enrich the information available to researchers..

SEA SPONGE (*EUPLECTELLA*) AND FEATHER STAR (*CHARITOMETRIDAE*) AT THE BOTTOM OF THE CANYON ON THE SUMMIT OF MOUNT D, LOYALTY RIDGE (842 M). © MNHN / IFREMER

The KANADEEP project is organized by the Muséum national d'histoire naturelle and the National Research Institute for Sustainable Development. It also includes researchers from the CNRS and Ifremer from both mainland France and from teams in New Caledonia working on seabed water columns, ecology, and geology.

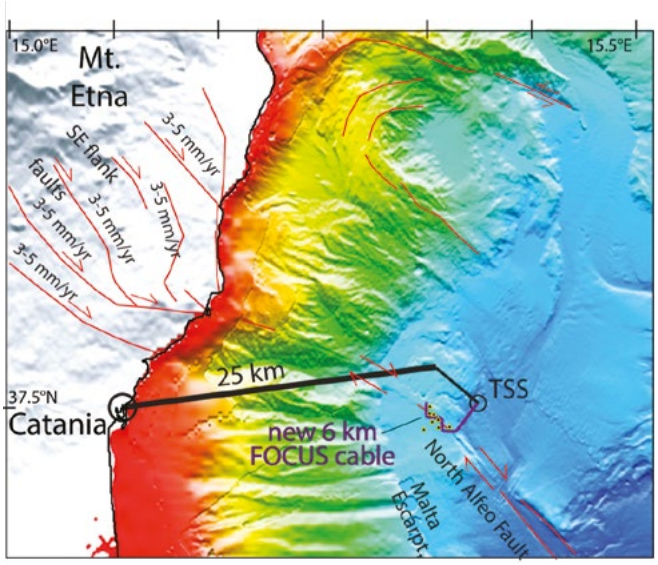
Specialists in marine fauna from other countries (Australia, Russia, Taiwan) also participate in this project. These cruises are part of the *La planète revisitée* program.

http://nouvellecaledonie.laplaneterevisitee.org/fr/kanadeep-2
https://expeditions.mnhn.fr/campaign/kanadeep

PREDICTING
UNDERWATER HAZARDS

FOCUS X1: DETECTING MOVEMENTS OF THE EARTH'S CRUST AND UNDERSTANDING EARTHQUAKE HAZARDS

Laser interferometry, a very precise technique for measuring displacements and vibrations, has long been used to monitor the integrity of major structures like bridges and dams in real time. Tectonics researcher Marc-André Gutscher, Director of the Laboratoire Géosciences Océan (LGO) at the European Institute for Marine Studies (IUEM) in Brest, was the one to come up with the idea of using this technique to observe a submarine fault line. After two years of fine-tuning, a laser interferometry system was deployed near the town of Catania, Sicily. The expedition, which ran October 7–20, 2020, relied heavily on support from Ifremer and the French Oceanographic Fleet.



THE FIRST CRUISE OF THE EU'S FOCUS PROJECT, RECIPIENT OF A 2018 ERC (EUROPEAN RESEARCH COUNCIL) GRANT, TOOK PLACE ON OCTOBER 7–20, 2020, ALONG AN ACTIVE UNDERWATER FAULT OFF THE COAST OF SICILY IN THE IONIAN SEA. (BATHYMETRIC MAP.)
© CNRS-UBO-UBS / Marc-André Gutscher

The new monitoring apparatus aims to detect slight movements of the earth's crust in order to understand earthquake hazards. The scientists chose to place it on the North Alfeo submarine fault, located east of the Mt. Etna volcano.

The fault is nearly 80 km long and lies more than 2,000 m below the surface of the water. FOCUS X1 laid a fiber-optic cable next to the fault and then "interrogated" the cable by firing laser pulses. This records even the most minuscule displacements and temperature variations in the cable and translates them into seismic data.

Deploying the system at a depth of more than 2,000 m was a challenge in itself. A special cable with connectors adapted for the seafloor had to be developed, and then the ensemble had to be connected to the EMSO underwater observatory operated by Italy's National Institute for Nuclear Physics - Catania (INFN-LNS). Plus, in order to be able to register slight tectonic shifts, the cable could not just be placed on the seafloor—it had to be buried under the sediment. Ifremer was asked to design a submarine plow capable of performing this delicate operation.

After eighteen months of work, the tool was finalized and loaded onto R/V *Pourquoi Pas?* along with all the equipment required for the system deploy. The plow, operated by ROV *Victor 6000*, did its job well: nearly 6 km of cable was laid along a rugged terrain. Eight seafloor geodetic stations were also deployed. The Catania observatory is now receiving real-time feedback from the light signals traveling along the fiber, and can thus monitor the fault's activity.

Many partners contributed to FOCUS X1's success:

- the Laboratoire Géosciences Océan (CNRS - University of Western Brittany)
- the Marine Geoscience Unit (Ifremer)
- IDIL (company based in Lannion)
- the National Institute for Nuclear Physics - Catania (INFN-LNS)
- iXblue

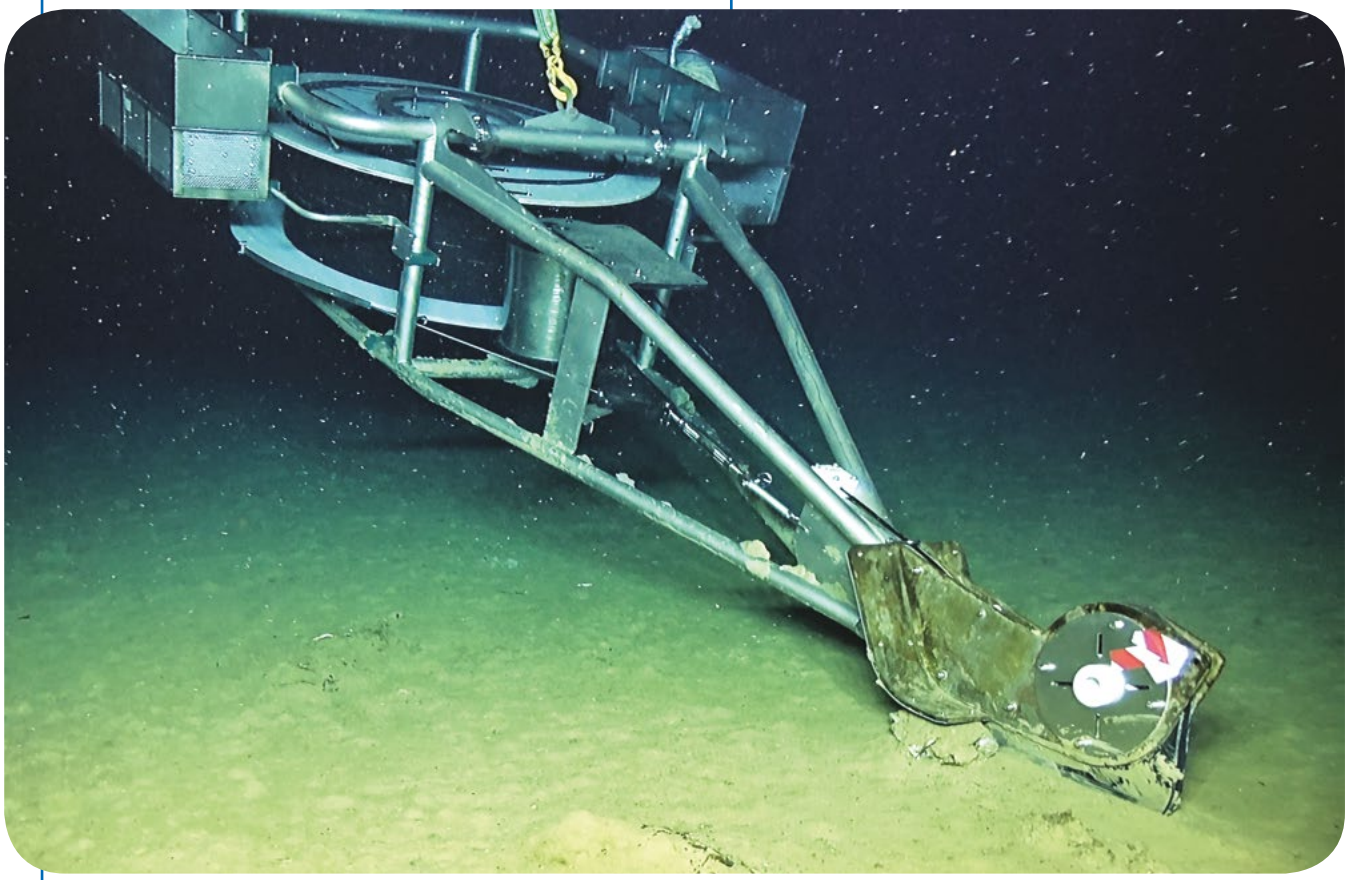
This project, along with the optical and acoustic instruments monitoring the fault, was funded by a €3.5 million European Research Council grant.

