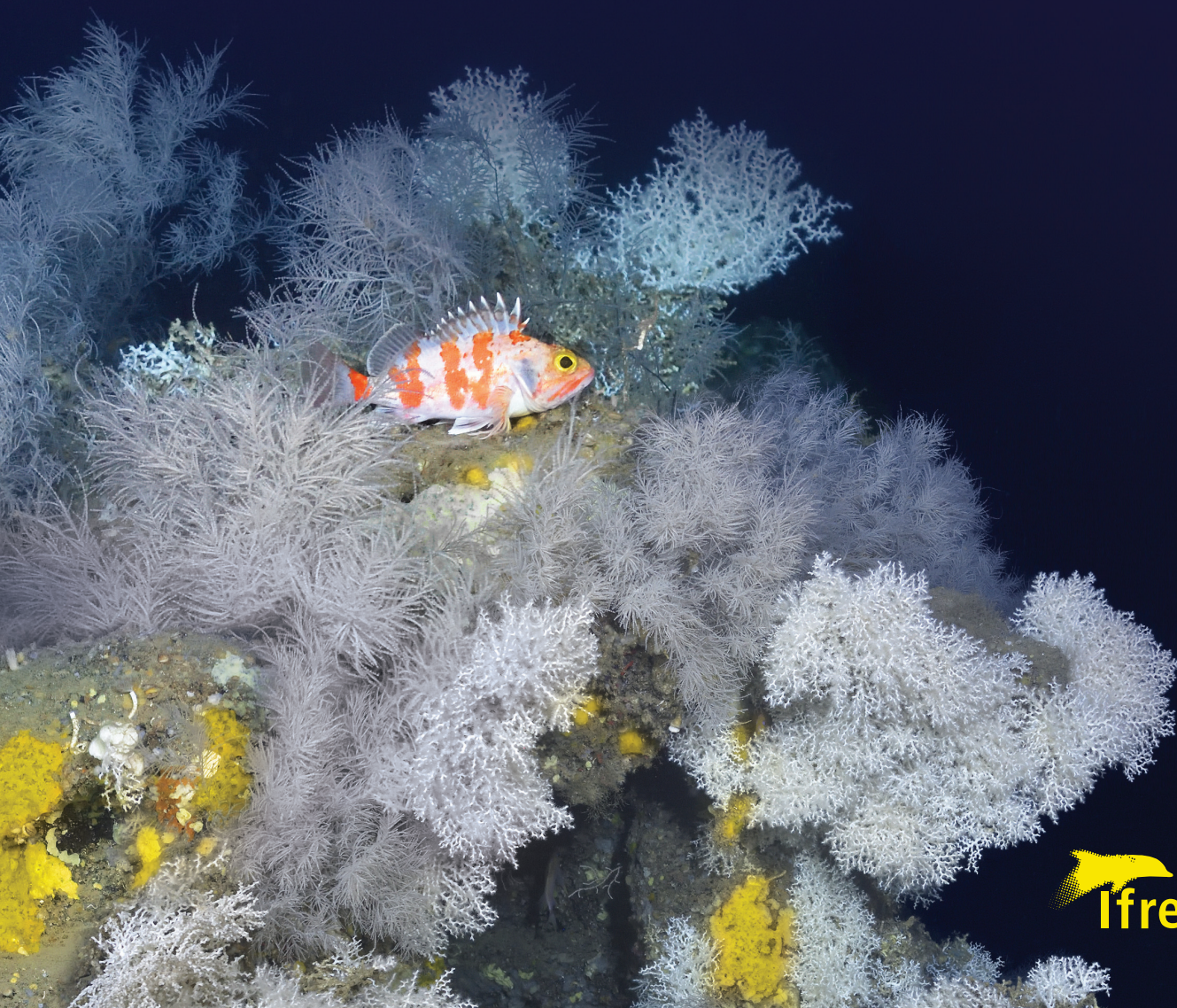

ANNUAL REPORT

2017





IFREMER

IN BRIEF

Created on 5 June 1984, Ifremer, as the national institute for integrated research in marine sciences, relies on its observational and monitoring capacities to produce scientific knowledge and know-how with economic value in response to societal issues.


Ifremer is a state-owned public industrial and commercial institute (EPIC), placed under the joint supervision of the Ministry of higher education, research and innovation and of the Ministry of ecological and inclusive transition.

Through a systemic approach, Ifremer is part of marine environmental observation on all scales and of understanding ecosystems, the processes governing them and the services they help provide, in a context of global change.

To these ends, it designs and deploys infrastructures for marine environmental research and monitoring and tools for observation and experimentation and manages databases.

As of 1st January 2018, Ifremer operates the French oceanographic fleet on behalf of the entire scientific community.

Ifremer contributes to national and European strategies for research and innovation, by producing:

- **fundamental knowledge;**
 - **more finalised results to respond to the questions raised by society;**
 - **results and technologies contributing to the socio-economic development of the maritime world.**
- 
-

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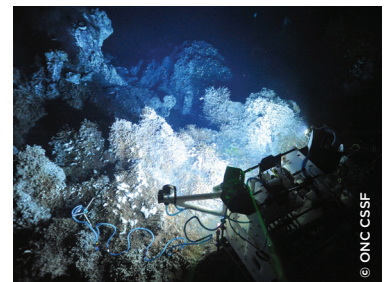
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EDITORIAL

François JACQ

CHAIRMAN AND CHIEF EXECUTIVE OFFICER

2017 was firstly a year for hindsight and taking stock, with the milestone of the Institute's HCERES assessment. These assessments are high points in the life of institutes like Ifremer, forcing us to step to the side and think about our practices, as the sine qua non condition for maintaining our creativity.

The assessment committee's report reflects on the Institute with a positive and strong image, paying tribute to the commitment of its personnel, its international recognition and its talents.

It also concurs with our own analysis on possible pathways for progress: being careful not to over-diversify, reinforcing innovation and our ability to embrace emerging themes. We have read this report attentively and it will prove to be a precious source for preparing the future.

2017 will also have been a year of tangible achievements, with various actions launched years ago now producing results or or being brought to completion.

In this way, the work undertaken to unify the oceanographic fleet, which had been the subject of discussions over nearly thirty years, was carried through successfully. As of 1st January 2018, management of the French oceanographic fleet will be in place, within Ifremer, serving the entire scientific community concerned. Although this new system must now be got up and running, we can already rejoice in the work accomplished. It now provides a promising framework, a source of efficiency for the French fleet. The credit goes to all those, amongst the partners involved, who ensured that the general interest prevailed. It is now up to us to successfully develop what has been achieved, but this initial phase gives us reason to be confident.

In the framework of its remit to support public policy-making, Ifremer has continued to work to concentrate on fields showing great synergy with our research activities and where its added value is known, working closely with the French State to ensure increasingly effective support. In 2017, this was shown through the finalisation of the terms for health monitoring management.

2017 was also the year of maintaining our quality certification and moving up to the new ISO 9001: 2015 standard. This can only reinforce the rigorous way we conduct our activities and anticipate risks.

The Institute's activities are also characterised by stronger inclusion in site policies and the ensuing successes: I-SITE MUSE, with its strong marine dimension in Occitania, the ISblue interdisciplinary graduate school (EUR) project in Brittany; notable successes in the framework of the European Horizon 2020 programme; relaunching cooperation with the German AWI and Marum institutes; stronger

partnerships with start-ups, for instance in the field of energy; and an active scientific policy, as well as in New Caledonia, with the revamping of the framework of our activities.

Two major endeavours underway also entered their final phase in 2017. Firstly, there is the transfer of headquarters to Plouzané, a long, complex project for the staff concerned, which should be complete in early 2019, knowing that the Institute will then have to rebuild its central services. Secondly has been the reorganisation of the financial sphere, to equip the Institute with a management system in compliance with best practice and State requirements, after a complicated year setting it up, as is often the case in such matters.

Finally, 2017 will have been a year to reflect and to prepare the future. The ocean is increasingly perceived both as an issue and an asset. What was already obvious to us has become so for others. We must empower and nurture this watchword through the most relevant actions over the short, medium and long terms.

The work conducted in 2017 aimed to prepare the Institute project for the next ten years; 2018 will be the year to fulfil its realisation. Ifremer's ambition is to be the national reference institute for marine sciences and technologies. It intends to affirm its uniqueness and its added value. The latter relies on our ability to maintain a triad bringing together science, support for public policies and innovation, in relation to the economic realm. The Institute must be both true to its heritage and open to the world. This will enrich us and make us strong. The developments engaged aim to both build on our achievements and prepare ourselves for the future. Our identity lies in the fact that we constantly reinvent ourselves. The coming years will prove this, even as the need for knowledge about the oceans becomes more acute than ever. ■

//

**The Institute must
be both true to its heritage
and open to the world.
This will enrich us
and make us strong**

IFREMER

KEY FIGURES



142

PHD STUDENTS
SUPERVISED BY IFREMER
RESEARCHERS



31

POST-DOCTORAL
FELLOWS



510

SCIENTIFIC ARTICLES
PUBLISHED IN 2017 AND
INDEXED BY *WEB OF SCIENCE*



36

EUROPEAN H2020
PROJECTS



158

ADVICE & EXPERTISE

€200M

BUDGET
(NOT INCLUDING INTERNAL
TRANSACTIONS)

1,480

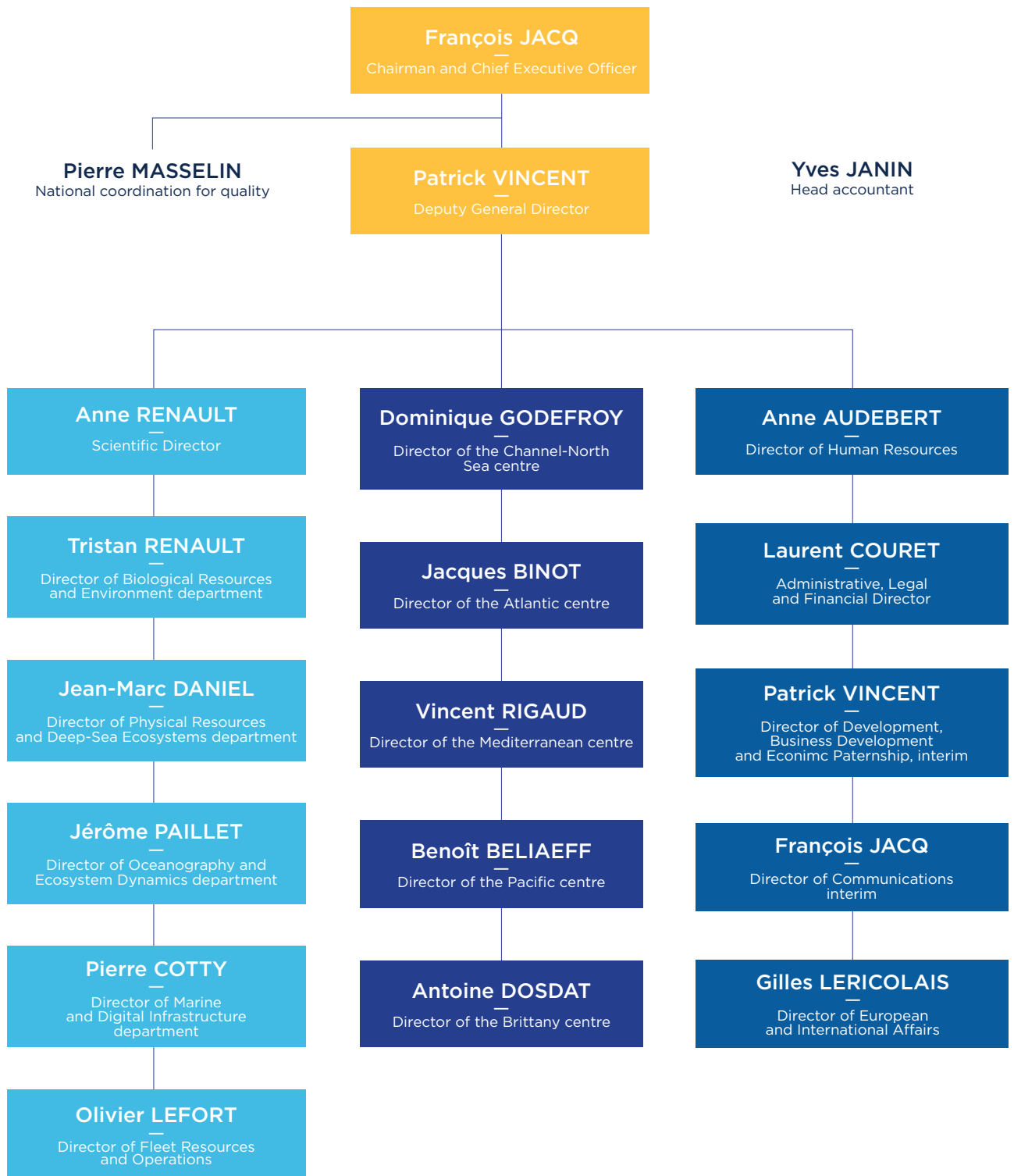
STAFF MEMBERS
(1100 SCIENTISTS, ENGINEERS
AND TECHNICAL STAFF)

89

NEW HIRES
IN 2017

ORGANISATION CHART

as of 31 December 2017



2017

IN PICTURES

← MARCH

HERMINE: A PUBLIC UTILITY CRUISE to explore the wealth of minerals of deep seafloors

In the framework of the fifteen-year licence granted by the International Seabed Authority to France in 2014 for polymetallic sulphide explorations, a multidisciplinary team from Ifremer spent 45 days aboard RV *Pourquoi pas?* to explore underwater volcanoes located along the Mid-Atlantic Ridge.



© Ifremer/Nautilus/Campagne Hermine



© Centrale Nantes



© Ifremer, Centre Bretagne

APRIL →

IFREMER AND CENTRALE NANTES engineering school join efforts to create the THEoREM research infrastructure

THEoREM is a scientific interest grouping based on networking the two institutions' marine engineering hydrodynamic testing facilities. On the European scale, the objective is to provide research bodies and industrial firms with competitive testing facilities for their research and innovation studies on interactions between man-made structures and the ocean environment.

↓ MAY

A WORKSHOP TO DISCUSS AWI-MARUM-IFREMER joint scientific activities held at Ifremer's Brittany centre

This workshop led to a call for joint projects between the three institutions to support new, shared scientific ideas. Ten projects were submitted and two of them were selected (Telepresence; Effects of climate change on fish larvae).



© Ifremer, S. Lesbat



↑ JUNE

INAUGURATION OF THE DATARMOR SUPERCOMPUTER, new marine data computing/processing infrastructure

Datarmor is located at the Ifremer Brittany centre and boosts storage capacities while supplying marine data-processing power fifteen times greater than that of the previous computer.



OCTOBER

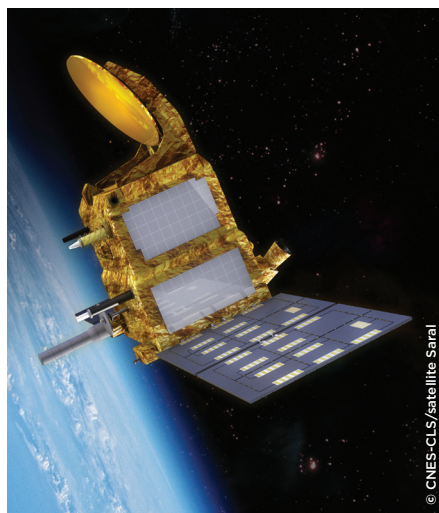
VISIT BY FRÉDÉRIQUE VIDAL,
the Minister of Higher education,
research and innovation, to Ifremer's
stand during the nationwide science
festival *Fête de la Science* in Paris.



NOVEMBER

**13TH MARITIME ECONOMY
MEETING, LE HAVRE**

Interview with François JACQ.
Oceanographic research:
a vital prerequisite for economic
development.



© CNES-CLS/satellite Saral



DECEMBER

**SIGNING OF A FRAMEWORK
AGREEMENT FOR COOPERATION
WITH THE FRENCH SATELLITE
SERVICES PROVIDER CLS**

on 15 December, in order to develop
cooperation in the fields of space
and airborne measurements, the
environment, energy and mining,
fisheries and maritime surveillance.



© Marum-Ifremer Group



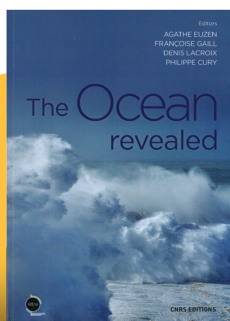
© Ifremer-RREX-V Hérault



JULY

**RREX CRUISE:
better understanding marine currents
to better understand the climate**

Aboard RV *L'Atalante*, a team of twenty-one scientists is studying interactions between the gigantic seamount chain in the middle of the North Atlantic called the Reykjanes Ridge and marine currents, including the North Atlantic Drift. This current is the extension of the Gulf Stream in this region and contributes to regulating the global climate.



SEPTEMBER

«THE OCEAN REVEALED»

This book was published under the aegis of the National environmental research alliance (AllEnvi) and under the scientific direction of A. EUZEN, F. GAILL, D. LACROIX AND P. CURY. It provides an inventory of French scientific research on seas and ocean. Twenty-three Ifremer scientists were contributors.

CNRS Editions, 322 p.
French and English editions.



**FOR THE 30TH ANNIVERSARY
OF THE EVHOE OCEAN
RESEARCH CRUISES,**

a one-day feedback event was organised to assess the monitoring of seabed-dwelling or seabed-related species, their diversity, their abundance and how the Bay of Biscay and Celtic sea ecosystems are changing, and to propose new approaches to integrate this knowledge.

1

SCIENTIFIC POLICY

The Institute's scientific policy has the main objective of strengthening its position in the world of higher education and research. Accordingly, it contributes to the strategy set out for the Institute. The policy takes the form of actions which should make it possible to inspire, coordinate and facilitate scientific activities in-house and to grow the Institute's collaborative network.

In 2017, Ifremer pursued its efforts to recruit PhD students and post-doc fellows and to support both the international mobility of its PhD students and the hosting of foreign researchers in its teams. Site-policy projects, aiming to bolster cooperation with organisations located on the same geographical site, were also supported.

A milestone for the year 2017 was the HCERES assessment and launch of «strategic reflection» in the context of the future State-Ifremer objectives contract for 2019-2023.

Finally, amongst the Institute's structuring projects which should be highlighted are: the successful EUR ISblue Interdisciplinary School for the Blue planet sponsored by the university of western Brittany (UBO) and I-SITE MUSE from Montpellier university of excellence, and, for overseas France, reworking the scientific project of the Ifremer unit located in New Caledonia.

Scientific policy trends and priorities

The scientific management team was largely reorganised in 2017, notably with the arrival of a new director, Anne Renault, formerly at CNRS.

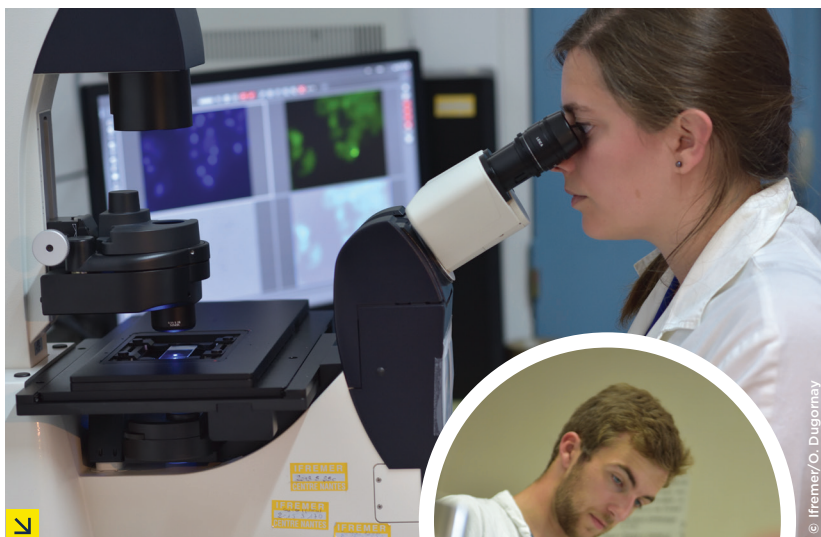
Scientific management contributed to carrying out recurrent scientific policy activities (in particular, the recruiting of PhD students and post-doctoral fellows, supporting mobility and site policy), while developing new tools to bring exploratory projects to the fore, promoting risk-taking and launching novel collaboration on themes drawn from the major challenges of the future for Ifremer.

Two important calls for projects

In this way, two new calls for projects were launched:

- the "Inter Centres" call aiming to develop new dynamics between units in Ifremer centres and fostering collaborative work on emerging issues and
- the Colloquia call to support the organisation of workshops and symposiums to better structure the communities and bring together researchers from different disciplines.

In future, these orientations will be developed in house, based on the contents of calls for projects and the hiring profiles for engineers and research scientists. Outside of the institute, major orientations will consist in reinforcing the Institute's position in terms of partnerships on some sites and in making strategic choices for participation in GIS scientific interest groupings, GDR research groupings and in large-scale French, European and international programmes. Similarly, it will be vital to design and conduct actions which can give the Institute even greater visibility and renown on national and international levels, by increasing the success rate with the most relevant "windows" (Europe, ANR and major international programmes). ■



Filtration of sea water for multiannual monitoring of microbial communities in the coastal zone

Ifremer's assessment by the High council for the evaluation of research and higher education (HCERES) took place in two steps:

- a self-evaluation report produced by the Institute on 1st October 2016;
- and the evaluation by an expert committee in the first quarter of 2017.

During the current objectives contract period (2014-2018), far-ranging work has been carried out: consolidating scientific activities and partnerships, clarifying public policy support activities, developing the territorial network, making far-reaching changes for the oceanographic fleet, overhauling the financial management and human resource management systems, with streamlining efforts and increased rigour and finally, the headquarters transfer which weighs heavily on all activities.

The evaluation report published in June 2017 highlights the actions undertaken since the previous assessment in 2013. It notes the Institute's trajectory of trends and changes and confirms that the choices made were relevant ones.



510

ARTICLES PUBLISHED IN 2017
and indexed by Web of Science



9

IFREMER IS A PARTNER
in 9 joint research units (UMR)
and is the supervisory authority
for 8 of them.



142

PHD STUDENTS
supervised by Ifremer
researchers (84 of them
salaried PhD students)



31

POST-DOCTORAL FELLOWS
(25 of them salaried)

Strong points

Several strong points for Ifremer were thus noted.

They include:

- better prioritise the Institute's missions in accordance with the means at its disposal to ensure that actions are viable;
- strengthen the steering of the scientific strategy, so as to seize upon emerging fields;
- compensate for organisational weaknesses, particularly those related to the transfer of the headquarters to Brest;
- clarify the Institute's role and position in societal debates.

Recommendations for improvement

Some weaknesses were also identified, giving rise to the following recommendations:

- better prioritise the Institute's missions in accordance with the means at its disposal to ensure that actions are viable;
- strengthen the steering of the scientific strategy, so as to seize upon emerging fields;
- compensate for organisational weaknesses, particularly those related to the transfer of the headquarters to Brest;
- clarify the Institute's role and position in societal debates.

Most of these recommendations tie in with the observations in the self-evaluation report. They will help enrich the work already begun to prepare the future. ■

Projects in the Investments for the future programme

The Investments for the future programme (PIA) aims to promote excellence in French research and higher education. Since 2017, Ifremer has been particularly involved in the ISblue and MUSE projects.

ISblue, winner of the third PIA phase

This EUR graduate school project, devoted to the sea and sponsored by the University of western Brittany (UBO), was selected and will be financed for a ten-year period. Creating ISblue (*Interdisciplinary graduate school for the blue planet*) also includes the extension of funding for LabEx MER* for ten additional years.

Its research programme has five themes: the ocean and climate regulation, ocean-Earth interactions, sustainable coastal systems, living ocean and ecosystem services and long-term observation systems. This involves pushing back the frontiers of knowledge by setting up interdisciplinary research projects, hosting international post-doc fellows, chairs and visiting professors, and supporting actions at sea, in continuity with the actions begun by LabEx MER.

The training programme is interdisciplinary (ranging from law to engineering), closely linked to research and highly attractive for the best French and international

students. It will propose new curricula (coastal tourism, ocean data science). Students and lifelong learners will be able to build their own learning pathway. Project-based learning will be provided to students in universities and engineering schools, in close interaction with socio-economic partners.

Ifremer was already present in LabEx MER as a founding member and will take an active part in ISblue in the fields the EUR themes focus on. Alongside UBO, CNRS and IRD, the project will also involve some of the laboratories associated with the IMT-Atlantique, ENSTA Bretagne and ENIB engineering schools, as well as the French Naval academy.

MUSE, winner of the second PIA phase

In the framework of the I-SITE (Initiative Science, Innovation, Territories, Economy) call for projects, Ifremer is more particularly involved in the MUSE project, sponsored by the university of Montpellier. MUSE comprises a dozen research bodies (including Ifremer), schools of higher education and health-care institutions, representing nearly 6,000 scientists in all, in the fields of food safety, sustainable development of natural resources and ecosystems and improving treatments for emerging infectious diseases, chronic diseases or cancers.

Ifremer and its partners in the joint research units UMR Interaction hosts-pathogens-environment (IHPE) and Marine Biodiversity, Exploitation and Conservation (Marbec), members of the Mediterranean centre for environment and biodiversity (CeMEB) LabEx, are associated with the project on the themes of protecting and exploiting marine biological resources. ■



Preparing the Institute project

Ifremer began preparing its future 2019-2023 objectives contract in 2017. This preparation is based on thought and discussion about the "institute project" for the next ten years.

Various working groups were formed to define the orientations for the 2030 horizon:

- Ifremer's "fields of excellence": the deep ocean, coastal and shore processes, marine bio-resources and the ocean processes which regulate the climate;

- the "challenges": evolving living organisms, the digital ocean, observations and modelling for the future;
- the "cross-cutting orientations" at the Institute: foresight, innovation, information systems and databases, the dialogue between science and society.

This process of reflection was launched in June 2017, with the goal of reaching its conclusions in autumn 2018. Preparatory work with the supervisory authorities, who will provide concomitant support in drawing up the contract, will begin in spring 2018.



* LabEx MER: laboratory of excellence whose objective is to strengthen knowledge and understanding of the ocean's functioning, made up of seven partners: UBO, UBS, university of Nantes, CNRS, IRD, Centrale Nantes engineering school and Ifremer.

Interview Benoît BELIAEFF

Director of Ifremer's Pacific centre



Which sectors are affected by the new project in New-Caledonia?

— The two sectors this project focuses on are aquaculture and the environment of the New Caledonian lagoon and its reefs with their exceptional biodiversity. It will last four years (2017-2021), with the perspective of economic development and environmental protection.

The major stakes for aquaculture in this Pacific archipelago are firstly the «sustainability» of shrimp farming (*Litopenaeus stylirostris*), as the second ranking export product (approximately 1,500 tonnes per year) though far behind nickel, and secondly the emergence of a value chain producing microalgae. They are linked to another major stake, which is preserving the marine environment in the New Caledonian lagoon, which has been on the Unesco World Heritage list since 2008 and which is still subjected to various anthropogenic pressures (tourism, fisheries, terrigenous inputs, urbanisation and waste waters). This means that it is vital to reconcile protecting these outstanding natural spaces in the New Caledonian archipelago with developing marine activities.

What are its major orientations?

— The project proposed by Ifremer, responding to the sustainable development objectives for aquaculture (Ressac: Resources and aquaculture systems in New Caledonia) aims to cope with the

vulnerability of aquaculture systems exposed to sometimes cyclonic climate hazards and other environmental risks, as well as being highly dependent on inputs (feed for the farms).

The Ressac project mainly focuses on shrimp farming. The objective is to improve health and hygiene and increase the production in farms or rearing ponds by: defining health and performance indicators for farmed animals; characterising the potential, particularly as fodder, of microalgae already selected in a previous project (Amical); studying the activity of probiotic bacteria in these cultures, by understanding their interactions with the host (farmed fish or shrimp), its environment (in hatcheries or ponds) and pathogenic agents (viruses, bacteria, etc.) which may be present. Special attention will be given to hatchery production of shrimp post-larvae which have been hard hit by high mortality rates over the past few years, limiting the later production of shrimp in ponds.

The second - environmental - line of research conducted by Ifremer is focused on describing pressures exerted on the lagoon ecosystems of New Caledonia (Présence project), with the major objectives of: studying the various pressures due to development, such as terrigenous inputs linked to devegetation; understanding the role played by ocean-lagoon and land-lagoon interfaces in the lagoon's hydrological structuring and finally integrating this knowledge to better appraise the impact of these pressures on the ecosystem's status.

Who are our partners?

— The local and regional authorities of New Caledonia (South and North provinces) and the New Caledonian government, who have all signed the framework agreement between New Caledonia and the Institute for the 2017-2021 period, are cofinancing the Présence and Ressac projects. The research activity on microalgae is taking place in the laboratory for microalgae studies (LEMA) in the Technopole science park, managed by the New Caledonian economic development agency (Adecad). In addition, twenty researchers and technicians from Ifremer are working in collaboration with the university of New Caledonia, IRD and, in metropolitan France, with Ifremer laboratories, including the algae physiology and biotechnology lab (PBA) and the staff who are part of the joint research unit UMR integrative biology of marine models in Roscoff.

A large school of tuna swimming in blue water. The fish are silvery with dark stripes and are moving in a coordinated pattern. The water is a deep blue, and the fish are the primary focus of the image.

2

LIVE FROM
RESEARCH



14

**Ocean and marine
environmental
dynamics**

26

**Resources
and ecosystems
of the deep sea**

20

**Biological resources
and environment**

Ocean and marine environmental dynamics

Observing and understanding the dynamics of the marine environment is a major orientation for Ifremer, in response to various societal challenges. This especially means assessing the influence of climate change on the ocean and how the ocean regulates the climate, and to understand ocean-atmosphere interactions with the perspective of improving oceanographic and meteorological forecasts. In addition, the Institute is pursuing its studies of inshore and coastal ecosystem dynamics, and particularly how they respond to anthropogenic influences, whether these are direct and localised or more global.

Extreme ocean phenomena

An unusual number of very intense hurricanes occurred in the Caribbean over the year 2017. Although significant progress has already been made, many challenges - especially scientific ones - remain to better understand the occurrence, intensity and impacts associated with these extreme events.

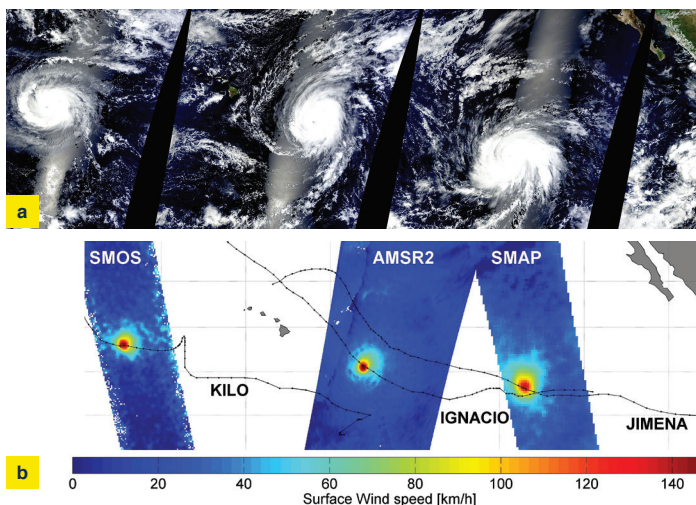
Ocean/atmosphere interactions

Working within Ifremer's Orpheo project, in collaboration with many national and international teams, the Physical and spatial oceanography laboratory (LOPS) is focusing both on quantitative interpretation of observations and on understanding the processes of ocean/atmosphere interactions guiding changes in these systems. This requires combining different types of observations (remote sensing from space and *in situ*) with different modelling approaches. Recently, it was possible to rapidly supply initial analyses based on new algorithms benefiting from the increased capacities of current satellite sensors. They confirmed the exceptional nature of this hurricane season.

Wind structure in hurricanes

The year coincided with the end of the SMOS-Storm project conducted in partnership with the European Space Agency (ESA). In this framework, passive remote-sensing microwave measurements proved their usefulness in characterising the structure of wind in hurricanes. SMOS's observation capability was illustrated, for the day of 29 August 2015 alone, when three

hurricanes (Kilo, Ignacio and Jimena) were ongoing simultaneously in the Pacific basin, by the wind map produced by analysing the brightness temperature emitted by the surface and sensed by the SMOS radiometer. The "true-colour" image is a composite produced by the Modis instrument showing the cloud structures in the atmosphere. More generally, these studies have proved it possible to combine passive microwave measurements from various space missions (European, Japanese, American) to create a unique description of each hurricane's evolution.



(a) Composite image from Modis instrument on August 29, 2015, when three tropical hurricanes (Kilo, Ignacio, Jimena) occurred in the Pacific basin

(b) The surface wind speed (kilometre per hour) is reproduced using data from the microwave radiometers of the SMOS, AMSR-2 and SMAP satellites. The track of the centre of the hurricanes is indicated (black curve)



The coupling of waves, the atmosphere and the ocean

Numerical studies are also being carried out to broaden the scope of investigations and better specify input from the coupling of waves, the atmosphere and the ocean. In partnership with the university of Reunion island, CNRS, Météo-France and IRD, Ifremer took part in setting up coupled ocean-atmosphere-wave models in the Indian Ocean and South Pacific basins. This led to an improved representation of the spatial structure of waves, spray in the hurricane and the storm surges which are induced. The twenty years of simulations performed show that the intensification of hurricanes and their ocean response are better reproduced by considering all these interactions. In

the framework of a PhD thesis funded by Ifremer and in partnership with the European Centre for Medium-Range Weather Forecasts (ECMWF), studies are evaluating how sensitive the model is to the parametrisation of atmosphere-wave coupling, based on comparisons with various available observations (satellites, buoys and platforms). They show that the strong winds (20-40 metres per second) modelled are underestimated and that more appropriate parametrisation reduces this bias. This also highlights the differences between observations, related to the difficulty of defining a terrain reference for strong winds, and emphasizes the efforts still needed in data interpretation.