A PLOW SPECIALLY DESIGNED BY IFREMER

INTERVIEW WITH JAN OPDERBECKE, HEAD OF THE UNDERWATER SYSTEMS UNIT OF THE OCEANOGRAPHIC FLEET DIVISION AT IFREMER

WHAT EXACTLY IS THIS PLOW?

It has several components. There's a reel with a brake system so that the cable can be unspooled in a controlled fashion, and a plowshare that carves a furrow into the sediment a few centimeters deep so that the cable can be buried. There's also an interface for connecting to the ROV, since the plow itself has no propulsion system; it's the *Victor 6000* that pushes it along. And it has a buoy to keep the system steady while it's underground. The plow is deployed separately from *Victor 6000*. It carries ballast to help it sink down to the seafloor, and then once it's there the ROV clamps it with its manipulator arms. *Victor 6000* also connects the ends of the cable to the measurement terminals.



THIS PLOW, DESIGNED SPECIALLY BY IFREMER, WAS USED TO DEPLOY AND BURY A FIBER-OPTIC CABLE NEAR CATANIA, SICILY, AT A DEPTH OF MORE THAN 2,000 M. THE OPERATION WAS A MAJOR COMPONENT OF THE FOCUS PROJECT, DIRECTED BY MARC-ANDRÉ GUTSCHER OF THE LABORATOIRE GÉOSCIENCES OCÉAN IN BREST.
© IFREMER/KLINGELHOEFER FRAUKE, GUTSCHER MARC-ANDRE

HOW WAS THE PLOW DEVELOPED?

> We started from a model that we designed a decade ago as a prototype. A feasibility study determined that we'd be able to adapt that concept for FOCUS X1. Then came the design phase, which took a long time. Once we'd worked out every detail of the mechanical design, we moved on to building the device. And lastly, we fine-tuned the whole cable-reel-brake-plow system.

DID YOU TEST IT IN A TANK, OR WERE YOU ABLE TO TRY IT OUT IN REAL-WORLD CONDITIONS?

> It's pretty hard to operate the full system in a tank, because all of it together, including the buoy, takes up a lot of room. We were able to test some of the components, though. After that we conducted a full-scale test in the Mediterranean, which let us establish a procedure and carry out a complete operation from the deck of a research vessel. All of that was studied, described, and documented, so that the operators would have precise guidelines.

HOW DID THE PLOW PERFORM DURING THE CRUISE?

> The operation was a great success. There were some challenges to overcome, though, as with any experimental system. The terrain was very steep, and it wasn't all of one type—sometimes the seafloor was too hard, other times too soft. At one point the cable got tangled up on the reel. The operators showed immense skill in getting the apparatus hoisted back up. But in the end, the plow and the *Victor 6000* managed to bury the full 6 km of cable.

WHAT WILL YOU TAKE FROM THIS CRUISE?

> I think it's a wonderful example of how the FOF can support a scientific project, both in terms of designing and engineering an unusual piece of equipment and in terms of working with Genavir to put a new device into operation in a complex environment.

MONITORING FISH STOCKS

PREDICTIVE ECOLOGY STUDIES

INTERVIEW WITH MATHIEU DORAY, RESEARCHER IN IFREMER'S FISHERIES ECOLOGY AND MODELING UNIT, AND SANDRINE VAZ, RESEARCHER AT IFREMER'S MEDITERRANEAN FISHERIES LABORATORY

WHAT'S SPECIAL ABOUT STUDYING THE ECOLOGY OF FISHERIES?

> **Mathieu Doray**: During the 2000 PELGAS cruise, which aimed to estimate sardine and anchovy populations in the Bay of Biscay, we realized that it was very difficult to study small pelagic fish outside of their ecosystem. That was what led us to start collecting data on the components of that ecosystem: its hydrology, the organisms the fish fed on (phytoplankton and zooplankton), and their predators (cetaceans and seabirds). In addition to collecting the usual data from acoustic soundings and specimen fish, we also added new sensors, put out plankton-trapping nets, stationed observers to spot mammals and seabirds, and pumped surface water so we could count how many eggs were present in a sample. This ecosystem-based approach is becoming more widespread these days, especially in light of the EU Marine Strategy Framework Directive's demand for data on ecosystems as well as fish stocks. PELGAS has inspired other French studies including the IBTS in the English Channel and North Sea and MEDITS in the Mediterranean.
>
> **Sandrine Vaz**: We used to concentrate on a predetermined list of species and perform studies financed by the European Union. But there was a growing desire to do more. The first change this led to was the decision to identify every single species captured in a sample; with a bottom trawl, that could easily be 400 to 500 different species. This meant we completed an extremely detailed survey of biodiversity every year, with the same protocols and focus areas. Then we wanted to go beyond trawl captures and acoustic measurements, so we introduced plankton nets and observers with binoculars. With IBTS we were also able to expand our work monitoring larvae to include all ichthyoplankton types.

SAMPLING FISH STOCKS TO UNDERSTAND CHANGES IN BIODIVERSITY AND FISHERIES. THIS PROCESS TAKES PLACE IN THE SORTING ROOM ABOARD THE R/V *THALASSA*. © Ifremer / R. Faillettaz

Some of our other colleagues look at food webs to figure out who eats what and how much of it. It's thanks to the vessels that make up the French Oceanographic Fleet, even the smallest ones like the *L'Europe*, that we can perform all of these measurements and observations. We've gone above and beyond the original scope of our fisheries studies, and now we're able to use the data we've gathered to meet the EU's increasingly high expectations. We've pushed public policy forward by ten or fifteen years.

WERE THESE CRUISES BADLY DISRUPTED BY THE PANDEMIC AND LOCKDOWN?

Sandrine Vaz: Obviously there were a lot of challenges to deal with. Some trips were canceled. Others got rescheduled, which meant they were no longer taking place at their usual or preferred time of year. There were also problems accessing British waters in the Channel due to Brexit.

We won't be able to analyze how much these disruptions have affected our data quality until we have more distance from the event, but some gaps are to be expected. On the other hand, despite the year's difficulties, we managed to complete the most crucial parts of our projects.

Mathieu Doray: I have to commend our teams' adaptability. Dealing with all of the uncertainties was a complicated endeavor, but looking back, it really demonstrated the resilience of the system. Only the PELGAS cruise was completely canceled, and even then we were able to use the EVHOE trip in October to do acoustic measurements and pelagic trawls using professional fishing boats. That gave us our first data on the condition of these species in autumn.

Sandrine Vaz: Yes, we have to applaud the effort everyone put in to achieve our objectives.

The science teams had to deal with a lot of complications from the longer voyages and all the required testing. And the Genavir crews went beyond the call of duty to help us out.

HOW WILL YOU USE THE DATA YOU'VE COLLECTED?

Mathieu Doray: We've developed methods for validating, storing, and analyzing the data. And the amount of data to be dealt with is considerable: on PELGAS, we've been collecting information on roughly 150 different ecosystem parameters every year for twenty years. The first thing we do is mapping. We make a map for each parameter so we can see how the spatial distribution changes from year to year. Then other tools let us perform statistical analyses on these sets of maps. Another way we analyze the data is by creating indicators. For example, we'll calculate the average abundance of a species and track it over time. We've used this method to identify a reduction in the average weight and size of sardines and anchovies in the Bay of Biscay in the Mediterranean.

Sandrine Vaz: The data helps us answer questions about global warming: how the climate is changing, how marine environments are being used, and what pressures they're experiencing. We build models that describe how a population will distribute itself in the presence or absence of certain pressures. From there, we can simulate the effects of a few degrees of global warming, or the potential impact of a fishing ban on the species in a particular area. Our models are robust enough to provide realistic simulations to the people managing these waters. This is what Ifremer is for—our whole purpose is to translate research into guidance. That's why we talk about observation, research, and expertise as a triad.

Mathieu Doray: Cruises basically let us observe a particular place at a particular time in great detail, and modeling gives us the ability to simulate the things we can't observe, like what happens during other seasons, or what will happen if the temperature increases.

WHAT'S TO COME FOR THESE PROJECTS?

Sandrine Vaz: Recurring fisheries cruises are unique platforms for carrying out research on a wide variety of topics, including biodiversity, species distribution, habitat preferences, and species life cycles. Researchers can explore a lot of avenues simultaneously, and each one contributes to our overall understanding of ecosystem functioning and our ability to make long-term global predictions. A lot of today's work concerns the climate issue and applications—in fisheries, of course, but also in the development of offshore wind farms.

Mathieu Doray: We're also aware that we don't have all the data we need to answer all the questions raised by these different ecosystem pressures. We'll need to integrate recent advances in technology so we can accomplish more in our studies. With the increasing precision and automation of video and acoustic imaging tools, the arrival of drones, the development of new genomics techniques, and the availability of artificial intelligence to handle massive data streams, there are some very interesting possibilities on the horizon. We also need to reduce the environmental footprint of our research cruises.