Satellite hurricane observations

Moreover, since 2016, LOPS has led the *Satellite Hurricane Observations Campaign* (SHOC) at ultra-high resolution (< 1 km), via the European Sentinel-1 mission's imaging radar. This mission can deduce the surface wind from radar echo analysis, by using the instrument's new polarisation properties with a better characterisation of hurricane intensity. Thus, surface wind speeds up to more than 75 metres per second (i.e. 270 kilometres per hour) can be estimated. These studies make it possible to implement a new acquisition strategy adapted to the operational Sentinel-1 mission in the Copernicus programme. Complementing this, LOPS took part in the *National Oceanic and Atmospheric Administration's* (NOAA) airborne surveys, conducted in extratropical cyclones using instrumented aircraft, by planning flights to be concomitant with acquisitions from satellites of interest. ■

Mouche A. et al., 2017. *IEEE Transactions on Geoscience and Remote Sensing* 55, 6746 - 6755.
<http://doi.org/10.1109/TGRS.2017.2732508>

Stopa J. et al., 2017. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* 10, 2147-2155.
<http://doi.org/10.1109/JSTARS.2016.2609101>

Toxic microalgae and ciguatera

Ciguatera, also called "the itch" (la gratte in French), is food poisoning affecting people who have consumed fish or gastropod molluscs which have themselves consumed dinoflagellate-type microalgae from the *Gambierdiscus* genus producing ciguatoxins (CTX) and maitotoxins (MTX).

This gastroenteric and neurological syndrome shows up in humans a few hours after eating contaminated fish or molluscs and can last for years, particularly in its effects of skin irritation and tactile disorders. CTX and MTX are toxic at very low doses (< 1 microgramme per kg); they accumulate in fish and are transformed into increasingly toxic forms as they move up the food chain: making them a major challenge for public health.

Although for centuries these cases of poisoning were limited to tropical zones, global climate change is leading to the geographical spread of this microalgae beyond the tropics, particularly to the Canary Islands. The Intergovernmental Oceanographic Commission (IOC, Unesco) has launched an international strategy for research on ciguatera, led by the International Atomic Energy Agency, the French Polynesia Louis Malardé institute and Ifremer since 2016.

Two studies funded by Ifremer, NOAA and the Pays de la Loire regional council (working in collaboration with Spanish, Japanese, American and Brazilian scientists) have made it possible to screen the toxicity of forty-four strains belonging to thirteen species in the *Gambierdiscus* and *Fukuyoa*¹ genera. It was the *Gambierdiscus excentricus* species which produced the most toxin, of both CTX and MTX types, when cultured. The species was described in 2011 and has not been detected in the Pacific or Indian Oceans. An approach combining cell culture assays and use of high resolution mass spectrometry identified one of the toxins responsible for its toxicity, maitotoxin-4 (MTX4), which is an analog of maitotoxin². Eight strains of this species were obtained across the Atlantic (Canary Islands, Caribbean and Brazil) and all of them produced MTX4, suggesting that the species' toxin profile is consistent across the Atlantic Ocean. Although *G. excentricus* grows slowly in culture, the species' high production of toxins indicates that it is probably one of the largest contributors to ciguatera in the Atlantic, including in the French West Indies. Thorough analysis of these microalgae leads us to suspect the presence of other toxins, which must be isolated and described in order to determine the specific toxicity of these microorganisms. ■

1. Litaker et al., 2017. PLOS One 12(10): e0185776
<https://doi.org/10.1371/journal.pone.0185776>

2. Pisapia et al., 2017. Marine Drugs 15: 220
<https://doi.org/10.3390/md15070220>



Coral reef: hyperspectral image showing the evolution of coral cover with degraded zones in red and improved zones in blue

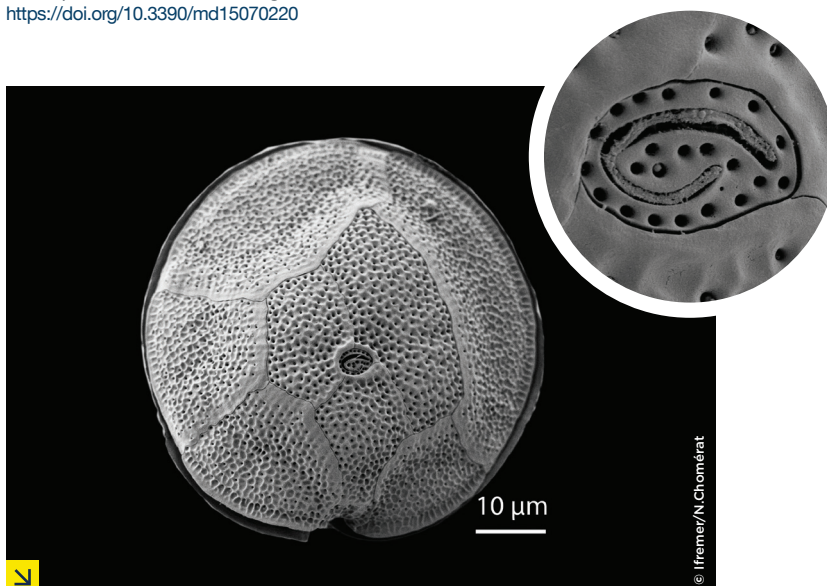
Coral reef assessed by hyperspectral imaging

Coral reefs in intertropical regions are some of the richest (25% of marine biodiversity) but also the most vulnerable marine ecosystems. Globally speaking, it is estimated that only 30% remain in satisfactory condition (Ifremer). Therefore, acquiring knowledge about these ecosystems and monitoring them are major stakes in the context of global change and ocean acidification.

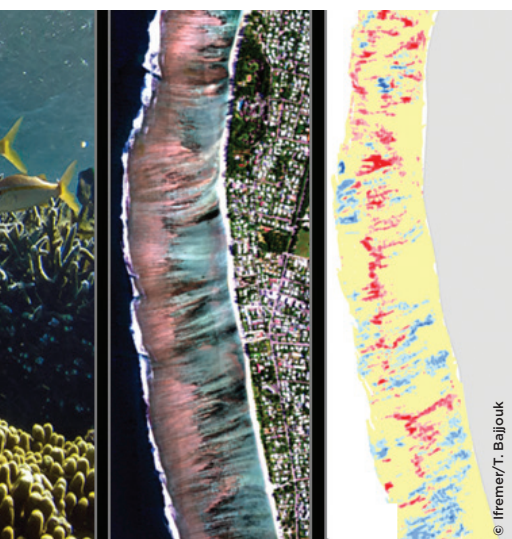
In Reunion Island, where the narrow reef is subjected to numerous impacts from human activities, local monitoring on a station-by-station basis conducted in the framework of the *Global Coral Reef Monitoring Network* (GCRMN), does not allow the strong spatial heterogeneity characterising these reef ecosystems to be taken into account. This context led Ifremer, along with various academic and institutional partners, to develop a new spatial approach based on airborne imaging.

Combining several sensors

Indeed, combining a remote-sensing (airborne) sensor with an optical one (video camera equipped with hyperspectral sensors placed on the reef) measuring continuously over the whole spectrum of light, offers new opportunities, thanks to their spectral



The *Gambierdiscus* sp. microalgae producing toxins that cause ciguatera disease, seen under scanning electronic microscope



range and their spatial resolution. The bathymetry and the percentage of coral coverage have also been better estimated, by proposing a "spatialised" (per pixel) indicator of the state of health which is called "hyperspectral coral vitality". This makes it possible to take better account of this spatial variability in assessing the status of the entire reef platform. The acquisitions made in 2009 and 2015 were used to evaluate the changes which had occurred over a five-year period, both for coral coverage and vitality and for the geomorphology of the seabeds, thus opening new perspectives for large-scale operational monitoring.

Since initially processing was limited to the reefs in the lagoon alone, recent studies have provided dramatic improvement, it has been possible to estimate the bathymetry to depths reaching 25 metres, as well as the abundance of the main types of seabeds to depths of 10 metres.

Today, Ifremer is extending the use of hyperspectral imaging to address other research questions, such as better understanding of the food web associated with engineer species, or the characterisation of the spatial-temporal dynamics of seagrass meadows in relation to factors of anthropogenic or natural pressure. ■

Petit T. et al., 2017. *Remote Sensing of Environment* 190, 348-365.
<https://doi.org/10.1016/j.rse.2017.01.004>



In Memoriam

Fabienne GAILLARD : a life turned towards the oceans

Fabienne GAILLARD passed away in 2017. She was part of the Ocean physics laboratory (LPO) adventure from the outset and was its deputy director between 2008 and 2011. She was a truly remarkable figure of this laboratory for her scientific rigour and outstanding personal commitment and her implication in serving the community. Her research activity focused on climate variability, ocean heat content and the water cycle.

When she arrived at Ifremer, Fabienne GAILLARD joined the ocean acoustic tomography team. One of the last articles she contributed to notably reviewed the data from the Cambios cruises for which she was chief scientist in 1997 and 1998 and looked at using acoustic methods to detect the Mediterranean waters flowing into the Atlantic through the Strait of Gibraltar.

Over the past ten years, Fabienne GAILLARD developed the ISAS (*In-Situ Analysis System*), a data-processing tool enabling *in-situ* measurements to be projected onto a regular grid and assigned a statistical error bar. For nearly twenty years now, it has become an essential tool for synthesising the *in-situ* temperature and salinity fields supplied by the global Argo network: a major contribution to the Argo project and to our understanding of the variability of the world ocean.

In 2016-2017, fundamental scientific results were obtained thanks to the most advanced version of ISAS, concerning the impact of El Niño's interannual variability on the heat content of the world ocean. For the first time, the strong mark of this interannual variability was established in subtropical regions of the Southern Ocean. These stu-

dies are also the expression of Fabienne's wishes - she realised the scientific impacts that ISAS products could have and wanted to disseminate this tool to a very large community of oceanographers and climatologists.

Although Fabienne Gaillard's scientific activities devoted to *in-situ* data products represent a legacy of utmost importance, they were not limited to this aspect alone. We remember too that she was a pioneer in setting up the Odatis digital research facility devoted to ocean data, and more generally that she will have left her mark on the activity of the Institute's oceanographic teams and of its partners.

Dushaw B.D. et al., 2017. *Journal of Geophysical Research: Oceans* 122, 8983-9003.
<https://doi.org/10.1002/2017JC013356>

Gaillard F. et al., 2016. *Journal of Climate* 29, 1305-1323.
<http://doi.org/10.1175/JCLI-D-15-0028.1>



Modelling Mediterranean lagoon ecosystems

The Mediterranean coastal lagoons, situated at the interface between land and sea, have been exposed to significant inputs of nutrients for decades, leading to the eutrophication (environmental imbalance due to excessive inputs of nutrient substances) of these fragile ecosystems. In response to recent environmental regulations, some lagoons have received management actions aiming to reduce these inputs.

Today, the issue raised for these environments in the restoration phase concerns the nutrient loads they can tolerate, ensuring both good environmental status as defined by the Water Framework Directive (WFD) and productivity compatible with maintaining uses there, especially shellfish farming. The approach implemented to provide operational tools to help manage these environments is based on finding the appropriate spatial and temporal scales to best describe the way these complex systems function.

The MARS-3D model is used to define hydrodynamic descriptors on the lagoons: the "mixing volume" indicator can be used to locate any hydrodynamic boundaries within a lagoon and determine the time needed to cross them. These boundaries are the source of heterogeneity in water masses (particularly changes in salinity due to exchanges between the sea and lagoon basin and modification of freshwater inflows) and divide the lagoon into "physical boxes" with known morphological characteristics. The mixing volume also provides information about the characteristic mixing-process time.

An ecosystem model, with interconnected physical boxes in which the interactions between the main biogeochemical compartments are described, was built on the Bages-Sigean lagoon (4,000 hectares). Global sensitivity analysis methods were applied to this tool, firstly to identify which processes engender the greatest variability and secondly to supply status indicator values for the water column and phytoplankton in accordance with

WFD criteria. A level of uncertainty was linked to each one, taking those which affect forcings and model parameters into account.

This model is currently being developed on the Thau lagoon to add an "oyster" compartment via a bioenergetic model adapted to this lagoon utilised by shellfish farmers. It will be used to better understand how this ecosystem functions and what factors determine its progressive return to good environmental status. ■

Fiandrino A. et al., 2017. *Marine Pollution Bulletin* 119, 132-144.
<https://doi.org/10.1016/j.marpolbul.2017.03.006>



Sigean lagoon in the Mediterranean



Today, the issue raised for these environments in a restoration phase concerns the nutrient loads they can tolerate, **ensuring both good environmental status as defined by the Water Framework Directive (WFD) and productivity compatible with maintaining uses there, especially shellfish farming.**

Interview

Stanislas DUBOIS

Research scientist at the coastal benthic ecology laboratory, Ifremer



Tubes built by honeycomb worms
©Ifremer/S.Dubois

What are honeycomb worms?

— Honeycomb worms (*Sabellaria alveolata*) are marine worms which are very common in Europe, and especially in France. They live in tubes that they build by agglomerating grains of sand and shell fragments to form reefs on the foreshore, sometimes covering dozens of hectares. This engineer species modifies the immediate surroundings and creates a unique, natural, so-called biogenic habitat which is ecologically significant. For this reason, honeycomb worm reefs are protected by several European directives.

Why is your laboratory focusing on this species in particular?

— The species undergoes strong human pressure: its reefs are destroyed or trampled because they extend in great part over very popular rock-pool and shore fishing areas, like in the bay of Mont-Saint-Michel, or are occasionally subjected to passing tractors for nearby shellfish farming activities. We are regularly solicited by natural area managers who want scientific insight about these reefs' dynamics and their state of health.

Furthermore, we use the species as a study model to understand the ecological role played by engineer species in ecosystem functioning.

What are the latest scientific advances in the case of honeycomb worm reefs?

— We have shown that honeycomb worm reefs shelter and attract other species, thus creating pockets of biodiversity. Owing to the three-dimensional structure of their constructions, honeycomb worms modify the organic matter or even the temperature of the sediment. These reefs also act to trap marine sediments and locally protect the coast from erosion.

Finally, honeycomb worm reefs are truly biological filters, sometimes containing 30,000 individual filter-feeders per square metre. These worms are also food for crabs and fish of the foreshore.

So, the entire structure of the food web can be modified by this species' engineering work, which can locally influence the diets of benthic species.

Do these results apply to all engineer species?

— Yes, to a great extent. We are developing "functional diversity" indicators. By studying the diversity of species associated with engineer species, we assess the various functions provided by these biogenic habitats. It is a new way of looking at diversity. Later, we want to develop probabilistic and deterministic habitat models in order to predict the presence and the development of certain engineer species on our coasts. This will open new research perspectives, whilst providing support for environmental managers.

Biological resources and environment

Supporting the sustainable development of fisheries and aquaculture in the context of global change and finding better valuable uses, specifically through innovative biotechnologies, for marine biological resources, thanks to their exceptional diversity, are major challenges for Ifremer.

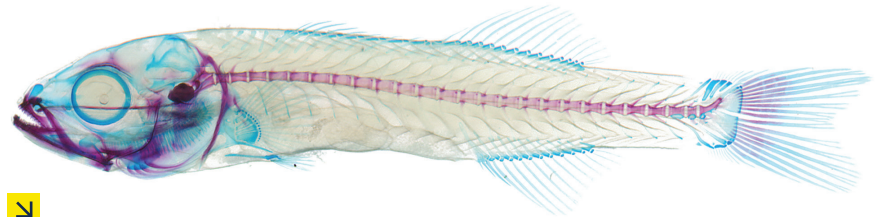
The growing importance of environmental changes requires that their interactions with developing human activities (exploitation of living resources, discharging contaminants, various developments, especially in coastal zones) be studied. In this context, Ifremer is continuing the monitoring and research studies which are indispensable for acquiring knowledge about the marine environment and the species which live there and for developing and implementing strategies to preserve biodiversity and to manage uses of maritime areas.

Research studies aim to identify the sources and potential orientations to develop fisheries and aquaculture and to elucidate the combined effects of numerous, multi-scalar phenomena driving how these developments evolve (altered marine biodiversity, deteriorated chemical quality of waters, climate change, globalisation of the seafood trade, growing competition for resources and/or areas, resilience of production systems, changes in governance, etc.).

Effects of ocean acidification and rising temperature

The increase in atmospheric carbon dioxide (CO₂) leads to a rise in temperature and the acidification of the ocean. Several projections of the Intergovernmental Panel for Climate Change (IPCC) indicate that the mean partial pressure of CO₂ (pCO₂) in the oceans, which is currently 400 micro-atmospheres, will double in 2050 and exceed the value of 1,200 µatm by the year 2100. Ocean pH has dropped on average by 0.1 unit since the pre-industrial era and may therefore drop by 0.4 unit to reach a pH of 7.6 in 2100.

Ifremer is involved in studies aiming to assess the potential effects of ocean acidification on marine organisms, especially finfish and bivalve molluscs. Studies have thus been undertaken to analyse the effects of chronic exposure to the levels of acidification forecast for 2050 and 2100 over the entire life cycle of European seabass (*Dicentrarchus labrax*). They have shown that these two levels of acidification have little influence on fish's growth, development and survival, but that acidification does nevertheless induce a speeding-up of the ossification process and improved morphogenesis.



Acidification promotes ossification in seabass larvae (25 millimetres, 45 days old), stained by dipping in Alcian blue (indicates zones of cartilage) and in Alizarin red (ossified zones) observed under scanner
© Ifremer/A. Crespel/J.L. Zambonino

However, the study of the transcriptome (all expressed genes) of whole larvae did not allow the molecular actors involved in these phenomena to be identified.

Furthermore, the results obtained indicate that although fish succeed in maintaining their internal acid-base balance when confronted with acidification of the water, it is to the detriment of their *hydro-mineral*[®] balance.

The consequences this imbalance has on their swimming capability, their digestive function and their behaviour

are currently being investigated. After four years of chronic exposure, the larvae became adult broodstock fish. Initial observations have shown that acidification accelerated the sexual maturation process and altered reproduction (particularly, lower gamete quality).

We can assume from these results that the drop in pH foreseen over this century will affect marine finfish, particularly their biological processes related to reproduction, with probable consequences for population dynamics. This work highlights the need to undertake long-term studies over the animal's entire life cycle.

As for bivalve molluscs, these species of economic and ecological interest are widespread at every latitude, from the intertidal zone to the deep-sea environment. Although most species are already known to be sensitive to ocean acidification, the biological consequences of the phenomenon on bivalves remain uncertain. Indeed, most of the studies published to date did not take the synergetic or antagonistic effect of other stress factors into consideration. To go further, Ifremer's teams have looked for the effects a scenario with acidification at pH 7.9 would have on the larval phase of the cupped oyster *Crassostrea gigas*.



Veliger larvae of *Crassostrea gigas* cupped oysters (at end of D-larva stage, 90 micrometres)

■ ■ ■

This acidification scenario, whether combined or not with a scenario of marine water warming (19°C and 22°C) was explored from the first larval stages. In terms of the phenotype, larval growth in *C. gigas* is affected by acidification alone, but not in association with the warming tested. However, it was also demonstrated that maintaining normal growth under acidification and warming conditions was accompanied by the activation of some cellular (anti-oxidant and metabolic) responses. These responses in larvae have an energy cost for the individual, and the consequence would be less energy to invest in other major physiological functions (defence, survival, nutrition).

Therefore, in a joint scenario of acidification and warming, *C. gigas* larvae could be more vulnerable to other disturbances, such as unfavourable nutritional conditions. ■

* The body fluids of marine finfish are hypotonic with respect to sea water, meaning that the osmotic concentration (300 mOsm per litre) of the fluids in their bodies is lower than that of the marine environment (1,100 mOsm per litre); osmotic regulation is performed by their gills.

Crespel A. et al., 2017. *Marine Biology* 164, 155.
<https://doi.org/10.1007/s00227-017-3178-x>

Harney E. et al., 2016. *Journal of Proteomics* 135, 151-161.
<http://dx.doi.org/10.1016/j.jprot.2015.12.001>

||

In a joint scenario of acidification and warming, oyster larvae could be more vulnerable to other disturbances, such as unfavourable nutritional conditions.

A toxic microalgae and defence capability in the cupped oyster

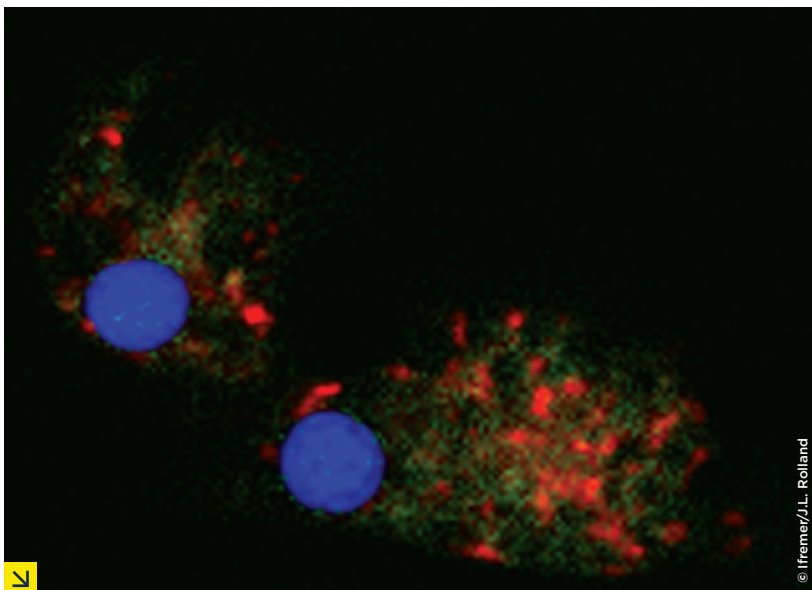
In the context of mass mortality episodes affecting the cupped oyster *Crassostrea gigas*, along French coasts, interactions between the invasive toxic microalgae *Alexandrium pacificum* and the oyster's ability to resist microbial infections were explored.

Studies conducted at Ifremer in 2017 showed that exposing *C. gigas* oysters to the invasive toxic algae *A. pacificum* (*catenella*) under conditions of exposure reproducing those of blooms, caused the death of hemocytes, the immune cells in the oyster, and this occurred via the programmed mechanism of apop-

tosis (cell death mechanism). It should be noted that the oyster's circulatory system is not limited to vessels and the heart, but that hemocytes can enter all its tissues freely. These initial results let us suspect that the death of immune cells induced by *A. pacificum* can strongly affect the cupped oyster's defences and thus contribute to mortality phenomena by weakening the animals confronted with microbial infections.

Moreover, the studies showed that the paralytic toxins (PSP) produced by these microalgae accumulate in the immune cells of the cupped oyster and lead to their death. Finally, although no direct relationship has been established yet between the presence of PSP-producing toxic algae and bivalve mortality, observations made *in situ* show a positive correlation between the presence of microalgae which produce saxitoxins and episodes of mass mortality of cupped oysters.

The studies carried out should make it possible to better appraise the risks of mortality for farmed bivalves which are regularly confronted with this toxic microalgae's blooms. ■



Observation under inverted confocal microscope of two hemocytes of the *Crassostrea gigas* oyster, with nucleus (in blue), saxitoxin (green) and mitochondria (red)

Abi-Khalil C. et al., 2017. *Aquatic Toxicology* 190, 133-141.
<http://doi.org/10.1016/j.aquatox.2017.07.001>

Special coastal habitats

Coastal and estuarine areas occupy approximately 6% of the surface area of marine waters and are amongst the most productive zones on Earth. These systems are areas where the human population is concentrated and associated with high economic and social stakes, as well as having great ecological importance.

Indeed, they can be areas for nurseries, growth or shelter for numerous species, especially fish and birds. The growing phase in fish's life cycle which takes place there is important, so it is easy to understand why their degradation and destruction is responsible for the decline of the marine species depending on these habitats. This means that the diminishing quality of these coastal habitats may affect the size of commercial species stocks.

Among the coastal habitats of the French Atlantic coast, is one for which particularly little is known, both in terms of the species and functional diversity associated with it and the ecological role it plays (especially for fish communities): these are the consolidated muds where small tube-building crustaceans called the *Haploops* spp. dig galleries and construct their tubes. These gregarious, suspension-feeding amphipods are highly predominant in these habitats. They have been described as engineer species since they modify the physical structure of the seafloor by forming colonies of tubes (agglomerates of mud and mucus). They colonise coastal ecosystems and have spread extensively over the past thirty years off the coasts of Brittany, in the bay of Vilaine and the bay of Concarneau.

Investigations have been made to study the ecological roles of the species *Haploops nirae* with respect to juvenile fish and benthic invertebrates in coastal waters. By creating a highly heterogeneous habitat, the species fosters greater species diversity and the appearance of trophic niches which are broader and more specialised than those present in surrounding habitats. In *Haploops* habitats, some communities of high-energy prey for fish are about a hundred



Consolidated mud at depths of 15-30 metres, where small amphipod crustaceans (*Haploops* sp.) build tube of mud and mucus (2 to 3 centimetres high; *Diplecogaster* fish)



***Haploops* spp. as engineer species shape the physical structure of the seafloor and as high-energy preys foster trophic niches and greater species diversity.**

times more present than in neighbouring habitats (without *Haploops*). It has been confirmed that these are unfavourable habitats for flat fish; however, they seem to serve as shelter for small individuals of some species, especially fish like young poor cod (*Trisopterus minutus*).

A conceptual model for the ecological role of engineer species has been developed and can be used to predict the effects that propagating these habitats have on juvenile fish. ■

6%

**OF THE SURFACE AREA
OF MARINE WATERS**
occupied by coastal and
estuarine areas

Chaalali A et al., 2017. *Ecology and Evolution* 7, 5542-5559.
<http://doi.org/10.1002/ece3.2857>

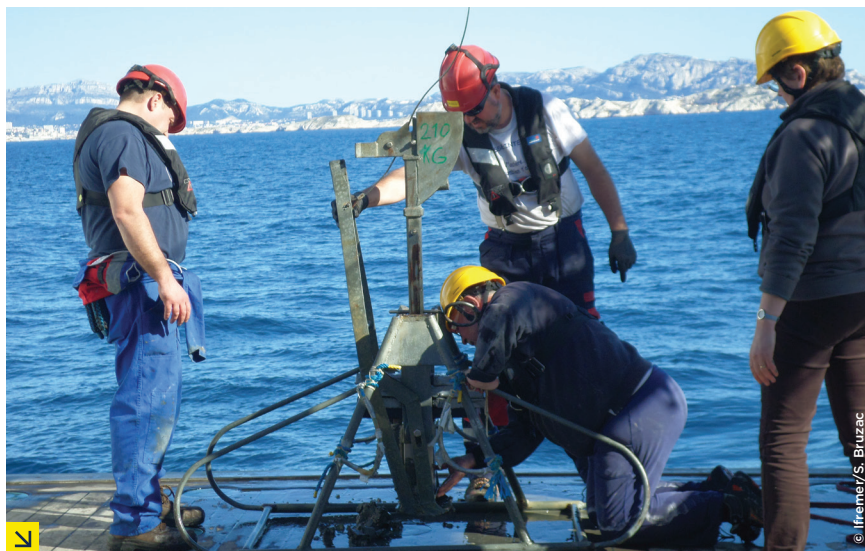
Chemical contaminants and the ocean

The chemical contaminants produced by human activities transit towards the marine environment via rivers, wind, low-altitude air and rain, or are directly discharged into the ocean, exerting spatial and temporal chemical pressure on the global scale. The sources of these inputs to the ocean are more numerous due to the development of industrial chemical production and farming practices, as well as increased domestic urban wastewater discharges.

Historic monitoring of heavy metals, organic compounds like polychlorinated biphenyls (PCB), polycyclic aromatic hydrocarbons (PAH) and organo-tins, which has been done at Ifremer for some thirty years, is now accompanied by the monitoring of what are called emerging contaminants: nanoparticles, microplastics, pharmaceutical products, hygienic products, plant protection products, biocides, food additives, different types of antifouling paint, flame retardants (other than PCBs), fluorinated compounds and rare earth derivatives.

European monitoring

European monitoring of some chemical contaminants and the associated ecotoxicological risks is now regulated in the framework of conventions for regional seas (Ospar in the North-east Atlantic and Barcelona in the Mediterranean) and in that of two European Framework Directives: the WFD for inland and inshore waters and the MSFD for coastal and offshore waters. The stakes for



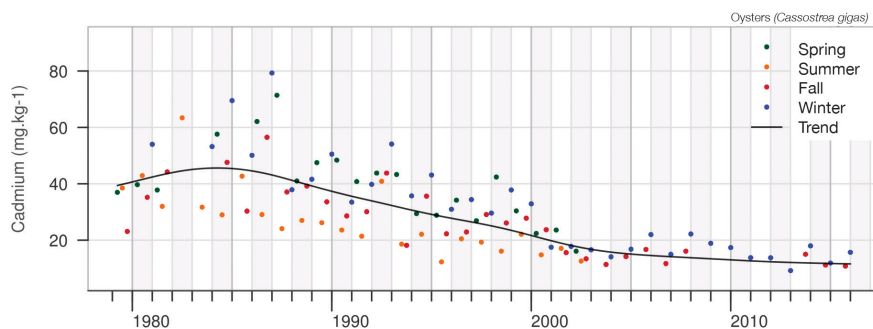
Taking sediment samples with Reineck corer to analyse contaminants

monitoring depend on the ability to titrate chemical contaminants at trace levels, interpret the concentration levels of highly diversified contaminants in water, sediment and living organisms, and then measure their effects from molecular level to bivalve- and fish-population levels. Ifremer has coordinated the national coastal chemical contamination monitoring network (Rocch) for over thirty years. This long-term monitoring network provides the very basis of coastal chemical monitoring. It is also the pillar of expertise acquired over the long term that enables Ifremer to

steer the work on descriptor 8 (chemical contaminants and effects) of the MSFD monitoring system launched in 2016.

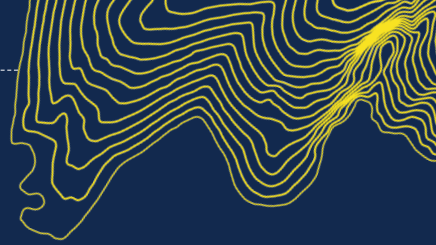
Biological impacts of contaminants

Organisms assimilate chemical contaminants either via the food chain or by simple contact with water or sediment. The contaminants affect all species' abilities to adapt and resist. Effectively, they can cause cellular modifications, attack genetic material and by cascading effects, alter major physiological functions like breeding, growth and immune system defences. Ifremer is one of the pioneering institutes which started an integrated approach to monitoring chemical contaminants and their biological effects on bivalve molluscs and finfish in the early 1990s.



Trends in cadmium concentrations in oysters of the Gironde estuary from 1979 to 2016 (Ifremer/ Rocch network) © Ifremer/réseau Rocch

Burgeot T. et al., 2017. *Marine Environmental Research* 124, 92-105.
<https://doi.org/10.1016/j.marenvres.2016.10.009>



Interview

Jean-Marc FROMENTIN

UMR Marbec: Marine biodiversity, exploitation and conservation, Ifremer

— Studying the behaviour and migrations of marine top predators by electronic tagging



Why are marine predators like tuna or sharks being tagged?

— The prime objective of tagging marine animals, whether tuna, sharks, mammals, seabirds or reptiles, is to study and understand their movements in the ocean. At first glance, that might seem to be rather insignificant information, but it is fundamental for addressing key scientific questions, such as identifying feeding and breeding zones, migratory routes, the extent of these habitats and animals' presence there, as well as understanding how these animals react to environmental variations of either natural (like the *El-Niño* phenomenon or fluctuations in plankton production) or anthropogenic (fisheries, marine pollution, climate change) origin.

What is an electronic tag?

— An electronic tag is a miniaturised device (about 15 cm), composed of a miniature computer, a precision clock and a series of sensors, the most common ones recording temperature, pressure, light intensity or GPS positions. These tags can be implanted in the animal's abdominal cavity or attached externally with a fastener. The external pop-up type tags that are deployed on tuna or sharks, automatically release after a given period of time and come up to the surface where they emit the information stored in them to satellites. The data emitted are then recovered via satellite monitoring systems like Argos and transmitted to scientists to be analysed. The GPS location data or light intensity data are used to reconstruct the animals' movements during the tagging period (their track) and those from temperature and pressure sensors make it possible to identify the water masses and depths where the animal goes.

What have we learned about the migrations of bluefin tuna and porbeagles?

— Electronic tagging has totally revolutionized our understanding of marine animals' movements. In this way, tagging bluefin tuna and porbeagle sharks showed that, while each track is unique and differs from one individual to another, identical seasonal migrations are found for all individuals of the same species. For instance, porbeagles in the North Atlantic migrate towards the Bay of Biscay in springtime and stay there in summer, whereas bluefin tuna in the Western Mediterranean come back to the Gulf of Lion over the summer and stay there until late autumn. These seasonal migrations are synchronous and recurrent from year to year and show that fish are capable of memorising a prey-rich area and

finding the site again at a precise time of the year, even if they are very far away. This strategy enables them to optimise their search for food and also explains why these two large migratory species (a bluefin tuna or a porbeagle can cover from 5,000 to 15,000 kilometres a year) can be found in large numbers in a relatively limited geographical area at a given period of the year. This corresponds to a favourable habitat but makes them vulnerable to fisheries.

Can technological and scientific improvements be expected in the near future?

— Yes, absolutely! This technology was mainly developed in the 1990s and is constantly evolving. After implanting accelerometers which can detect small movements and where food is taken, scientists are now working on more sophisticated sensors which will provide information about the physiological status of tagged fish and detect spawning periods and grounds. Furthermore, research is ongoing to reduce the size of tags and lower their cost, which will allow a larger number of individuals and marine species to be tagged.

Resources and ecosystems of the deep sea

Interactions between the hydrosphere, the biosphere and the geosphere take place at the seafloor. This interface records both surface phenomena and those starting much deeper, whether resulting from slow evolution or from rare, disastrous events. Thanks to its ocean-research vessels and underwater vehicles and submersibles, Ifremer develops, deploys, operates and utilises autonomous or cabled seafloor observatories in various places worldwide. These tools provide better understanding of deep ecosystem dynamics and the impact of global change on the ocean and coastal environments. They also make it possible to propose technological innovations which boost the economic sector and contribute to "blue growth". The public's interest in these extreme environments also creates the opportunity to launch participatory science experiments.

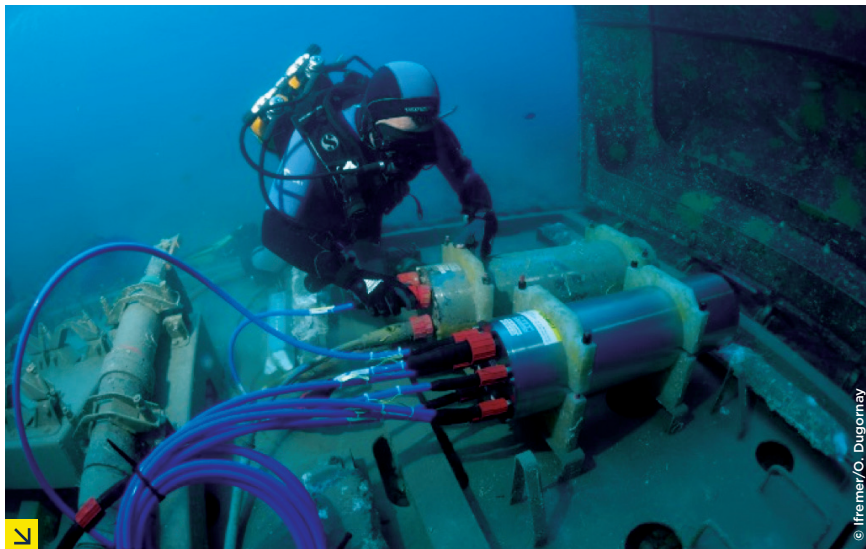
Seafloor observatories, what are they used for?