Serving the marine science community

Priorities and plans for the future

INTERVIEW WITH OLIVIER LEFORT, DIRECTOR OF THE FRENCH OCEANOGRAPHIC FLEET, AND ÉRIC DERRIEN, CEO OF GENAVIR

© Ifremer/ A. Bodenes

WHAT ARE THE RESPECTIVE ROLES AND MISSIONS OF THE OCEANOGRAPHIC FLEET DIVISION AND GENAVIR?

Olivier Lefort: I'd summarize it by saying that as of January 1, 2018, the French Oceanographic Fleet is a Very Large Research Infrastructure (TGIR) operated by Ifremer. Ifremer owns all the research vessels except R/V *Marion Dufresne*, which belongs to the French Southern and Antarctic Lands, and the local-class vessels, which are operated by the CNRS. To run the French Oceanographic Fleet (FOF), Ifremer relies on the Oceanographic Fleet Division (DFO), which is part of the Institute, and three operators: LDAS for the *Marion Dufresne*, the CNRS for the local vessels, and Ifremer subsidiary Genavir for all of the fleet's other research vessels and onboard systems.

The DFO's main role is to develop the cruises and see them carried out. To do that, we interface with the science teams. We facilitate the submission of applications for cruises and get them evaluated by independent commissions. We schedule the voyages in accordance with FOF's rules of operation. And finally, we get the cruises underway and perform quality assessments once they're done.

The DFO's other job is to upgrade infrastructure and create new tools. Our Vessels and Onboard Systems unit builds and modernizes our research vessels, while our Underwater Systems unit does the same for our underwater systems.

These units bolster their technical know-how through research and development, and are in charge of acquiring or developing the scientific tools and IT equipment that our researchers need to collect, access, and analyze their data. For a recent example, look no further than the DeepSea'nnovation project, recipient of a nearly €4 million grant from the EquipEx+ program. The goal of that project is to give science teams cutting-edge technological tools. Once such tools have been purchased, developed, or created, most of them will be entrusted to Genavir's use.

Éric Derrien: Genavir is essentially the main operator for the FOF. We equip, organize, and carry out the research cruises that the Oceanographic Fleet Division designs. We also transport and arrange lodging for personnel, manage ship logistics, make sure that the vessels are provisioned with consumables, and handle all the costs of operating the vessels. We store, maintain, transport, and operate all of the scientific equipment, mobile apparatuses, and underwater vehicles that are carried on the vessels. We also collect and validate the digital scientific data gathered during the cruises. That data is then sent to Ifremer's Scientific Information Systems for the Sea department.

Olivier Lefort: The DFO and Genavir synergize so that we can adapt to different arrangements. It's not a static relationship; we're always communicating. I also think it's important that Ifremer be able to rely on an operator specialized in oceanography. Genavir has that expertise along with a great deal of experience, which is rare to find in France or even in Europe. What they do goes beyond the traditional role of an operator.

Éric Derrien: That's our specialty, and it makes us unique in the maritime world. We're the only operator in France that works with research vessels.

HOW DO YOU PLAN A CRUISE?

Olivier Lefort: There are two phases, and each of our organizations takes charge of one. The Oceanographic Fleet Division handles the earlier stages of setting up a cruise. In concrete terms, we work with the mission heads to schedule out operations three years in advance. That includes defining the work that needs to be accomplished, establishing how long each cruise will be, and positioning each trip on the calendar.

It also means ensuring that any authorizations required for work in foreign waters are obtained in a timely fashion. Once we've created a year's program of activities, it's voted on and approved by the fleet's executive committee. From there it's up to Genavir to execute operations. We hand over control of a project at the preparation meeting two months before the start of the cruise. Genavir finalizes all the last little details of each trip, in accordance with its contract.

Éric Derrien: It's really designed so that we can complement each other effectively. We're always in communication, and that's what gives us the ability to set up each cruise properly and ensure it goes well.

WHAT ARE YOUR GOALS?

Olivier Lefort: All of the work we do at the DFO, and that Genavir does after us, has the aim of ensuring that the major objectives we've defined will get accomplished in appropriate conditions and produce high-quality data. Carrying out a set of tasks and maintaining a certain quality of service, as Éric Derrien has noted, are both equally important. The whole system is built around that, including the end-of-mission evaluation forms that both our teams fill out. The evaluation isn't just a formality. It's a step that's been in place for twenty years, and it's emblematic of how a cruise isn't just about departing from point A and arriving at point B.

Éric Derrien: The evaluation gets incorporated into the performance indicators for our mutual quality assurance systems.

Olivier Lefort: Collecting that information helps us both grow. It's an ongoing process of improvement.

HOW DO YOU ENVISION WHAT'S TO COME IN THE MEDIUM TERM?

Éric Derrien: Genavir's expertise is recognized by the entire scientific community. We'd like to put that expertise to use on a larger scale. We could become an operator for other European research institutions, for example, or expand our specializations and take on new kinds of clients.

Olivier Lefort: My hope is that we'll be able to continue to transform our vessels, equipment, and vehicles in order to meet the needs of the scientific community and respond to some of the major challenges we're facing. One of those challenges is creating a greener fleet.

We've already started to address that issue, but the solution won't just be a matter of technology. We'll need to completely rethink how our cruises are conducted. We intend to build vessels that integrate technologies that have less of an impact on the environment. Achieving real results, though, will mean changing the whole cruise process. A work group has been formed to figure out what the future of our regional-class vessels will look like, and that future is going to include more remote work and improvements in supply chains and personnel logistics, so that we can reduce the overall environmental footprint. We'll be working collaboratively to implement these changes over the next ten years so that our cruises can evolve.

Éric Derrien: And in fact, there are already joint steps being taken to reduce the FOF's environmental footprint. At the request of Ifremer CEO François Houllier, we applied for Green Marine Europe certification, and received it in fall of 2020.

Vessel and vehicle evolution

MEDIUM-TERM UPGRADES AND MODERNIZATION FOR THE FRENCH OCEANOGRAPHIC FLEET

Sustainable, long-term upgrades to the French Oceanographic Fleet are necessary to ensure that France continues to be a guiding light for marine research in Europe and across the world.

The fleet's medium-term program was presented and voted upon at the Ifremer Board of Directors meeting on October 8, 2020. It fulfills both a recommendation from the Audit Court and a commitment made in Ifremer's 2019–2023 Statement of Objectives. The program of activities aims to modernize and streamline the fleet's resources; it was endorsed by the new Science Council in December 2018 and by the member bodies of the fleet's executive committee in June 2019. The road map runs through 2035 and includes all of the fleet's significant investments: new vessel construction, from local vessels all the way up to ocean- and global-class crafts; refits; and equipment acquisition to replace ships that have reached their end of life or become obsolete.

This turnover is part of a larger push to improve the fleet's environmental impact. For several years now, Ifremer has been working on strategies to reduce vessel fuel consumption and make use of low-sulfur, low-emission gasoline. As part of these efforts, the Institute recently opted to join and actively participate in the Green Marine Europe voluntary environmental certification program, coordinated by Surfrider Foundation Europe. Making further progress will require the fleet to take advantage of this opportunity to design and modernize its new research vessels and underwater vehicles.

The FOF's medium-term plans therefore embrace an ambitious ecodesign initiative reflecting an in-depth consideration of each phase of a cruise, its impact, and appropriate technical remedies, all with the goal of reducing the overall environmental footprint.

The major objectives of the medium-term plan are:

- To maintain open-water capacities in the Atlantic, Indian, and Pacific oceans, including major work on R/V *L'Atalante* in 2021 that should keep the vessel in the fleet through 2030
- To carry out a midlife refit for R/V *Pourquoi Pas?* in partnership with the Ministry of the Armed Forces. The refit is scheduled for 2024/2025 and aims to prolong the vessel's working life by twenty years.
- To maintain deep-sea exploration capacities through the construction of a next-generation robot rated for dives up to 6,000 m
- To condense the coastal and regional fleet from six vessels to five. R/V *Thalia* will be replaced in the Channel-Atlantic area in 2025 by one regional vessel, and R/V *L'Europe* will be replaced in the Mediterranean in 2030 by another regional vessel that will be 40 meters in length. A third regional vessel will replace R/V *Alis*. That replacement will be overseen by Ifremer with the support of the National Research Institute for Sustainable Development (IRD), and they will examine possibilities for cooperation with the governments of New Caledonia and French Polynesia, especially in terms of financing. Until the arrival of the new vessel, R/V *Antea* is scheduled for deployment to the western Pacific starting in 2023.

The creation of this plan does not constitute a financial commitment from the French government, but its approval by the Ifremer Board of Directors serves to underline common agreement on the plan's major features as regards the number and kind of vessels and underwater vehicles needed. It also signals that Ifremer and the government are reasonably confident they will be able to find ad hoc methods of funding these projects, including through regional or EU-level co-funding.

MEDIUM-TERM UPGRADES AND MODERNIZATION FOR THE FRENCH OCEANOGRAPHIC FLEET

DEEP-SEA VESSELS

L'Atalante

Replacement of L'Atalante

Marion Dufresne

Replacement of Marion Dufresne

Thalassa

Replacement of Thalassa

Pourquoi pas ?

COASTAL AND REGIONAL VESSELS

Alis

Antéa

Pacific regional vessel

Thalia

Channel-Atlantic regional vessel

L'Europe

Mediterranean regional vessel

Thetys

Mediterranean coastal vessel

Côtes de la Manche

Channel-Atlantic coastal vessel

LOCAL VESSELS

Sépia II

Néreis II

Antédon II

Planula IV

Neomysis

Albert Lucas

Sagitta III

UNDERWATER SYSTEMS

Idef^{X}

Aster^{X}

Uly^{X}

Nautile

ROV +

Victor 6000

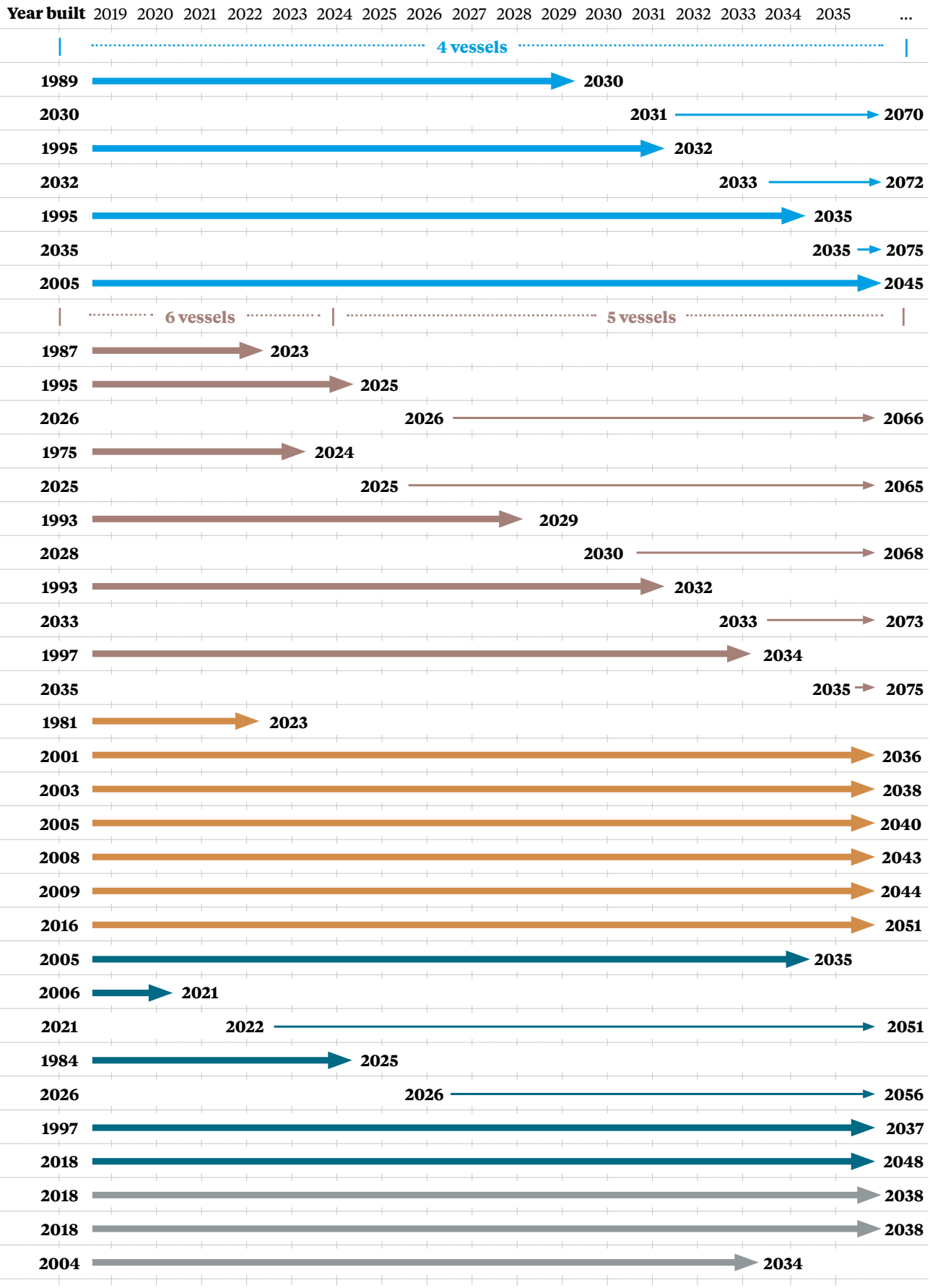
Ariane

HEAVY EQUIPMENT

Sismique 1

Sismique 2

Penfeld


Year built
2019 2020 2021 2022 2023 2024 2025 2026 2027 2028 2029 2030 2031 2032 2033 2034 2035 ...
4 vessels
1989 2030
2030 2031 2070
1995 2032
2032 2033 2072
1995 2035
2035 2035 2075
2005 2045
6 vessels
5 vessels
1987 2023
1995 2025
2026 2026 2066
1975 2024
2025 2025 2065
1993 2029
2028 2030 2068
1993 2032
2033 2033 2073
1997 2034
2035 2035 2075
1981 2023
2001 2036
2003 2038
2005 2040
2008 2043
2009 2044
2016 2051
2005 2035
2006 2021
2021 2022 2051
1984 2025
2026 2026 2056
1997 2037
2018 2048
2018 2038
2018 2038
2004 2034

FRENCH OCEANOGRAPHIC FLEET HONORED WITH **GREEN MARINE EUROPE** CERTIFICATION

As part of the push toward sustainability, Ifremer and Genavir have chosen to join the Green Marine Europe voluntary environmental certification program. The program is an adaptation of one developed by Green Marine in North America twelve years ago, and is coordinated by Surfrider Foundation Europe. It guides maritime industry stakeholders through a self-assessment process, which is then independently verified by an external organization. The European program initially covered only ship owners, but has expanded to other maritime actors.

Candidates must analyze their fleets or facilities according to seven performance indicators covering a wide variety of issues. These indicators include underwater noise, greenhouse gas emissions and pollutant air emissions, waste management, and prevention of spills and leakages. The certificate also encourages companies to incorporate best practices in ship recycling and establish positive relationships with other stakeholders in the maritime community.

Ifremer and Genavir have committed to reducing their environmental footprints. In October 2020, this new certification saw their efforts rewarded. The French Oceanographic Fleet particularly distinguished itself, receiving the best possible score for “underwater noise.”

MAKING QUIETER VESSELS

INTERVIEW WITH YVES LE GALL, HEAD OF THE UNDERWATER ACOUSTICS AND INFORMATION PROCESSING DEPARTMENT OF THE OCEANOGRAPHIC FLEET DIVISION AT IFREMER

© Ifremer/ A. Bodenes

WHY DOES THE FRENCH OCEANOGRAPHIC FLEET EXCEL ON THE ISSUE OF UNDERWATER NOISE?

Basically because we’ve been working on it for a long time. Fifteen years ago, environmentalists really started to put pressure on this issue. Our cruises sometimes employ high-powered acoustic devices to image sediment layers; those systems can have a huge physiological impact on nearby fauna, especially marine mammals. So the impact of sound waves is an issue we take very seriously.

Similarly, Ifremer conducts fisheries surveys to estimate the population levels of various fish species. Acoustic systems are one of the tools used in these biomass assessments, and we need to make sure the noise emanating from the ship doesn’t drive off the fish. Therefore, we’ve worked on reducing that noise to make our vessels quieter. These fish stock cruises have very strict demands, and meeting them has familiarized us with the sound issues. We now specify maximum noise production levels as part of the process of designing and modernizing our research vessels.

HOW DO YOU MAKE A QUIETER VESSEL?

> You have to have the right mode of propulsion—diesel-alternator groups powering an electric propulsion system. You also have to deal with on-board sound sources (motors, compressors, etc.) producing strong vibrations as they operate. Those devices need to be suspended so that they're decoupled from the hull. That way their vibrations can't radiate out into the water. The other important factor is maintenance. A damaged propeller or a hull covered in barnacles can make noise or even induce cavitation. That's a very noisy phenomenon where air bubbles form and pop, creating sound waves that cover a wide frequency spectrum. Cavitation can also occur at high speeds, but that's not a concern for our vessels.

HOW DID THE GREEN MARINE EUROPE PROGRAM ASSESS UNDERWATER NOISE GENERATION?