For a long time, studying processes and events which affect the sea floor was limited to short explorations, owing to technological and operational complications and difficult access.

Today, these multidisciplinary seafloor observatories, fixed-point observation systems that can function for long periods make it possible to study complex environmental processes linked to interactions between the geosphere, the biosphere and the hydrosphere. Their input is vital for studying the impact of global warming on the ocean, better understanding how deep-sea ecosystems function in view of their sustainable management and monitoring tectonic, volcanic, hydrothermal, gravity processes and the natural hazards associated with them (earthquakes, tsunamis, slope instability) which can hit coastal areas with high population densities.

Tempo-Mini observatory: first results

Ifremer was involved very early on in developing these observatories worldwide. For instance, the Tempo-Mini module has been deployed since 2011 at a depth of 2,196 metres on Juan de Fuca Ridge (North-east Pacific) on the *Ocean Networks Canada* cabled array. It is one



EMSO-Nice cabled observatory to monitor sediment stability in the Ligurian Sea

of the numerous instruments connected to this 800-km-long network. The Tempo-Mini was developed at Ifremer and it records high-resolution video images and environmental data which are used to study the temporal dynamics of a hydrothermal vent ecosystem. An identical module has been deployed since 2011 on the Mid-Atlantic Ridge in the Azores permanent seafloor observatory node (see insert). Absolutely extraordinary fauna grows there thanks to hydrothermal seeps of fluids laden with sulphur and other chemical elements. One major outcome of this deployment has been to highlight the influence that tidal rhythms and storms have on the abundance of invertebrate fauna on the deep seafloor

at depths of 1,700 metres: the tides influence bottom currents which in turn modulate the physical-chemical gradients in the habitat, leading to variations in abundance in some species.

EMSO: an European research infrastructure

Ifremer contributes to European research dynamics and to setting up the European research infrastructure EMSO, the European Multidisciplinary Seafloor and water-column Observatory. Since September 2016, EMSO has coordinated its Member countries' (Spain, Portugal, Ireland, United Kingdom, Greece, Romania, Italy and France) "deep-sea seafloor observatories" initiatives.

Armed by its long experience, Ifremer plays a major role in identifying and adopting best practices and in implementing standards for subsea systems architecture, calibration methods, working underwater and data flow management. Costof2, a system developed by Ifremer and currently marketed by the Rtsys company, is the electronic core chosen for the EMSO Generic Instrument Module called EGIM. The module is designed to measure seven essential parameters for ocean observation and for the MSFD on EMSO sites. Ifremer supported its partners during their deployments in Spain and in manufacturing two additional units for the observatories in the Canary Islands and off Sicily.



The EMSO-Azores node

The EMSO-Azores node, located on the Mid-Atlantic Ridge in Portugal's Exclusive Economic Zone, is used for temporal monitoring of seismic movements, hydrothermal circulation hydrothermale and the ecosystem.

Measurements are taken *in situ* along with fluids and biological sampling to supplement the set of parameters and incorporate a spatial component. Multidisciplinary sensors

are connected to two seafloor stations driven by a Costof2 electronic core. These stations communicate acoustically with a surface buoy which transfers the data to a shore-based server and communicates with connected instruments. The data are made available to the teams and to the general public in nearly real-time. Two years of servicing and upgrading this observatory were completed in 2017.

Scientific and technological teams from Ifremer and CNRS jointly operate several observatories, both in the Ligurian Sea and in the Azores. Ifremer also has the EMSO-Molène test site in the Iroise Sea, designed to assess and develop new systems.

The Institute is also in charge of a preliminary study prior to the setting up of a long-term observatory in the Sea of Marmara to continuously monitor the activity of the North Anatolian fault. It presents a major seismic hazard for the region of Istanbul (fifteen-million inhabitants).

The creation of the EMSO ERIC European Research Infrastructure Consortium is a sign of the European Union's recognition for these seafloor observatories. They enable true progress to be made in studying geological processes and deep-sea ecosystems. Integrating the data acquired by various scientific disciplines is underway and will supply new answers about the functioning and dynamics of these environments and how human activities impact them. ■

Lelievre Y. et al., 2017. *Proceedings of the Royal Society B*, 284: 20162123.
<http://dx.doi.org/10.1098/rspb.2016.2123>

Congo River sediments feed a chemosynthesis ecosystem and a carbon sink in the abyssal plain

The ANR Congolobe (2011-2015) project focused on studying the terminal lobes of the Congo deep-sea fan, a site where very large quantities of terrigenous organic matter are transferred and buried in the deep seafloors.

The project is led by the joint research unit UMR for climate and environmental sciences and had two main partners: Pierre & Marie Curie university and Ifremer. The Institute was represented by a multidisciplinary team combining deep-sea ecosystems and marine geosciences. The project follows on from the exploration the channel and its terminal section made during the ZaiAngo and Biozaire (1998-2003) projects, when peculiar ecosystems were discovered.

Using the ROV *Victor 6000* during the WACS and Congolobe cruises, taking surface samples and *in-situ* measurements make it possible to draw up assessments and describe how an exceptional 5,000-metre deep ecosystem functions.

The unusual oxygen consumption rates measured on the seabed indicate that there is significant recycling of organic carbon. This means that the lobes are a sizeable carbon sink over the 2,500 km² of the active system, with a burial rate which is a thousand to ten-thousand times greater than that of the Atlantic abyssal plains.

The oxidation of large amounts of organic matter produces methane and sulphides which nourish microbial mats and dense aggregates of bivalves living in symbiosis with chemoautotrophic bacteria. These habitats develop quite locally and are probably short-lived. The result is a balance between the enormous inputs of carbon and repeated burials under submarine avalanches. ■

Rabouille C. et al. (Eds.), 2017. *Deep-Sea Research Part II*, 142, 1-244.
[https://doi.org/10.1016/S0967-0645\(17\)30273-4](https://doi.org/10.1016/S0967-0645(17)30273-4)



Sampling and in-situ measurements on a bivalve habitat using ROV Victor 6000



The zone of deep deposits is principally made up of terrestrial sediments from the Congo river which are transported by submarine landslides over nearly 800 kilometres in the canyon, then in the underwater channel.

Analysis of a marine sediment core reveals nearly one-hundred-thousand years of climate history of the Australian continent

Many research studies have been undertaken in marine geosciences to reconstruct the evolution of environments related to past climate variability, based on recordings in marine sediments. Very often the evidence on land has been obliterated, whereas the marine recordings have preserved the traces.

The Murray-Darling basin is the largest hydrographic network in Australia, a watershed covering one seventh of the continent and irrigating nearly 75% of the country's farm land. Against the backdrop of the extreme drought conditions currently plaguing Australia, there are major stakes for water management and growing our knowledge about the factors controlling hydrology. Studies had already proved that Australia became arid over the past few thousand years, but

its more ancient paleoclimate evolution was still poorly known to date. Until now, the impossibility of determining the geographical origin of rainfall feeding the vast Murray-Darling basin had limited the understanding of the factors controlling its hydrological evolution over time.

Collaborative work with Australian researchers (*Australian National University, Canberra*) made it possible to trace the evolution of the rainfall regime in Australia over the past ninety-thousand years. The study was based on a thirty-three-metre-long marine sediment core, recovered off the mouth of the River Murray during an oceanographic cruise (Auscan, 2003). By using neodymium (a metal from the group of rare earths) isotopes as a proxy to trace the provenance of sediments exported by the river, the different parts of the basin fed by rains during various

climate periods of the Quaternary were identified. One of the results related to this study concerns wet periods in the past which were mainly caused by monsoon rainfall from the north of Australia, linked to southward shifts of the intertropical convergence zone (ITCZ). ■

Bayon G. et al., 2017. *Scientific Reports* 7: 44054. <http://dx.doi.org/10.1038/srep44054>

1/7th

OF THE AUSTRALIAN CONTINENT

is drained by the Murray- Darling river system

When the upper Rhine river flowed into the Mediterranean

The geological layers of the Gulf of Lion margin have been mapped in three dimensions using seismic data. These data have made it possible to trace the history of the sediments and quantify the volumes deposited over the past six million years.

The results highlight four main points.

- A dramatic increase in terrigenous sediment input between 6 and 5.3 million years. These inputs took place during what is called the "Messinian Salinity Crisis", an environmental disaster: under the thrusting of the tectonic African Plate, the Strait of Gibraltar was almost closed off, and this led to a dramatic drop in the Mediterranean Sea's level due to evaporation and its subsequent dessication. The fall in sea level increased the slope of fluvial networks and enhanced upstream erosion by rivers, as shown by the formation of the Rhone canyon.
- A sediment input three times higher over the last 5.3 million years

(Pliocene) compared to the Miocene period (23 -5.3 million years). This trend is in agreement with published measurements from the World ocean and its trigger (climate or tectonic) is still open to debate.

- A decrease in detrital volume around 2.6 million years. This is attributed to a regional change in the drainage pattern of rivers in the north-western Alps. Until then, the upper Rhine flowed into the Mediterranean, but towards 2.6 million years, part of the upper course of the Rhone (Aar river) was cut off and reversed to feed into the Rhine. The Rhone River then took on its current configuration.

- A doubling of sediment inputs to the Provençal basin approximately one million years ago. This evolution is attributed to more intense glacial and interglacial cycles in the Mid-Pleistocene.

Trends in the sediment fluxes, spatial-temporal variations in subsidence (downward sinking due to the sedimentary

load), as well as fluctuations in sea level were put into a stratigraphic model to test their impacts would have on the sedimentary architectures. Comparing modelled geometry with seismic geometry confirmed that the margin evolution scenario was coherent, in terms of both the sediment budget and tectonic evolution. ■

Leroux E. et al., 2017. *Basin Research* 29, 305-339. <http://doi.org/10.1111/bre.12178>

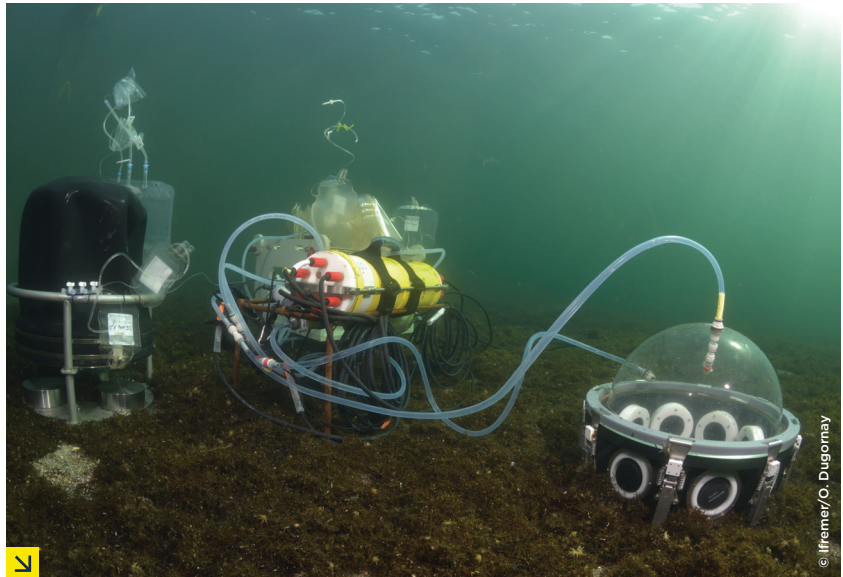
High frequency monitoring of Mediterranean lagoons

Acquiring environmental measurements at high frequencies, i.e. from a minute to an hour, is a major challenge in understanding the physical, chemical and biological processes in coastal systems. Thus, the temporal variability of environmental conditions in these water/sediment interface environments and the biological responses induced by them are often poorly quantified due to the lack of well-adapted instruments and methods.

The project called Chamaut (automated benthic chambers in the coastal environment) was financed by the CNRS interdisciplinary challenge dubbed «instrumentation at the limits» and Ifremer's «Site policy» call for projects. It gave rise to the development of three stand-alone, automated systems (operating autonomously for twenty-four to seventy-two hours) making it possible to isolate part of the benthic compartment and thus quantify the exchanges between sediment and the water column (benthic fluxes) under highly different environmental conditions (day/night, strong/weak winds, etc.).

The complementary expertise of the teams from Ifremer's Brittany centre, UMR Marbec, the European centre for environmental geoscience research

A set of light sensors and probes (oxygen, pH, salinity), an automated water sampling system and miniaturised chemical analysers are used to estimate the concentrations of ammonium, phosphate and nitrate/nitrite in the water, down to ten metres deep.



High-frequency automatic chemical analyses and water samples, seafloor station in the Thau lagoon

and teaching (UMR Cerege) and the Experimental marine ecology centre (UMS Medimeer) led to the designing of upgradeable bottom stations which are adapted to coastal seabeds and can be deployed from small boats to depths reaching ten metres.

Divers can deploy this equipment in fifteen minutes. The cruises conducted in 2017 in Mediterranean lagoons provided some very encouraging initial results, both technological and scientific. The variation in dissolved oxygen and ammonium concentrations measured inside the benthic chambers is consistent with the biological and chemical processes involved (photosynthesis, respiration, remineralisation).

The data acquired also contributed to the metrological qualification of measurements systems. This multidisciplinary

project for a technical development in the coastal environment has now broadened the perspectives for using these bottom stations. They include studying the role played by the benthic compartment in regulating the fluxes of matter (carbon, nitrogen, phosphorus), quantifying nutrient fluxes via inflows of ground water into Mediterranean lagoons or quantifying the role of seagrass meadows and various macrophytic seaweeds in ecological restoration with respect to eutrophication. ■

Le Fur I. et al., 2017. *Hydrobiologia* 808: 175.
<http://doi.org/10.1007/s10750-017-3421-y>

Interview

Marjolaine MATABOS

Research scientist, Deep-sea environment laboratory, Ifremer



Participatory science, also called “citizen science” or “collaborative science” is a way of collecting scientific information in which volunteers take part in acquiring, processing or analysing data. For a long time, this was limited to naturalistic surveys and census projects, but a new branch of participatory science has recently been created, called crowdsourcing. This process consists in giving a large number of web users tasks to perform via internet interfaces. The approach has developed tremendously and is based on the fact that the same datum will be analysed many times by different people, thus enabling statistics to be used to smooth errors and eliminate outliers.



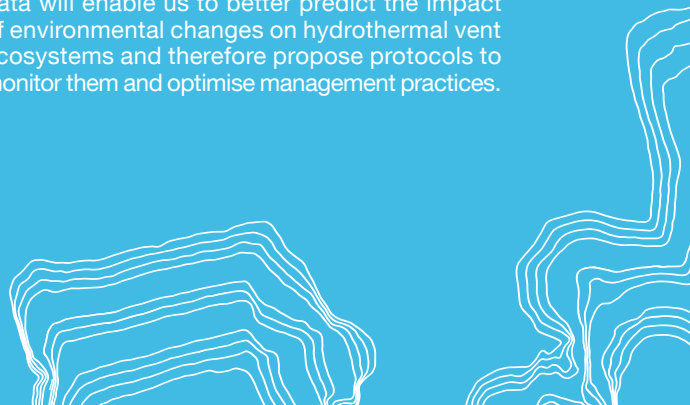
**Deep-Sea Spy game:
more than 10,000
players have already
participated to date!**

How do you play the Deep-Sea Spy game?

— In the application called *Espion des grands fonds* (www.deepseaspy.com), internet users are asked to annotate photographs of fauna. These are images collected at deep hydrothermal vents. Ifremer has deployed observation modules at two deep-sea observatories located at the Juan de Fuca Ridge in the Pacific and the Mid-Atlantic Ridge off the Azores islands. Since 2011, the cameras have recorded more than 5,000 hours of video footage, whose analysis is very time-consuming. Until we can automate these tasks using computer algorithms, the contribution from volunteers is essential for processing the entire data set. A beginner's guide is available when people sign up, making it possible to train participants to identify species and thus enabling everyone to take part! In addition, the application is a powerful tool for scientific outreach and provides a new approach to raise awareness and educate young people about today's challenges for the resources of an environment which is still hardly known to the general public.

What will the results be used for?

— Because they are so difficult to access, the study of hydrothermal systems had long been limited to analysing samples collected on an occasional basis. Consequently, our knowledge about the dynamics and the functioning of these ecosystems is still quite limited. These images supply new information about organisms' daily dynamics, their behaviour, their interactions and their response to environmental changes. In fact, a recent study based on data from the Momar seafloor observatory (off the Azores) showed the influence of tides on the behaviour and abundance of two species which live on the seabed. This data will enable us to better predict the impact of environmental changes on hydrothermal vent ecosystems and therefore propose protocols to monitor them and optimise management practices.



3

RESEARCH INFRASTRUCTURES AND INFORMATION SYSTEMS

The ocean remains a hard-to-access environment, requiring extensive technological resources for its observation and exploration. In this context, the Research infrastructures and information systems department (IRSI), created on 1st January concomitantly with setting up the Oceanographic fleet management division (DFO), provides continuous services and conducts projects aiming to create or improve marine research infrastructures.

IRSI consolidates the scope of the Marine data and IT unit (IDM) and the Argo operational coordination unit. The two technological units for Underwater systems and Vessels and shipboard systems have also joined the DFO.

This new organisation offers the advantage of making the department more coherent with respect to its themes structured around information systems and databases, at a time of increasing demand for marine data and growing interest in the subject.

Interview

Bernard POULIQUEN

Vice-chairman of the Brittany regional council, in charge of higher education, research and the digital transition



Datarmor was inaugurated in June 2017, with the financial partners of the State-region plan contract and the scientific partners who will use it in attendance. Its architecture is composed of several specialised IT clusters: distributed memory computing, shared memory computing, «reference data», «working data», interactive services, etc.

Users' progressive migration from Caparmor (the previous computational infrastructure) to Datarmor took place over a two-month period without any interruption in service for the users. Data transfers were managed in the form of real-time synchronisation of the two computers.

What scientific goals are associated with Datarmor?

— Datarmor's prime objective is to develop the skills and techniques to analyse and interpret very large volumes of marine data which are the legacy of continuous observation systems (satellites, ARGO, etc.) or from specific sensors (videos from underwater vehicles, multibeam echosounders, seismic surveys). Setting up 'parallel architecture' big-data storage spaces is a critical asset, on one hand to make reference data available and conducive to high-performance computation and on the other hand, to provide work spaces in proportion to the volume of data. The aim for oceanographers is to use a highly reconfigurable experimental platform to perfect their methods which could then be applied to operational data throughputs.

The second aim is to facilitate research processes both within and between institutions based on preconfigured dedicated environments called VREs (Virtual Research Environments), very precisely targeting the authorised utilisations, by providing on-line services which have been made interoperable.

What appealed to you in the Datarmor project?

— The project is sponsored by Ifremer and its partners (SHOM, UBO, IRD, ENSTA Bretagne). The issue of infrastructures to manage and utilise large volumes of scientific data was clearly identified in our discussions with the French State and the institutes, when drawing up our CPER 2014-2020 State-region plan contract. On that basis, investing in the Datarmor project for a computer specialised in the computation and processing of marine data, seemed an obvious choice, all the more so in that the project is designed for an already-built ecosystem and the academic partners mentioned above, as well as for economic players.

What are the expectations held by the State and the regions with respect to this type of project, at the crossroads of science, information technologies and communications?

— For the Brittany regional council, it is vital to have infrastructures and tools fostering the utilisation of the millions of scientific data that Ifremer and its partners collect, failing which they will not be utilised as they should be, or even stored for use to answer future research questions. Today, data hosting and the ability to mobilise, process and present data, have become a compulsory exercise for all stakeholders involved.

How does the Datarmor project fit into the economic development of the Brittany region and beyond?

— Marine sciences and technologies are naturally part of our strategic orientations on both regional and European levels. Therefore, although this tool is of course intended for use by all researchers present on the *Campus mondial de la mer* site and beyond, it is open to all economic stakeholders and should help create economic value.

The site's attractiveness and visibility on both French and European levels are now reality, with this centre providing much greater computing power than that offered by the previous one, while remaining in the «mesocentre» range of the national computation centre hierarchy.

It should be noted that the increased volume of satellite data and their related processing (obviously important for ocean observation) simply further validates the choice that was made to finance and implement the Datarmor project.

Moving towards long-term observation of the deep sea: Deep Argo floats

The international Argo programme has deployed a global array of nearly 4,000 free-drifting floats which transmit temperature and salinity profiles down to depths of 2,000 metres. This is a key contribution to the global ocean observation system set up to monitor, understand and predict the role the ocean plays in planet Earth's climate.

For the past few years, France has been preparing a new phase of the Argo programme, and particularly extending it to greater depths, in the framework of the Équipe NAOS project. A new deep-sea profiling float called Deep Argo, has been developed to cover nearly 90% of the oceans' total volume with floats that descend to 4,000 metres. The main design difficulty - reconciling light weight and resistance to pressure - was overcome. Two prototypes were developed by Ifremer before being transferred to the NKE company; then two industrial prototypes were manufactured and deployed in 2014. A pilot experiment is currently being conducted in the North Atlantic based on eleven



Deployment of Deep Argo profiling floats

floats deployed during oceanographic cruises. In the short term, data from these floats will be used to better assess circulation in deep water, which is still largely unknown, as has been shown by the first Deep-Argo floats which do not follow presently known circulation patterns. ■

The "Earth system" research infrastructure (IR) and the Ocean Odatis cluster

The "Earth system" data clusters were created through a joint initiative of CNES and CNRS, with the objective of promoting coordinated management and creating centralised access to all Earth observation data.

Four thematic focuses were identified: *Form@ter* (solid Earth), *Theia* (land surfaces), *Aeris* (atmosphere) and *Odatis* (ocean). Their remit is to supply products and services stemming from all sorts of data, whether satellite, airborne or *in situ*. Some twenty French organisations are involved, including those in the Environmental alliance (AllEnvie). The founders and main contributors are CNES, CNRS, IRD, IGN, Météo-France, Irstea and Ifremer.

The portal to access the catalogues of data managed by Odatis was commissioned for service in 2017.

Odatis' governance was also implemented in 2017, with the appointment of a new director and a scientific manager, and the creation of

- an executive committee with representatives of the main contributing partners, and
- a technical coordination committee aiming to make the various data centres and the Odatis portal interoperable. ■



Accreditation of Ifremer's data centre by Unesco

In 1961, Unesco's IOC set up the IODE (International Oceanographic Data and Information Exchange) organisation with the aim of promoting marine research, exploitation and development, shared use of marine data and more generally, facilitating exchanges between Member States on the subject.

Based on a network of marine data centres from Member States, the IODE programme defined two levels of quality standards and today it has fifty-five National Oceanographic Data Centres (NODC) and twenty-four Associate Data Units.

The twenty-fourth IODE session, which was held in March 2017 in Kuala Lumpur, accredited Ifremer's data centre (Sismer) as an NODC, seeing the Institute's certifications for quality: ISO 9001 and best practice: ISO 20000 specific to information technology and service management for marine data. Sismer is now one of six accredited data centres worldwide.



Interview

Pierre BAHUREL

Director of the Mercator Océan company



What is the European Copernicus marine environmental monitoring service and what is Mercator Océan's role?

— The objective of the European Union's Copernicus programme is to develop the use of Earth observation data to improve our knowledge about the environment and support the sustainable development of our economy. This 4.2-billion-euro programme for the 2014-2020 period, supports satellite observation missions, as well as six thematic services designed to structure user value chains. The European Union has entrusted Mercator Océan with responsibility for one of them, i.e. the Copernicus Marine Environment Monitoring Service (CMEMS). CMEMS must supply stakeholders in the marine and maritime realm – entrepreneurs, operational public-sector actors, policy-makers, researchers, citizens – with access to reliable and validated information describing the status of the marine environment in the entire global ocean. To that end, we manage a network of a hundred suppliers in Europe, utilise our own operational ocean-simulation capabilities, integrate and qualify all of this and disseminate, to over 10,000 direct subscribers worldwide, the products created from observations and models describing the past, present and near future of the blue (currents, temperature, waves, etc.), green (biogeochemistry) and white (ice) oceans.

Mercator Océan is becoming more European. What expectations arise from this expansion of the Mercator Océan firm?

— The Mercator Océan company was created in 2010 by Ifremer, CNRS, IRD, Météo-France and SHOM, following some fifteen years of developing our scientific and operational capacity. By clearly choosing a development model based on the general interest (our products are open-

source and free of charge), the five founding shareholders set the condition of ensuring its recognition on the European scale: by the European Union on the one hand – which we were able to achieve in 2014 with Copernicus – and by opening it to other stakeholders – the first step of which was taken in December 2017, when we were joined by CMCC (Italy), the Met Office (United Kingdom), NERSC (Norway) and Puertos del Estado (Spain). The aim is to anchor our development model – the general interest, international ambition, scientific excellence and support for applications – within the structure itself of the shareholdings and thus strengthen the company's scope, its ability to mobilise the finest expertise, conduct complex missions and lastly, to enhance the confidence received from the European Union in conducting its major programmes.

Ifremer is involved on several levels in Mercator Océan and in the CMEMS*. What is your appraisal of this involvement and what do you expect from it in coming years?

— Ifremer is a shareholder, but also a supplier, client and partner of Mercator Océan. Therefore, Ifremer sets the strategy and supports the enterprise's development, and contributes to and benefits from its results: each associate has developed the same close relationship with Mercator Océan, each affixing its own brand. Of course, Ifremer's brand is that of a specialist of the sea, but also that of a truly influential European stakeholder. This is how; ten years ago, Ifremer placed Mercator Océan as the leader of an «operational oceanography» community in Europe, after laying the groundwork with the European Mersea project. You can see how successful the Institute then was in giving the Coriolis approach a more European dimension, making it an operational pillar of the CMEMS to manage *in-situ* observations. I can attest to how Europeanising the shareholdings of Mercator Océan was supported by Ifremer's strategic - and pragmatic - resolve. We have great need of this coherence of vision and action for the coming years, within a more open shareholding and against even stronger European, scientific and economic competition. We really need to strengthen the marine identity of our operational support - for instance, working more on living resources - in a multidisciplinary dimension, and Ifremer can help us to do so. By cultivating this relationship, we will strengthen our own capacity to develop and our position in Europe and internationally.

* Copernicus Marine Environment Monitoring Service



4

THE FRENCH OCEANOGRAPHIC FLEET

2017 saw the culmination of the reflection process begun in 2016 on the unification of the French Oceanographic Fleet VLRI research infrastructure. It provided a dialogue, conducted with the various stakeholders in question and laid the foundations for a new organisation for the VLRI, relying on Ifremer as the fleet's single operator.

Within Ifremer, a division to manage the oceanographic fleet (DFO) was created on 1st January 2018, based on a cluster devoted to sea-going operations, two engineering units (Vessels and shipboard systems and Underwater systems) and a management team.

Other milestones in 2017 were the mid-life upgrade of the research vessel *Thalassa*, the launch of the final phase of upgrades to the seismic equipment, and the first scientific cruises for the HROV *Ariane*.

Unification of the French Oceanographic Fleet (FOF) Very Large Research Infrastructure

The VLRI has four ocean-going research vessels, six inshore vessels (less than 36 metres LOA), seven station vessels, one light vessel, heavy embarked equipments, for instance the seismic equipment, and underwater vehicles. By nature, this fleet is complicated to manage.

Firstly, it has several remits: research and education, public service and research-industry partnerships. Furthermore, its missions are carried out in compliance with other commitments taken with respect to third parties (such as the French Navy, which co-finances RV *Pourquoi pas ?* and the TAAF territorial authorities who own RV *Marion Dufresne*).

Until now, this fleet was characterised by being managed by four different operators, each of them with their own obligations and ways of working. Despite the progress achieved, especially thanks to the creation of a Fleet joint service unit in 2011, the situation was still not optimal.

A single operator

The unified FOF VLRI entrusted to a single operator, i.e. Ifremer, is going to simplify its organisation, by providing an integrated programme of sea-going facilities and optimising their management, to the benefit of the scientific community. It came into effect as of 1st January 2018, based on the following principles:

- unified budget (all subsidies are combined into a single grant going to Ifremer),
- setting up an Oceanographic fleet management division (DFO) at Ifremer, with dedicated governance under the responsibility of the Ministry in charge of Research,
- unified scheduling within the DFO, in compliance with the specifications for ship scheduling that set out the balances to be maintained between the different types of activity.

Ifremer is in charge of drawing up ship schedules, developing and optimising sea-going facilities and equipment, steering the organisations in charge of manning the vessels (notably Genavir).



Thalassa: upgrading work

VLRI governance

The FOF steering committee, of which CNRS, IRD, the marine universities network and Ifremer are members, is chaired by the Ministry of Higher education, research and innovation. Each year, the committee examines and approves the ships schedule proposed by the DFO and the related budget, both forecast and implemented. The budget is then voted on by Ifremer's board of directors.

The aim of the FOF scientific council is to help maintain the fleet at world-class level. Its main role is to provide scientific intelligence and foresight for the FOF VLRI.

Lastly, the national fleet commissions (offshore and inshore fleets) remain in charge of assessing cruise applications and evaluating *a posteriori* the scientific results from cruises. ■



As the FOF's operator, Ifremer is responsible for managing the Very Large Research Infrastructure to the benefit of the scientific community.

Mid-life upgrade of Thalassa

Commissioned in 1996, RV Thalassa is a 74-metre-long ocean-going vessel employed to carry out research missions and fisheries science cruises in support for the public authorities.

Thanks to the financial support of the French State (ANR and ERDF) and regional and local authorities (Brittany Regional Council, Finistère county and Brest Métropole urban council), the ship's mid-life upgrade work was done by Piriou Naval Services from June to September 2017 in Concarneau. The vessel was in dry-dock until the start of August: the housing designed to hold the sonars was put into place and acoustic equipment was installed underneath the hull, while the main equipment, including the gen sets, were brought on board and positioned. The sea trials were conclusive and were followed by testing of the scientific equipment required for the bottom-trawling cruises: Evhoe (Celtic Sea and Bay of Biscay) and CGFS (English Channel). The ship is now compliant with the recommendations from ICES (International Council for the Exploration of the Sea) required for fish-stock assessment cruises in terms of radiated noise in water. ■

Subsaintes

The Subsaintes cruise was made off the Lesser Antilles and contributed to improving knowledge about the geological processes involved in volcanic hazards, earthquakes and tsunamis, at the heart of the Guadeloupe and Martinique networks which observe and monitor volcanoes and earthquakes.

On 21 November 2004, the Saintes quake (moment magnitude of Mw 6.3) ruptured the subsea Roseau Fault, located south-west of the Saintes archipelago (Guadeloupe). Thirteen years later, RV *L'Atalante* performed complete and detailed, very high-resolution mapping of Roseau Fault (at a depth of approximately 1,000 metres) using the autonomous vehicle *AsterX*. The remote-controlled *Victor 6000* vehicle was used to make observations of geological details and took numerous samples. These data will help to acquire better knowledge about the origin of tsunamis and are a first in the study of subsea seismic deformations.

It is expected that these hazards will be better taken into account in risk-prevention strategies for the Lesser Antilles, with implications for other regions in the world exposed to similar telluric risks.

The scientific team was made up of researchers and engineers from several national (IPGP, university of Nice Sophia Antipolis/Géoazur, university of Lyon, university of Paris Sud and Ifremer) and international (the universities of Columbia in the United States, Girona in Spain and Bergen in Norway) institutes. ■



Upgrading the seismic equipment

For the seismic equipment upgrade project, 2017 way-posts involved pursuing the last two steps of the project. These were:

- upgrading the seismic source associated with the SIS-1 device (2D seismic equipment), with a new system of flexible floats to be used in deploying air guns. This system will be stored in two 12-metre containers installed on the quarterdeck of research vessels and special ramps will be used to deploy it at sea. All of the elements making up the float system were delivered in December 2017.
- extending the SIS-1 device to a length of 6,000 metres: new

streamer sections were delivered and validated.

Integrating the new equipment designed for SIS-1 will continue in 2018 and will be followed by validation trials at sea aboard RV *L'Atalante*. Once these developments are in place, the new seismic equipment made available to the scientific community will be complete.

Over the year 2017, the SIS-1 seismic equipment was deployed during the *Garanti (L'Atalante)* and *Mirage (Marion Dufresne)* cruises. Other cruises are scheduled in 2018 and ten have been requested from 2019 onward.

The HROV Ariane

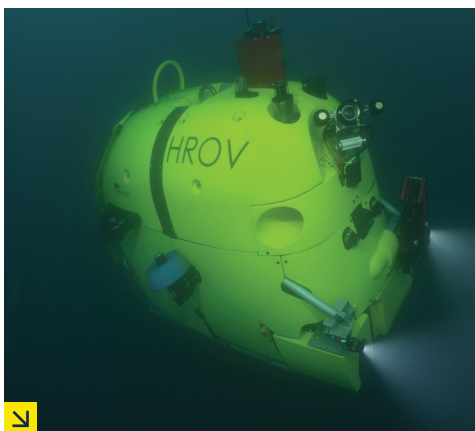
This underwater vehicle with an embedded power supply (operating either by remote control or autonomously) has joined the range of Ifremer's subsea systems.

Following a series of technical trials conducted at sea in March aboard RV *L'Europe* before transferring the vehicle in "exploration/sampling" mode to Genavir,

Ariane made its first scientific cruises in 2017. The Videocor 1 cruise's objective was to study cold-water coral ecosystems in the Mediterranean. One month after this initial success, *Ariane* made its first dive in the Atlantic Ocean, from aboard RV *Côtes de la Manche*, enabling an immersion depth of 450 metres to be reached and the second Hapoge scientific cruise (exploring the Cap Breton canyon) to be conducted.

In September, *Ariane* was back in the Mediterranean, and after the second part of the Videocor 1 cruise, ran the first trials in the "mapping" configuration. The interest of this configuration lies in coupling the multibeam echosounder with a camera, making it possible to create acoustic and optical mosaics on the same dive. The other innovation lies in the possibility of tilting the multibeam echosounder's antennas to perform 3D acoustic mapping, with promising initial results.