> The examiners paid special attention to cavitation. Our vessels' noise levels are constantly being monitored by a number of sonar arrays attached to the hull. They also assessed our least-impact protocol for using certain kinds of sound devices. Every seismic survey trip we do includes an independent observer with the authority to halt soundings if a vulnerable animal is spotted. These observers also record a lot of data on fauna that is then sent to marine parks and sanctuaries. Getting a 5 in this category, the best possible score, also requires estimating ship noise levels for three vessels. To fulfill that requirement we estimated ship noise levels for the *Thalassa*, the *Pourquoi Pas?*, and the *L'Atalante*.

HOW DO YOU MEASURE THAT?

> We created special instruments to estimate how much noise our vessels were making. That's not an easy task. The water has to be deep enough to avoid reflections from the seafloor, the weather has to be calm, and the sensors have to be suited to the task of evaluating the vessel. We tested several different configurations of motors, varying their RPM. It was hard work, but we were able to get our estimations done, and it will let us continue to monitor the vessels into the future and compare performance before and after any upgrades. And if the results are ever less than satisfactory, we'll do what needs to be done to improve them.

New technologies

AUV *ULYX* TAKES ITS FIRST DIVE FROM R/V *L'EUROPE*
© Ifremer / T. Autin

AN OCEAN-FLOOR **ODYSSEY**

***ULYX*, A NEW AUTONOMOUS UNDERWATER VEHICLE FOR OCEAN SCIENCE**

Years of design and development have finally borne fruit with the French Oceanographic Fleet's newest vehicle: *UlyX*, a major leap forward in navigation technology and innovative instrumentation. This device reaffirms France's position at the forefront of deep-sea exploration and admits it into the very small circle of countries with an autonomous underwater vehicle (AUV) capable of reaching depths up to 6,000 meters. Every field of marine science—oceanography, geoscience, seafloor biology and ecology, water column studies—will benefit from this masterpiece of technology. It has been designed for use on a wide range of projects, from surveys of mineral resources and deep-sea ecosystems to biogeochemical environment descriptions.

UlyX is innovative on several fronts. It's one of the few AUVs in the world with a battery life of 24–48 hours. If it detects an interesting detail in a particular area, it can interrupt its course to enter stationary mode. It can see objects from afar and study them up close with an image resolution nearly akin to the human eye, thanks to a high-resolution camera developed by teams at Ifremer. It's also equipped with sounders and acoustic sonar arrays to characterize terrain and identify features of the seafloor. Plus, it has a number of instruments for measuring features like dissolved oxygen, methane, and magnetic fields. It can even take water samples for further physical and chemical measurements.

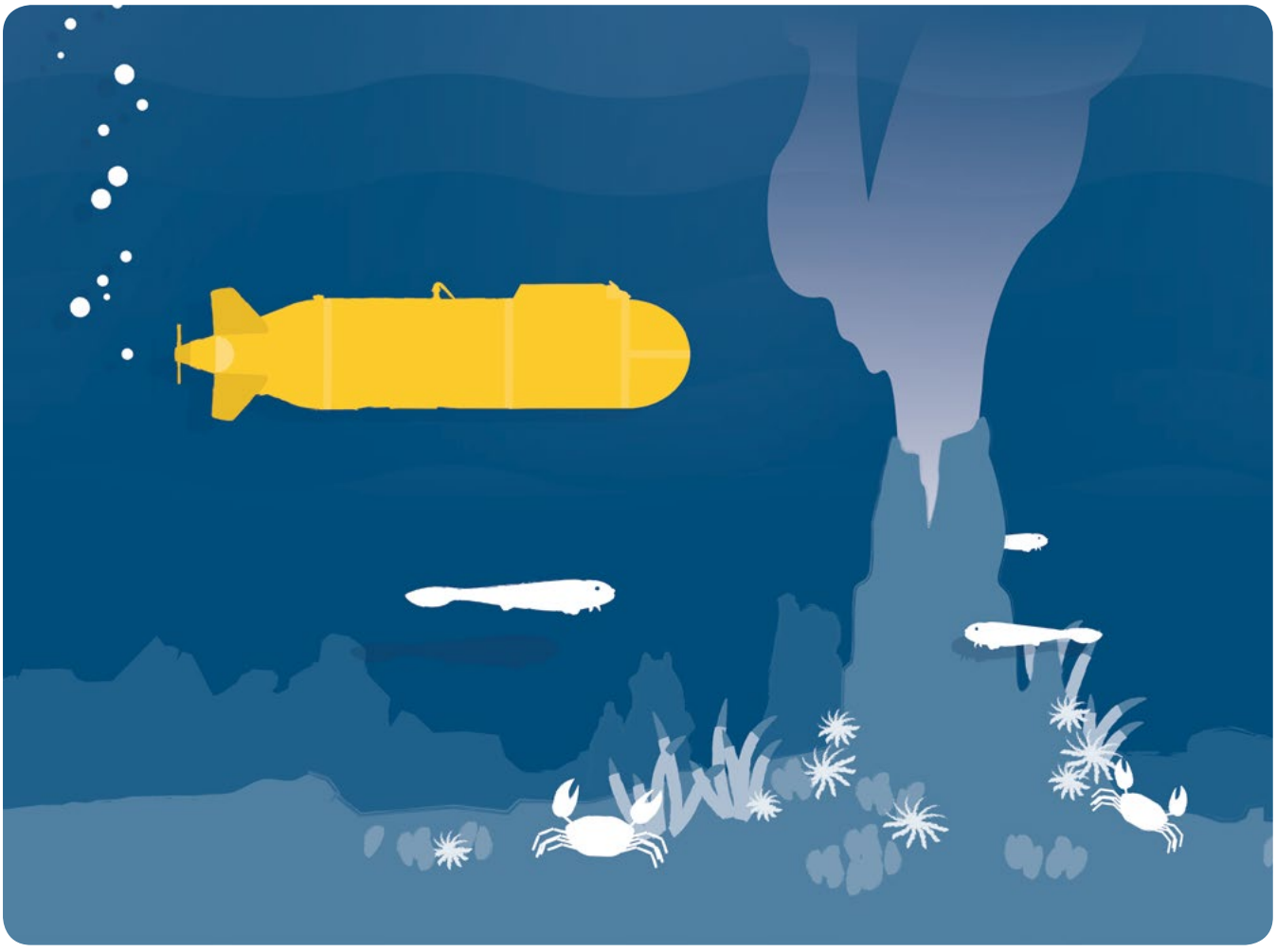
On a single dive *UlyX* can provide an enormous amount of data, two or three times what older devices are capable of. It's also "intelligent," able to cross-reference indicators to detect and explore areas of interest like hydrothermal vents and methane-filled cold seeps.

Eventually, its abilities could be augmented with artificial intelligence algorithms, depending on scientists' needs. That would let *UlyX* become a "customizable" ocean science vehicle.

Developing this new vehicle took five years and required Ifremer to mobilize a skilled team of more than forty scientists and engineers. The developers included a number of personnel from the Oceanographic Fleet Division, as well as contributors from half a dozen innovative companies and several technical partners in the PACA region. The vehicle's creation was made possible through joint funding from the Regional Council, the French government, the European Union via the European Regional Development Fund (ERDF), and Ifremer itself, for a total of €5.3 million.

DIVING INTO SUBMERSIBLE MODERNIZATION

Along with the centralization of the French Oceanographic Fleet came a forward-looking study of deep-sea exploration tools. An agenda was laid out after a preliminary discussion phase. The plan is structured around the entry into service of the 6,000-meter AUV *UlyX*, the modernization of ROV *Victor 6000*, and the development of a second ROV to replace the manned submersible *Nautile* in the medium term. The overarching goal of these projects is to provide the best possible tools for supporting scientific cruises over the next twenty years and maximizing their results.



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

In order to leverage the huge breadth and depth of available knowledge about ROV operations, the Oceanographic Fleet Division created a work group featuring a representative collection of ROV users. The group's discussions have set the direction for future evolutions in these systems, ensuring that scientists will have tools optimized to fit the needs of their projects. The work group considered needs in three main areas of research: ocean systems (geology, hydrology, ecology); marine resources (bioresources, minerals, marine energy); and climate change, including all related issues of risk and resilience.

A decisive first step was taken in mid-2020 with the delivery of a statement of scientific requirements for two key parts of the agenda: the *Victor 6000* upgrades and the development of the second seafloor exploration ROV. Drafting and approval of specifications is currently underway, with science and technology teams engaging in an unprecedented level of collaboration. A larger group was also created in 2020 to identify key targets for innovation in the scientific equipment used by deep-sea ROVs. Those insights resulted in DeepSea'nnovation, a PIA3 EquipEx project.

The work accomplished by these groups has defined several avenues for further progress. One objective will be to improve perception of the submarine environment. Applying current advances in augmented reality technology, the ROV operator's dive will be enhanced by 3D modules, optical mapping, contour lines, and structure-from-motion photogrammetry. Another major objective will be to make the ROV more maneuverable. New methods for handling the surface-seafloor connection are being worked out to reduce communication latency. The third and final objective will be to increase the ROV's payload, allowing it to carry more sensors, more scientific equipment, or even more samples. Such an upgrade has been almost unanimously requested by current ROV users. Together, these plans form part of a larger, long-term effort to promote sustainability and end the practice of discarding items like ballast materials onto the seafloor.