Finally, *Ariane* made two archeological dives on a historic shipwreck in the framework of collaboration with the Department of underwater and submarine archeological research (DRASSM). Its capabilities in terms of manoeuvrability and remote handling, along with the dexterity its pilots, have enabled complex tasks to be carried out, such as uncovering objects buried in sand or retrieving objects, which could only be done by divers until now. ■



© Ifremer HROV Ariane/O. Dugomay

The HROV Ariane during the Videocor1 cruise in the Mediterranean
Photo above © Ifremer/HROV Ariane/Videocor1

Interview

Cécile GUIEU

CNRS, Pierre & Marie Curie university,
Chief Scientist for the Peacetime* cruise



Seventeen French and foreign laboratories took part in the Peacetime cruise and project aboard RV *Pourquoi pas ?*. Funding for this cruise was supplied by the Mistral project in particular, as well as the FOF VLRI (cruise support fund), CNES and the NAOS Équipex project.

What scientific objectives were set for the cruise in the Mediterranean?

— The international, multidisciplinary Peacetime team aimed to study the processes at the air-ocean interface in the Mediterranean, where atmospheric inputs play a key role as a source of nutrients for the marine biosphere. We particularly focused on the impact of atmospheric deposition of Saharan dust on the functioning of the pelagic ecosystem and feedbacks to the atmosphere, both today and in future.

How did the cruise unfold?

— Aboard RV *Pourquoi pas ?*, with the co-chief scientist Karine DESBOEUF in charge of operations for the atmosphere aspect, we assisted our team of thirty-nine scientists to ensure that the cruise would take place under the best conditions.

Thanks to the crew's flawless work, we were able to make nearly one-hundred-twenty profiles in the water column to characterise it in physical, chemical and biological terms (ninety profiles with classic CTD rosette and twenty-seven with the "clean" rosette to take samples without any traces of metal from the frame, the cable, etc.). Zooplankton samples were taken to study its biodiversity and optical measurements were taken daily.

Suspended organic matter in the water was sampled using a *Marine Snow Catcher* deployed by cable and the surface micro-layer was sampled from a Zodiac inflatable dinghy. Along the entire transect, automatic chemical, biological and physical analyses were run continuously using a powerful peristaltic pump. The seawater sampled was also used for experiments in chemical reactors, providing a small-scale reconstruction of air/sea exchanges under current and future environmental conditions.

Samples of the atmosphere were taken using the mobile Pegasus platform, installed aboard an oceanographic vessel for the first time, to continuously monitor the air's composition. Lagrangian and Bio-Argo floats were deployed, and two Bio-Argo floats were recovered. Three drifting moorings (1,000-metre line fitted with different types of sediment traps, devices to measure *in-situ* respiration and physics instrumentation) were deployed and then retrieved. A *Moving Vessel Profiler* system towed by the ship to record physical and biological profiles in the water column made 1,000 profiles from the surface to 300 metres depth during the legs, making it possible to characterise the biogeochemical and physical environment crossed. We also succeeded in taking core samples during long stations for Ifremer's Abyss project on biodiversity in the deep sea.

Did the vessel's track and the May-June period enable you to find Saharan dust depositions?

— The leg planned for maximum probability of encountering a Saharan event could be modified, thanks to our strategy of adapting to atmospheric deposition forecasts.

The team of physicists on shore supplied us with daily information which enabled us to adjust our route if necessary.

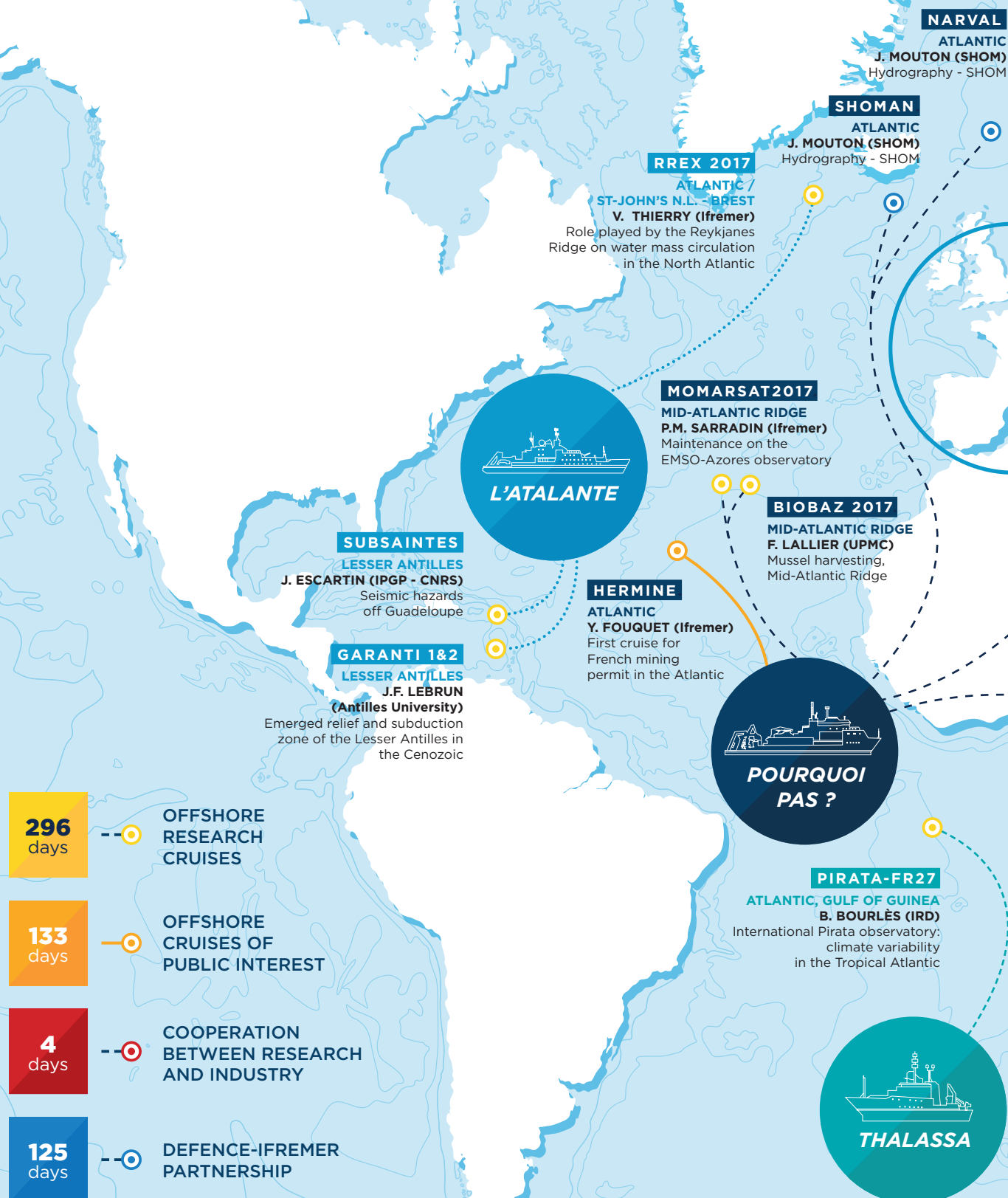
This made it possible for us to track a Saharan event for six days to the south of the Balearic Islands and to the north of Algeria. We are expecting some particularly original results!

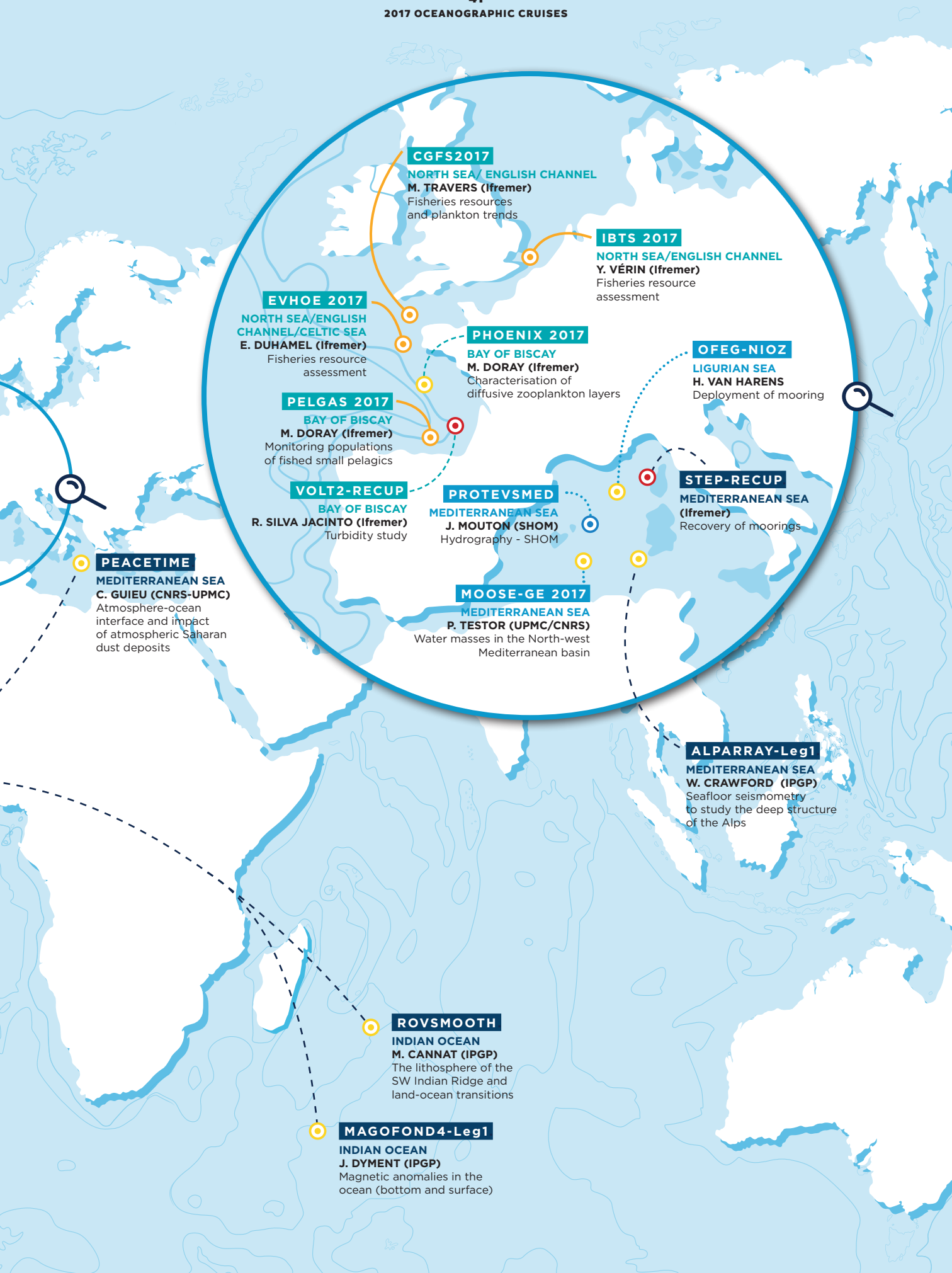
What is the scientific outcome of the cruise?

— Thanks to RV *Pourquoi pas ?*, her crew and the project team, all the studies envisaged prior to the cruise were achieved. The vast number of results obtained will enable us to better understand and quantify the way in which atmospheric depositions influence pelagic ecosystem functions so as to more accurately predict the fate of biodiversity in the Mediterranean.

* Process studies at the air-sea interface after dust deposition in the Mediterranean Sea
<http://peacetime-project.org>

OCEAN-GOING FLEET





COASTAL FLEET



HALIOTIS

BBWAVES

IROISE SEA

P. SUTHERLAND (Ifremer)

Interaction between waves and currents. Measurements of atmospheric fluxes

TREMOR 2

DIEPPE

V. GAULLIER (Lille University)

Sedimentation in Dieppe-Hampshire basin

HYD2M 1&2

RAZ BLANCHARD

L. MARIE (Ifremer)

Hydrodynamics of the Alderney Race, study zone

CROCO-CAUX

FÉCAMP

A. DUPERRET (CNRS-INSU)

Mapping of coastal platform off the chalky cliffs of Normandy

COMOR

BAY OF SEINE

E. FOUCHER (Ifremer)

Assessment of king scallop stocks in the Bay of Seine

ECHOSONDE 1&2

SAINT-NAZAIRE

M. DORAY (Ifremer)

Echosounder deployed to characterise the pelagic environment off Saint-Nazaire

NURSE 2017

BAY OF BISCAY

A. BRIND'AMOUR (Ifremer)

Coastal nurseries

SOLVEIG V

OFF NICE AIRPORT

R. SILVA JACINTO (Ifremer)

Sediment transfer in underwater canyons

CARTOHROV-17

CALANQUES MARSEILLE

E. RAUGEL (Ifremer)

HROV trials

MEDITS 2017

GULF OF LION

A. JADAUT (Ifremer)

Assessment of demersal living resources

PELMED 2017

GULF OF LION

J.H. BOURDEIX (Ifremer)

Assessment of small pelagic resources

VIDEOCOR 1&2

CALANQUES MARSEILLE

M.C. FABRI (Ifremer)

Video recording on coral zones - underwater canyon



THALIA

263
days

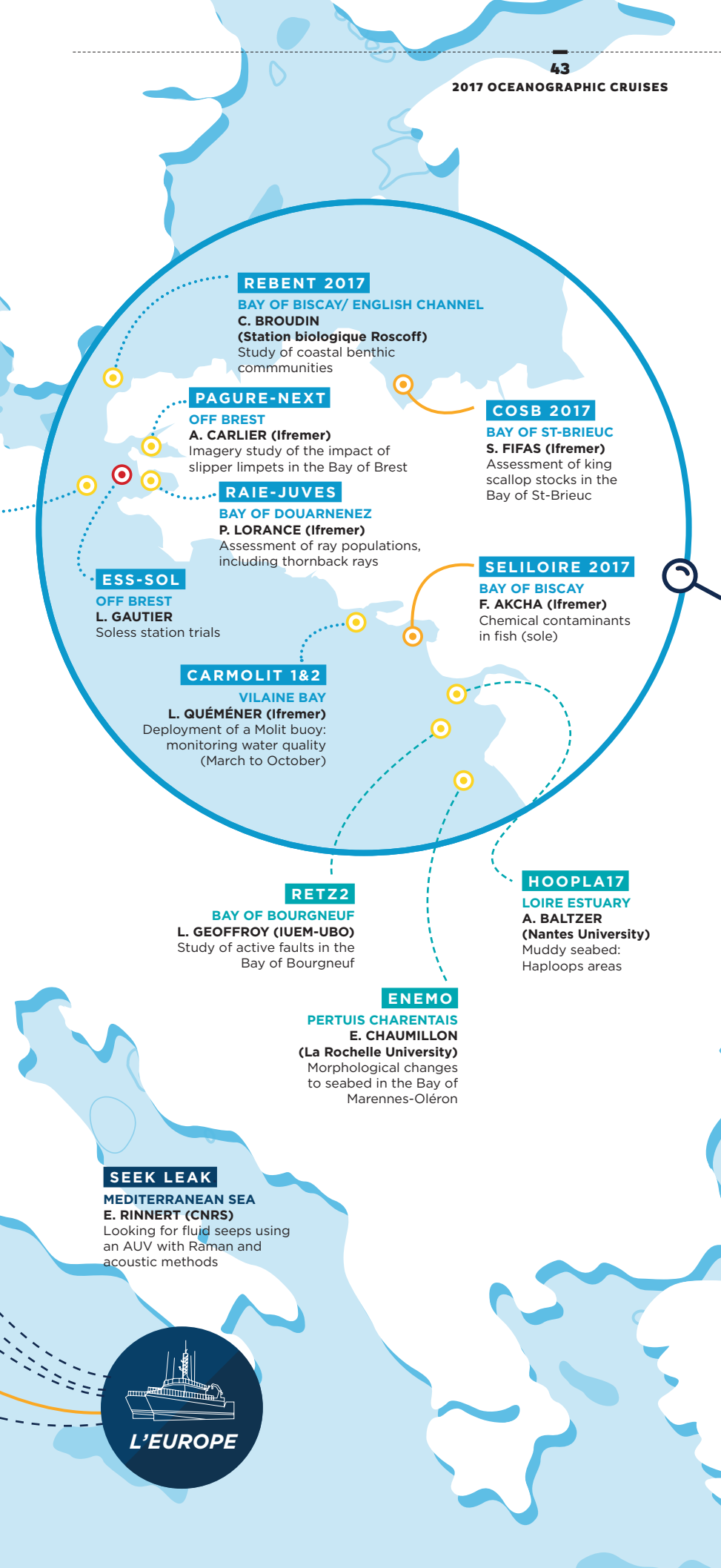
**COASTAL
RESEARCH
CRUISES**

109
days

**COASTAL CRUISES
OF PUBLIC INTEREST**

6
days

**COOPERATION BETWEEN
RESEARCH AND INDUSTRY**



TECHNICAL TRIALS MISSIONS



THALIA

S2MF
BREST
X. LURTON (Ifremer)

REM2040
BREST
X. LURTON (Ifremer)
Technology - sonar



L'EUROPE

DIVACOU10
La Ciotat
M. DROGOU (Ifremer)
Technology / acoustic tests

ESS-LOPS17-1&2
off Toulon
M. HAMON (Ifremer)
Technical trials: mixing of water masses and dissipation of energy



L'EUROPE

5

EUROPEAN AND INTERNATIONAL PARTNERSHIPS

In 2017, the European Commission published the interim evaluation which assessed the state of French participation in the Horizon 2020 programme with regard to the total funding engaged for the years 2014, 2015 and 2016. Over this period, Ifremer's mean success rate (30%) was more than twice that of the French success rate overall (14%) and three times that for Europe (10%). In addition, the last phase of the 2018-2020 work programme for H2020 took shape in 2017. Ifremer has actively participated in preparing this final phase.