Co-chaired by Valérie Chavagnac (GET) and Pierre-Marie Sarradin (Ifremer/REM/EEP), the discussion group comprised twenty scientists from the CNRS (IPGP, ENS, GET, LOV & SU Banyuls, LGO, MIO, CEREGE, AD2M), marine universities (Brest), the Muséum national d'histoire naturelle, and Ifremer.

SEAGRASS MAPPING: A NEW USE FOR ACOUSTIC DATA

Eelgrass beds are habitats of major interest requiring special protection measures under European Union directives on protecting water and the environment. These vast prairies of marine plants are effective bioindicators for the quality of coastal waters, and are used by many species as places to reproduce and raise their young. Researchers with the Marha (Marine Habitats) project investigated eelgrass distribution and abundance by turning some classic acoustic research methods to novel uses. Drawing on equipment and techniques normally used for geological mapping and fish stock surveys, they showed that acoustic data can also be used to map and analyze these seagrass meadows.

Since 2019, several expeditions have been carried out to that end on R/V *Haliotis*, a vessel equipped with a GeoSwath sonar and several single-beam echosounders. The readings will be used for three purposes: creating maps of seagrass bed distribution, distinguishing the kinds of grasses and algae that are present (eelgrass, kelp, etc.), and assessing abundance (relative density in areas of presence). However, analyzing the acoustic data is a delicate process; the echosounders have difficulty distinguishing between echoes from the seafloor and echoes from the seagrass canopy. Researchers have developed novel techniques to tell them apart, based on the amount of backscattered energy as a function of depth.

Initial results from this approach were promising, so more advanced analyses of the single-beam echosounder data have commenced. This will make differentiating between "bare seafloor" and "seafloor with grass" a more reliable process, and hopefully allow for identification of the types of algae present. The researchers will also look at additional metrics, including canopy height and the relative energy levels of the echoes from the seagrass and the seafloor substrate. Artificial intelligence techniques will be used to analyze the images as well.

These studies demonstrate just how effective it can be to apply traditional acoustic research techniques to innovative new fronts. They also show that such methods need not be limited to large vessels like R/V *Thalassa*; they can also be effectively deployed from small craft like R/V *Haliotis*.

The sharing goes both ways: soon the *Thalassa* will take the fruits of these *Haliotis* trips and make use of them in turn as it maps cold-water corals on the Marha project's ChEReef cruise.

EELGRASS BEDS ARE FOUND IN SANDY AND SILTY SEDIMENTS IN THE INTERTIDAL AND INFRALITTORAL ZONES OF THE NORTHERN HEMISPHERE (ATLANTIC OCEAN, ENGLISH CHANNEL/NORTH SEA, MEDITERRANEAN SEA). . © Ifremer / O. Dugornay

List of cruises

ALIS

ESSTECH AL 2020
CHRISTOPHE MENKES – IRD NOUMÉA
Technical testing
Pacific Ocean
Implementation of “oblique” trawling protocol with monitoring of trawl’s geometric parameters.

KANARECUP
KARINE OLU — IFREMER
Coastal scientific research
Ecosystem biology and functioning; Environment; Geoscience and paleoclimatology
Pacific Ocean
Retrieval of mooring lines for characterizing deep-sea current dynamics, water masses, particulate flows, and organic material.

SEAMOUNT 2020
FLORIAN BALETAUD – IRD NOUMÉA
Coastal scientific research
Ecosystem biology and functioning
Pacific Ocean
Description of the 3dimensional distribution of marine vertebrates on twelve seamounts and four reefs in the New Caledonia archipelago.

SuperNatural2
RICCARDO RODOLFO-METALPA – IRD NOUMÉA
Coastal scientific research
Ecosystem biology and functioning
Pacific Ocean
Study of coral reef response to climate change.

TONGA RECUP
CÉCILE GUIEU — INSTITUT DE LA MER DE VILLEFRANCHE (IMEV)
Deep-sea scientific research
Ecosystem biology and functioning; Marine physics, chemistry, and biogeochemistry; Oceanography
Pacific Ocean
Retrieval of mooring line and reoccupation of three seabed stations.

ANTEA

ESSTECH-AN-2020-1
FRÉDÉRIC DANJON — GENAVIR
Technical testing
Mediterranean Sea
Annual ER60 calibration, functional testing of sounders (ER60, ADCP) and noise at seabed depths > 300 m.

ESSTECH-AN-2020-3
YVAN REAUD — GENAVIR
Technical testing
North Atlantic Ocean
Kullenberg refit work on the Antea.

ESSTECHMVP-2
PIERRE YVES FOURNIER — GENAVIR
Technical testing
Mediterranean Sea
MVP200 validation following early 2020 technical stop and damage sustained during NARVAL voyage.

GEOBREST 2020
DAVID GRAINDORGE — UNIVERSITÉ DE BRETAGNE OCCIDENTALE (UBO)
Education
Geoscience and paleoclimatology
North Atlantic Ocean
Evolution of continental shelves: structural and morphological description, sediment records.

RESISTE-AN-2020
LAURE SIMPLET — IFREMER
Coastal scientific research
Ecosystem biology and functioning; Geoscience and paleoclimatology
North Atlantic Ocean
Investigation of physical and biological resiliency at a former marine aggregate extraction site.

SOLIBOB 2020-2
MATTHIAS JACQUET — IFREMER
Coastal scientific research
Geoscience and paleoclimatology; Marine physics, chemistry, and biogeochemistry
North Atlantic Ocean
Observation of internal wave and soliton impacts on the sediment dynamics of the Bay of Biscay shelf.

STOCKLINE2
BERNADETTE TESSIER — UNIVERSITÉ DE CAEN
Coastal scientific research
Geoscience and paleoclimatology
English Channel
Geophysical survey of subtidal sand stocks along the Normandy coast.

CÔTES DE LA MANCHE

GEOBAS 2020
VIRGINIE GAULLIER — UNIVERSITÉ DE LILLE
Education
Geoscience and paleoclimatology
English Channel
Tectonic-sediment relationships in the eastern Channel.

MASTER IGL GEOPHY 2020
BERNADETTE TESSIER — UNIVERSITÉ DE CAEN
Education
Environment; Geoscience and paleoclimatology; Marine physics, chemistry, and biogeochemistry
English Channel
Operation of tools for seismic acquisition, marine geophysics, and processing/interpreting data (seismic and sonar).

MSTULR 2020
ERIC CHAUMILLON — UNIVERSITÉ DE LA ROCHELLE
Education
Geoscience and paleoclimatology
North Atlantic Ocean
Scientific and methodological bases for characterizing seabeds (sampling and geophysics).

ORHAGO 2020
YANN COUPEAU — IFREMER
Coastal public interest
Ecosystem biology and functioning; Fisheries and population assessments
North Atlantic Ocean
Use of beam trawl to supplement several indicators of sole abundance and the state of benthic ichthyological populations in the Bay of Biscay.

PHRESQUE 2020-4
DAVID LE BERRE — IFREMER
Coastal scientific research
Ecosystem biology and functioning; Marine physics, chemistry, and biogeochemistry
English Channel
Maintenance and calibration of COAST-HF observation network (optical and acoustic).

ROCCHSED 2020
ANNE GROUHEL-PELLOUIN — IFREMER
Coastal public interest
Environment
North Atlantic Ocean
Monitoring of chemical contaminants in coastal marine sediments.

SELILOIRE 2020
AOURELL MAUFFRET — IFREMER
Coastal public interest
Ecosystem biology and functioning; Marine physics, chemistry, and biogeochemistry; Environment
North Atlantic Ocean
Study of biological integration effects of chemical contamination among marine organisms.

SOGIR 2020
ANTOINE NOWACZYK, HERVÉ DERRIENNIC – UNIVERSITÉ DE BORDEAUX
Observation
Marine physics, chemistry, and biogeochemistry
North Atlantic Ocean
Long-term observation of littoral zone responses to climate change and anthropic pressures.

SOLIBOB 2020-1
FRANÇOIS DUFOIS — IFREMER
Coastal scientific research
Geoscience and paleoclimatology; Marine physics, chemistry, and biogeochemistry
North Atlantic Ocean
Observation of internal wave and soliton impacts on the sediment dynamics of the Bay of Biscay shelf.

TP GIRONDE 2020
BERTRAND LUBAC — UNIVERSITÉ DE BORDEAUX
Education
Environment; Marine physics, chemistry, and biogeochemistry
North Atlantic Ocean
Introduction to modern coastal oceanography observation methods.

TPINT 2020
EMMANUEL POIZOT — CNAM INTECHMER
Education
Ecosystem biology and functioning; Marine physics, chemistry, and biogeochemistry
English Channel
Acquisition of geophysical and multidisciplinary data.

HALIOTIS

EPATH
GWENDOLINE GREGOIRE — CNAM INTECHMER
Coastal scientific research
Environment; Geoscience and paleoclimatology
English Channel
Study of the land-sea continuum and its paleogeographic evolution in the Saire area near Tatihou.

ESSTECH-HA 2020-1
XAVIER MORIN — GENAVIR
Technical testing
North Atlantic Ocean
Technical testing of acoustic equipment and related sensors: GeoSwath, sub-bottom profiler, EK60/ RoxAnn, Hydrins, HDS800 (Orpheon mode), CINNA, sound velocity profiler, and Valeport tide gauge.

ESSTECH-HA 2020-2
VALENTINE LANFUMEY — IFREMER
Technical testing
English Channel
Performance test for SBG Navsight Apogee inertial measurement unit equipped with Septentrio GNSS cards, for future installation on the *Côtes de la Manche* during 2021/2022 technical stop.

L'ATALANTE

ATA-NOISE
YVES LE GALL — IFREMER
Technical testing
North Atlantic Ocean
Acoustic measurement of noise generation.

EUREC4A-OA
SABRINA SPEICH — ÉCOLE NORMALE SUPÉRIEURE
Deep-sea scientific research
Atmosphere; Marine physics, chemistry, and biogeochemistry; Meteorology
North Atlantic Ocean
Study of ocean dynamics (mesoscale and submesoscale) and air-sea interactions.

HIPER
AUDREY GALVE — LABORATOIRE GÉOAZUR
Deep-sea scientific research
Marine geoscience
Pacific Ocean
Study of crust structure and seismicity at the Ecuadorian plate boundary.

MED-SHOM 2020
PIERRE-ANTOINE DUMONT — SHOM
Naval mission
Mediterranean Sea

PROTEVS GIB 2020
PIERRE-ANTOINE DUMONT — SHOM
Naval mission
Mediterranean Sea

SHOMAN 2020
PIERRE-ANTOINE DUMONT — SHOM
Naval mission
North Atlantic Ocean

L'EUROPE

EMSO KM3NeT 2020
PATRICK LAMARE AND VINCENT BERTIN — CNRS/ CENTRE DE PHYSIQUE DES PARTICULES DE MARSEILLE (CPPM), CARL GOJAK — INSTITUT NATIONAL DES SCIENCES DE L'UNIVERS (INSU)
Technology research
Technology
Mediterranean Sea
Technology at the EMSO KM3NeT observatory.

ESSAUV-20
PATRICK JAUSSAUD — IFREMER
Technical testing
Mediterranean Sea
Technology testing in support of future developments in the underwater vehicle fleet.

ESSCORAL 2020
LORENZO BRIGNONE — IFREMER
Technology research
Technology; Multidisciplinary
Mediterranean Sea
Operational validation of Ifremer's new 6,000-meter AUV.

ESSHROV-2020
LAURENT ARTZNER — IFREMER
Technical testing
Technology
Mediterranean Sea
Technical and operational upgrades for HROV *Ariane*.

MEDITS
GRÉGOIRE CERTAIN AND ANGÉLIQUE JADAUD — IFREMER
Coastal public interest
Ecosystem biology and functioning; Environment; Fisheries and population assessments
Mediterranean Sea
Observation and monitoring of fish stocks.

PELMED
JEAN-HERVÉ BOURDEIX — IFREMER
Coastal scientific research
Ecosystem biology and functioning; Fisheries and population assessments; Marine physics, chemistry, and biogeochemistry
Mediterranean Sea
Evaluation of small pelagic fish stocks and enrichment of understandings of the pelagic ecosystem.

ESS-GEN-EU-HROV-20
XAVIER PLACAUD — GENAVIR
Technical testing
Mediterranean Sea
Validation of *Ariane* with a 2,500-meter dive following technical stop at the end of 2019.

ESS-GEN-EU-AUV-20
XAVIER SAINT-LAURENT — GENAVIR
Technical testing
Mediterranean Sea
Validation of *AsterX* to ensure vehicle's full operational capacity for future missions following June 2019 technical stop.

ESS-DEC-EU-2020
ERWAN NEDELEC — GENAVIR
Technical testing
Mediterranean Sea
Tests of propulsion systems/generators and fishing-related scientific equipment following a long period of inactivity.

MARION DUFRESNE

ACCLIMATE-2
NATALIA VAZQUEZ RIVEIROS — IFREMER
Deep-sea scientific research
Geoscience and paleoclimatology
South Atlantic Ocean
Sampling of marine sediments in the Southeast Atlantic to address the lack of paleoceanographic data.

Bergen/Cardiff Coring Expedition
JAN HEIRET — BCCR NORCE — UNIVERSITY OF BERGEN/CARDIFF UNIVERSITY
Charter mission
South Atlantic Ocean
Sampling of marine sediments in the Southeast Atlantic.

MAYOBS15
EMMANUEL RINNERT — IFREMER
Deep-sea scientific research
Geoscience and paleoclimatology; Marine physics, chemistry, and biogeochemistry
Indian Ocean
Monitoring seismic and volcano activity around the island of Mayotte.

NIVMER
CÉDRIC BRACHET — INSTITUT NATIONAL DES SCIENCES DE L'UNIVERS (INSU)
Deep-sea scientific research
Indian Ocean
Retrieval of two tide gauge moorings measuring variations in sea level.

OHASISBIO12
JEAN-YVES ROYER — UNIVERSITÉ DE BRETAGNE OCCIDENTALE (UBO)
Ecosystem biology and functioning; Geoscience and paleoclimatology
Indian Ocean
Hydroacoustic observatory of seismicity, biodiversity, and ambient ocean noise: redeployment of autonomous hydrophone array.

OISO 30
CLAIRE LO MONACO — UNIVERSITÉ PIERRE ET MARIE CURIE
Observation
Marine physics, chemistry, and biogeochemistry
Indian Ocean
Study of seasonal, yearly, and decadal variations in ocean CO2: air-sea interactions, accumulation of anthropogenic CO2, and ocean acidification.

REMOBS
MARTIN ENGELS — FEDERAL INSTITUTE FOR GEOSCIENCES AND NATURAL RESOURCES (BRG) - GERMANY
OFEG
Geoscience and paleoclimatology
Indian Ocean
Retrieval of sixteen ocean-bottom seismometers.

POURQUOI PAS?

ESS SIS1 PP
FRÉDÉRIC BENON — GENAVIR
Technical testing
Mediterranean Sea
Validation of a specific seismic source for the CARAPASS 2021 mission requested by SHOM.

ESSROV-2020
FRANCK ROSAZZA — GENAVIR
Technical testing
Mediterranean Sea
Underwater tests.

ESSTECH PP 2020
LOIC TRELUYER — GENAVIR
Technical testing
Mediterranean Sea
Tests of scientific equipment following 2020 technical stop (Reson 7150, Reson 7111, OS38, OS150, gravimeter, DVL, and related sensors: nav, attitude, synchronization unit, etc.)

FOCUS X1
MARC-ANDRÉ GUTSCHER — UNIVERSITÉ DE BRETAGNE OCCIDENTALE (UBO)
Deep-sea scientific research
Geoscience and paleoclimatology
Mediterranean Sea
Implementation of an experimental fiber-optic apparatus for measuring seafloor deformation due to tectonic fault activity.

LuckyDivMic20
ANNE GODFROY — IFREMER
Deep-sea scientific research
Ecosystem biology and functioning
North Atlantic Ocean
Diversity and temporal dynamics of microbial communities in active hydrothermal vent edifices, colonization processes.

MaRoLiS PENFELD
SÉBASTIEN GARZIGLIA — IFREMER
Deep-sea scientific research
Geoscience and paleoclimatology; Multidisciplinary; Technology
Mediterranean Sea
Geotechnology for detecting the first signs of submarine landslides.

MoMARSAT 2020
PIERRE-MARIE SARRADIN — IFREMER
Deep-sea scientific research
Ecosystem biology and functioning; Marine physics, chemistry, and biogeochemistry; Environment
North Atlantic Ocean
Annual maintenance of the EMSO-Azores observatory and gathering of supplemental data on the Lucky Strike hydrothermal vent field.

NIOZ ANTARES
FRANCK ROSAZZA — GENAVIR
Charter mission
Mediterranean Sea
Inspection of a deep-sea mooring.

PERLE3
MIREILLE PUJO-PAY — OBSERVATOIRE OCÉANOLOGIQUE DE BANYULS
Deep-sea scientific research
Ecosystem biology and functioning; Marine physics, chemistry, and biogeochemistry
Mediterranean Sea
Formation and propagation of Levantine Intermediate Water, and its role in distributing nutrients and structuring plankton ecosystems.

SEALEX
SÉBASTIEN MIGEON — LABORATOIRE GÉOAZUR
Deep-sea scientific research
Geoscience and paleoclimatology
Mediterranean Sea
Identification and correlation of submarine sediment deposits on the Ligurian coast following the passage of Storm Alex through Alpes-Maritimes.

TÉTHYS 2

COGNAC 20
AURÉLIEN PONTE — IFREMER
Technology research
Technology; Marine physics, chemistry, and biogeochemistry
Mediterranean Sea
Evaluation of a strategy for deploying autonomous hydrophones to study submesoscale circulation.

DEO2M
LAURE MOUSSEAU — INSTITUT DE LA MER DE VILLEFRANCHE (IMEV)
Education
Ecosystem biology and functioning; Environment
Mediterranean Sea
Training in working at sea and access to deep-sea biodiversity.

EMSO ANTARES 2020
DOMINIQUE LEFEVRE — MEDITERRANEAN INSTITUTE OF OCEANOGRAPHY (MIO)
Coastal scientific research
Ecosystem biology and functioning; Marine physics, chemistry, and biogeochemistry
Mediterranean Sea
Maintenance and replacement of ALBATROSS instrumented mooring line (particulate flow measurements).

GEOMAST 2020
FRANÇOIS MICHAUD — LABORATOIRE GÉOAZUR
Education
Geoscience and paleoclimatology
Mediterranean Sea
Imaging of sediment and tectonic dynamics on the North Ligurian coast using low-impact seismic sources.

IADO 2020
JEAN-OLIVIER IRISSON — INSTITUT DE LA MER DE VILLEFRANCHE (IMEV)
Education
Ecosystem biology and functioning; Marine physics, chemistry, and biogeochemistry
Mediterranean Sea
Training in conducting an oceanographic cruise.

LASAIL 2020
JULIEN BAILLEUL — INSTITUT POLYTECHNIQUE UNILASALLE
Education
Geoscience and paleoclimatology
Mediterranean Sea
Land-sea geoscience field school.

METPAG 2020
FRANÇOIS BOURRIN — UNIVERSITÉ DE PERPIGNAN
Coastal scientific research
Geoscience and paleoclimatology; Marine physics, chemistry, and biogeochemistry
Mediterranean Sea
Measurement of suspended-particle characteristics.

MOOSE ANTARES 2020
MORGANE DIDRY — MEDITERRANEAN INSTITUTE OF OCEANOGRAPHY (MIO), DOMINIQUE LEFEVRE — MEDITERRANEAN INSTITUTE OF OCEANOGRAPHY (MIO)
Observation
Marine physics, chemistry, and biogeochemistry; Multidisciplinary
Mediterranean Sea
Long-term observation of hydrological, biogeochemical, and biological features in the Northwest Mediterranean.

MOOSE BOUSSOLE 2020
MELEK GOLBOL, ÉMILIE DIAMOND-RIQUIER, AND LAURENT COPPOLA — INSTITUT DE LA MER DE VILLEFRANCHE (IMEV)
Observation
Ecosystem biology and functioning; Marine physics, chemistry, and biogeochemistry
Mediterranean Sea
Maintenance of the BOUSSOLE buoy and gathering of additional bio-optical data.

MOOSE DYFAMED 2020
MELEK GOLBOL, ÉMILIE DIAMOND-RIQUIER, AND LAURENT COPPOLA — INSTITUT DE LA MER DE VILLEFRANCHE (IMEV)
Observation
Ecosystem biology and functioning; Marine physics, chemistry, and biogeochemistry
Mediterranean Sea
Long-term observation of hydrological, biogeochemical, and biological features in the Northwest Mediterranean.

MOOSE-GE 2020
STÉPHANE KUNESCH, XAVIER DURRIEU DE MADRON — UNIVERSITÉ DE PERPIGNAN
Observation
Ecosystem biology and functioning; Marine physics, chemistry, and biogeochemistry
Mediterranean Sea
Long-term observation of physical, biogeochemical, and biological properties of water masses in the Northwest Mediterranean and responses to climate change.

MORESCA2 2020
LAETITIA LICARI — CENTRE EUROPÉEN DE RECHERCHE ET D'ENSEIGNEMENT DE GÉOSCIENCES DE L'ENVIRONNEMENT (CEREGE)
Coastal scientific research
Ecosystem biology and functioning; Environment; Geoscience and paleoclimatology
Mediterranean Sea
Study of benthic metabolism and benthic foraminifera recolonization of Cassidaigne Canyon sediments impacted by historical red mud deposits.

MUG-OBS 2020
YANN HELLO — LABORATOIRE GÉOAZUR
Coastal scientific research
Environment; Geoscience and paleoclimatology
Mediterranean Sea
Redeployment of a multidisciplinary autonomous seabed station (EMSO Ligure network).

SIMGAP 2020
HÉLÈNE CARTON — INSTITUT DE PHYSIQUE DU GLOBE DE PARIS
Education
Geoscience and paleoclimatology
Mediterranean Sea
Course on seismic acquisition on the Ligurian Basin and shelf.

THALASSA

CGFS 2020
DIDIER LE ROY — IFREMER
Fisheries public interest
Ecosystem biology and functioning; Environment; Fisheries and population assessments
English Channel
Collection of fisheries data and population assessments.

ESSTECH-TL-2020
SARAH DUDUYER — IFREMER, DANIEL VAILLANT — GENAVIR
Technical testing
North Atlantic Ocean
Testing of winch at half capacity, i.e. 4,000 m of cable deployed into the water.

EVHOE
PASCAL LAFFARGUE — IFREMER
Fisheries public interest
Ecosystem biology and functioning; Environment; Fisheries and population assessments
North Atlantic Ocean
Collection of fisheries data and population assessments.

HYDROMOMAR 20
JULIE PERROT — UNIVERSITÉ DE PERPIGNAN
Deep-sea scientific research
Geoscience and paleoclimatology
North Atlantic Ocean
Long-term monitoring of seismicity in the MoMAR (Azores) zone.

IBTS 2020
COLINE LAZARD — IFREMER
Fisheries public interest
Ecosystem biology and functioning; Marine physics, chemistry, and biogeochemistry; Environment
English Channel, North Sea
Collection of fisheries data.

PIRATA FR30
BERNARD BOURLES — NATIONAL RESEARCH INSTITUTE FOR SUSTAINABLE DEVELOPMENT (IRD) BRITTANY CENTER
Deep-sea scientific research
Atlantic Ocean
Study and monitoring of climate variability in the tropical Atlantic.

THALIA

BENTH'OBS-BS 2020
JEAN-PHILIPPE PEZY — UNIVERSITÉ DE CAEN
Coastal scientific research
Ecosystem biology and functioning
English Channel
Introduction of long-term monitoring via two benthic stations.

COSB 2020
NICOLAS CAROFF — IFREMER
Coastal public interest
Ecosystem biology and functioning; Fisheries and population assessments
English Channel
Assessment of great scallop populations in Saint-Brieuc Bay and survey of related fauna.

DCE-BENTHOS 2020
AURÉLIE FOVEAU — IFREMER
Coastal public interest
Ecosystem biology and functioning; Environment
English Channel
Monitoring of coastal masses as part of the Water Framework Directive (benthic macroinvertebrates).

ESSTECH-TH-2020
HERVÉ BISQUAY — GENAVIR
Technical testing
North Atlantic Ocean
Technical tests of acoustic equipment and related sensors for BASSOP 2020: EM2040 multibeam echosounder, Pesk-Avel sub-bottom profiler.

NURSE 20
ANIK BRIND'AMOUR — IFREMER
Coastal public interest
Ecosystem biology and functioning; Fisheries and population assessments
North Atlantic Ocean
Sampling of coastal nurseries in the Bay of Biscay.

RESISTE-TH-2020
LAURE SIMPLET — IFREMER
Coastal scientific research
Ecosystem biology and functioning; Geoscience and paleoclimatology
North Atlantic Ocean
Investigation of physical and biological resiliency at a former marine aggregate extraction site.

SOGIR 2020
HERVÉ DERRIENNIC — UNIVERSITÉ DE BORDEAUX
Observation
Marine physics, chemistry, and biogeochemistry
North Atlantic Ocean
Long-term observation of littoral zone responses to climate change and anthropic pressures.

SOLIBOB 2020-3
MATTHIAS JACQUET– IFREMER
Coastal scientific research
Geoscience and paleoclimatology; Marine physics, chemistry, and biogeochemistry
North Atlantic Ocean
Observation of internal wave and soliton impacts on the sediment dynamics of the Bay of Biscay shelf.

TPINT 2020
EMMANUEL POIZOT — CNAM INTECHMER
Education
Ecosystem biology and functioning; Geoscience and paleoclimatology; Marine physics, chemistry, and biogeochemistry
English Channel
Gathering of geophysical and multidisciplinary data.

FLOTTE OCÉANOGRAPHIQUE FRANÇAISE PAR L'IFREMER

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