Ifremer has been strongly involved in European strategic networks, especially in the framework of the sixth forum of the European Marine Board think-tank for marine sciences and technologies, whose objective was to identify scientific needs for implementing the United Nations sustainable development goals. Through its presence in the national committee of IOC at Unesco, Ifremer supported the United Nation's adoption of the Decade of Ocean Science for Sustainable Development (2021-2030), the initiative was announced on 5 December in Paris. Ifremer also contributed to the G7's work on the Future of the seas and oceans launched in 2016 in Tsukuba (Japan) and further developed in 2017 during ministerial summit meetings in Turin.

Strong involvement in European strategic networks

To be at the heart of policy making and ensure that its strategic objectives remain a reference in Europe, Ifremer is present in numerous European networks.

The Institute contributes to European Marine Board analyses and has emphasised the specificities of marine sciences and their importance in the European scientific community. Ifremer also takes part in developing international scientific programming through collaboration in G7 (Future of the Seas and Oceans) working groups or in the Blue Planet task of the Partnership for Observation of the Global Oceans (POGO) and as a member of the IOC national committee.

Through its participation, as member of the Board, in the association of directors of European Fisheries and Aquaculture Research Organisations (EFARO), in 2017 Ifremer particularly contributed to thought and discussion on an integrated approach to collecting marine data on the regional



The marine science and technology group (European Marine Board) in Brussels, 6 December 2017

level, in the framework of the DC-MAP programme (fisheries stock assessment) and the MSFD. This proposal from EFARO was presented on 15 June 2017 in Malta.

In 2017, Ifremer also assumed the rotating chairmanship of the Fisheries and aquaculture research committee (SCAR-Fish) which, inter alia, advises the European Commission's DG R&I

for the preparation of its framework programmes. SCAR-Fish has set out its strategic agenda for research and innovation in the framework of the Horizon 2020 Societal Challenge 2. Moreover, in the framework of preparing the next European Union research and innovation programme FP9 (FOOD 2030), SCAR-Fish has set up foresight working groups on climate change, zero waste, freshwater aquaculture to identify their priorities of research and innovation.

Finally, Ifremer was solicited by the European Commission to implement, in partnership with the German marine research consortium (KDM), the new South Atlantic Flagship initiative for research and innovation to improve scientific knowledge about marine ecosystems, interrelations between oceans and climate change, food and energy production systems from the ocean and the dynamics of the Atlantic Ocean and its interconnected circulation systems. A partnership agreement (the Belém Statement) was signed by the European Commission, Brazil and South Africa in July 2017 in Lisbon. ■



Strengthened Franco-German cooperation

For many years, Ifremer has maintained structuring partnerships in the field of marine sciences and technologies with German research institutes and universities, notably with AWI and Marum. In 2017, the three institutes organised a workshop based on previously-identified working groups. This enabled the teams from the institutes to meet and discuss subjects of collaboration for which it was decided to allocate call-for-projects funding (see interview with Prof. Dr. Schultz). A Memorandum of Understanding (MoU) between the three institutes was signed at the outcome of this workshop.

In addition, in the framework of the CSA2 action of the joint programming initiative *JPI Oceans* and upon a proposal from the German Ministry of research (BMBF), on 1st August 2017, several Member States launched a joint call to study the environmental impact of polymetallic nodule mining in the Clarion-Clipperton zone. France decided to contribute in kind and solicited French research institutes. Ifremer responded positively to represent the country in this action, attentive to the need to particularly highlight understanding environmental mechanisms over the medium term.

Ifremer is taking part in international agreements on climate and ocean as a key stakeholder in European marine research.

An agreement between Ifremer and the Japanese Fisheries Research Agency (FRA)

Just over two years after the signature of the agreement between Ifremer and FRA, exchanges have developed rapidly. In particular, they have given rise to the implementation on French (Thau lagoon) and Japanese (Hiroshima Bay) sites, of an initiative dealing with a major theme in the agreement: knowledge about coastal ecosystem dynamics in relation to mariculture (oyster farming) for their integrated management.

The first mission by FRA scientists took place in July 2017, consisting in taking samples in the Thau lagoon. In return, a mission was conducted by

Ifremer scientists in October 2017 in Hiroshima Bay. These missions made it possible to gather the French and Japanese databases available since the 1970s on evolution of ecological states and shellfish yields in farms in the Thau lagoon and the Seto Inland Sea. Data processing enabled the ecological functioning in the two coastal environments to be compared. These studies were presented during the 17th French-Japanese Oceanography Symposium (COAST Bordeaux), held in Bordeaux in November 2017, notably under the aegis of CNRS, the French-Japanese Oceanography Society and Ifremer. ■



International cooperation in the Mediterranean

As a partner in the European Bluemed CSA coordination and support action project, Ifremer participates in drawing up the roadmap for this initiative, whose objective is to improve the integration of knowledge and coordination of efforts to promote blue growth in the Mediterranean basin. For Bluemed, 2017 was marked by the initiative's extension to the countries of the Union for the Mediterranean (UfM).

As a Bluemed partner, Ifremer worked with CNRS to organise an international meeting in July in La Seyne-sur-mer on infrastructures to support research and innovation in marine and maritime fields in the Mediterranean. In 2017, Ifremer also coordinated a task aiming to provide an initial look at the strategies and priorities of non-EU member Mediterranean countries in these fields. In this framework, the

Institute worked with the UfM to organise a Bluemed workshop called "Building a shared research and innovation agenda for blue jobs and growth across the Mediterranean" during the first UfM stakeholders' conference on the Blue economy (Naples, 29-30 November).

In 2017, Ifremer reinforced its cooperation with Morocco by signing agreements with the National fisheries research institute (INRH) in Casablanca in October 2017. This five-year agreement covers a wide range of topics, including fisheries and aquaculture, as well as instrumentation and the ocean research fleet. It covers too the transfer and adaptation to the National fisheries research institute (INRH) of the data management systems developed by Ifremer. ■



Signing of a framework agreement for cooperation between INRH (Morocco) and Ifremer, 12 October 2017

Interview

Michael SCHULZ

Director of the Center for Marine Environmental Sciences (Marum), University of Bremen (Germany)



Michael SCHULZ is Professor for Geosystem Modelling at the University of Bremen. He uses numerical climate models to decipher the role of the ocean in the climate system. His research focuses on the origin of climate variations at millennial-to-interdecadal timescales. He is also Chair of the German Commission for Oceanography (DFG), Vice-Chair of the German Marine Research Consortium (KDM) and has served as Coordinating Lead Author for the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC).

How would you value the collaboration between Marum and Ifremer?

— For more than two decades, our two institutions have had close ties, and at Marum we value this collaboration very highly. Ifremer supported us greatly during our founding phase when we undertook our ambitious steps towards operating large sea-going equipment. Over the years, our relationship in the area of underwater technologies has led to many joint projects, and it has reached a level that is beneficial for both partners. Today the collaboration goes far beyond technological aspects. A recent survey at Marum revealed a rich array of collaborations with Ifremer that essentially encompasses all research fields on our side, and that includes jointly-supervised PhD candidates and joint expeditions. I am convinced that the scope of the ongoing collaboration provides a very solid foundation for many future activities.

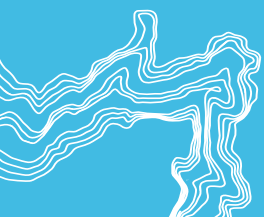
A partnership programme was launched earlier this year for visionary joint scientific projects among Marum, AWI and Ifremer. What are your expectations for this instrument?

— The three institutions have highly complementary research profiles and the partnership programme aims at achieving the full potential of synergies. It is our intention to promote forward-looking ideas in order to address research goals that none of the partner institutions would be able to tackle on its own. The first call for proposals was very well received by scientists at the three institutions and we received a very good number of innovative proposals. Given this success, we have now agreed to continue the programme.

How do you envision our future collaboration in the context of global challenges?

— It is encouraging to see that the general awareness for the marine environment has greatly increased in recent years. The existence of UN Sustainable Development Goal 14* is a clear indicator of this shift in recognition. However, I am sometimes left with the impression that stakeholders and the general public fail to fully appreciate a key component of the world ocean, that is, the deep sea. While the deep ocean is considered to be a key component in the climate system and as a potential source region for resources, it is less often recognised that the deep sea hosts the largest continuous ecosystem on our planet. And this environment is being exposed to increasing pressure. Ifremer and Marum need to combine their efforts even more to draw attention to this unique and threatened environment.

* Conserve and sustainably use the oceans, seas and marine resources for sustainable development.



6

SUPPORT FOR PUBLIC POLICY-MAKING

The Institute brings the French State its expertise in the implementation of maritime policies (WFD, MSFD, and the EU's Common Fisheries Policy, along with health and animal-health monitoring, mineral resources, biodiversity, etc.), and in decision making.

Work to support public policies represents about one third of Ifremer's activities. Part of this work is done within our research units and relies on the Institute's locations along French seafronts for the observation and monitoring of the environment and resources. Ifremer continued to structure its actions to support policy-making in 2017, by focusing on activities in close synergy with those of its research, having proven added value, and concurrently by transferring tried-and-tested monitoring activities to other, more relevant, operators.

A collective scientific expert assessment on eutrophication (CNRS, INRA, Irstea and Ifremer)

This collective scientific expert assessment (ESCo) on eutrophication was performed at the request of the Ministry of ecological and inclusive transition (MTES) and the Ministry of agriculture and food, directed by CNRS and with the financial support of the French Agency for Biodiversity (AFB).

Eutrophication is the disturbance of the normal functioning of aquatic ecosystems, which arises when some sensitive ecosystems are overly enriched in nitrogen and phosphorus nutrient loads from human activity. The best-known outward signs of this are "green tides" (blooms of green macroalgae) or "coloured water" (blooms of sometimes toxic phytoplankton).

Eutrophication generates major disruptions for aquatic ecosystems, as well as affecting human health and economic activities. Identifying the factors controlling these disturbances and the nutrient levels which should not be exceeded have led to controversy. That is why the collective scientific expert assessment was requested, to give public authorities the state of scientific knowledge they can base their policy-making decisions on. The report submitted in September 2017 went in this direction. ■



Signing of the framework agreement with France Filière Pêche

Ifremer and the French fisheries sector organisation FFP decided to renew their framework agreement related to the funding of projects involving scientists and fishermen.

The first framework agreement was signed in 2012 and was built around two main themes: improving knowledge about species and their environment, and fishing gear selectivity and reducing discards. The agreement made it possible to finance eighty-two projects, over half of which were steered by Ifremer and/or co-steered with the National committee for maritime fisheries and mariculture (CNPMEM).

The results from these scientific studies give French fishermen the leverage they need to more sustainably manage their fishing activities, which depend directly on the aquatic environment's state of health and its resources. Renewing the framework agreement should enable these partnership actions to continue, in order to assess the condition of stocks and the impact of fisheries, improve the selectivity of fishing techniques, provide more in-depth knowledge about resource biology and better understand the changes in ecosystems. ■





Aboard the RVL 'Europe'

© Ifremer/L. Chéret

Feedback on the implantation of the Water Framework Directive (WFD)

The year 2017 provided an opportunity for feedback on the implementation of the Water Framework Directive (WFD) in coastal environments, during a symposium on 15 and 16 November, jointly organised by Ifremer, the Ministry of ecological and inclusive transition (MTES, directorate for water and biodiversity) and the French Agency for Biodiversity (AFB).

These two days were full of enriching discussion, and highlighted successes in implementing the WFD (developing new indicators, characterisation of water bodies, methodological developments to characterise the ecological status of an environment or pressure impact, databasing of high quality data), as well as the expected developments to go beyond current limits as part of the next implementation cycle, i.e. new monitoring tools or technologies and ensuring the coherence of WFD and MSFD indicators and evaluations.

This work to share feedback from experience laid the foundations for the MTES to identify issues to address in the upcoming review of the WFD which has been announced. ■

Environmental status of marine waters

Ifremer, working in coordination with AFB and supporting the MTES directorate for water and biodiversity, pursued its contribution to the implementation of the second MSFD cycle, and more specifically, to the review of the 2012 initial assessment (Assessment 2018).

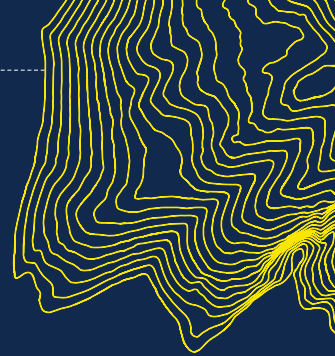
Specifically, the Institute is in charge of coordinating the "Environmental status" strand, which comprises assessing the status of the marine environment, the pressures exerted on it and how far it is from Good Environmental Status (GES). The levels of pressure exerted on

ecological stakes are the basis on which the environmental objectives aiming to achieve GES in marine waters are built. In comparison with 2012, Ifremer must also contribute to establishing the linkage between the MSFD and the Maritime Spatial Planning Framework Directive (MSPFD), on the inclusion of elements to assess marine waters in the strategic seafloor documents.

All the expected elements should be available in early 2018 and will be used by the decentralised State services for consultations to be engaged from the second semester of 2018. ■



Ifremer is in charge of coordinating the "Environmental status" strand, which comprises assessing the status of the marine environments, the pressures exerted on it and how far it is from Good Environmental Status (GES).



Interview

Patrick DEHAUMONT

General director of the French General Directorate for Food (DGAL),
Ministry of Agriculture and Food

As of 1st January 2018, changes will be made in the implementation of health monitoring networks (microbiology and marine toxins). How has the DGAL prepared this evolution?

Preparing for these developments began very early, from the moment the decision was made to transfer these health monitoring missions. The first step, conducted jointly by DGAL and Ifremer, consisted in very accurately describing in detail and formalising the missions carried out by Ifremer over the entire coast over the past five years. In the second phase, all of the parties concerned: State services, analytical laboratories and professional organisations were consulted to define a new, efficient and operational organisation. This

endorsed the decision to entrust the departmental Prefects (representing the State at county level), with these missions to monitor shellfish health in microbiological and toxicological terms, as part of official State inspection missions. Operationally speaking, the decentralised services (DDCSPP, county directorates for social cohesion and the protection of populations and/or DDTM, county directorates for regions and the sea) will sign agreements with the county-level analytical laboratories which will either perform or outsource sampling and analyses of shellfish. Professional shellfish farmers will be able to

take samples requiring special means of access at sea. This new organisation puts the State services at the centre of the monitoring system, while strengthening the linkage between classification, monitoring and management of production zones.

What are your expectations with respect to Ifremer within this new organisational scheme?

Seeing its knowledge of the marine environment and its experience in the field of health monitoring, Ifremer should maintain its role of support and expert assessment. This means the Institute will provide assistance to the DGAL contracting authority and the decentralised services, ranging from drawing up national monitoring strategies, assisting sampling operators and following the implementation of the health monitoring system. Ifremer remains the DGAL's preferred referent in terms of scientific and technical support, both nationwide and on the local level. The management actions related to health studies of zones, phytoplankton monitoring (Réphy), the watch for emerging marine biotoxins, as well as a monitoring network for chemical contaminants (Rocch), which all require extensive expertise, will continue to be ensured by Ifremer.

Is the convergence of health and animal-health monitoring systems planned for the medium or the long term?

The objectives of these two networks (health and animal health) meet, and their regulatory contexts are entirely different. However, since both systems are currently led by the Prefect State representatives at county level, perhaps in future, animal-health and health monitoring could be addressed together at the local level. This could provide more streamlined running of the monitoring arrangements around the various participants in the sector (State, Ifremer, professional health networks, laboratories). Furthermore, in 2019, the animal-health monitoring system will also undergo changes, moving towards refocusing Ifremer's role in assisting the contracting authority. During the year 2018, Ifremer will take part in designing the new system and in supporting services during the transition period.



7

BUSINESS DEVELOPMENT AND ECONOMIC PARTNERSHIPS

Ifremer's ambition is to contribute to economic development by creating economic value from its studies, as well as transferring their results to the socio-economic sector. This ambition leads to setting up contracts for collaboration, licensing or service provision, with start-ups, SMEs and large corporate groups.

In 2017, above and beyond maintaining relationships with its "historic" partner firms, the Institute bolstered its position as a preferred partner for the industrial world in marine sciences and technologies. It also continued to support innovative young firms or start-ups in maturing their technologies, to help them reach their market or create new ones. To complement this operational activity, thought and discussion have been launched to construct an upstream approach, encouraging researchers to think about how their research studies could be used as early as possible and the impacts they could have on the economic realm (as well as on public policies), to project themselves into the future and look beyond what is strictly needed for Ifremer today.

Colonisation dynamics on hydrothermal vent sites

Ifremer has contributed to our knowledge about deep-sea ecosystems for many years. For the period from 2017-2020, Statoil R&D is working with Ifremer in a European project called **MERCES***, aiming to acquire fundamental knowledge about deep-sea environments.

The project's objective is to better comprehend the resilience of hydrothermal ecosystems, especially the colonisation dynamics and the ecological connectivity along the gradient of hydrothermal activity, from inactive sites to active areas.

In the framework of this cooperation, Ifremer will study the hydrothermal fauna's colonisation dynamics after experimentally removing it from a given surface (defaunation), in order to study hydrothermal vent ecosystems ability to naturally regenerate and the underlying mechanisms. The teams will also focus on the spatial distribution of fauna on sulphide mounds along a gradient of hydrothermal activity, going from inactive sites to active ones, and including peripheral areas.

New information is expected about colonisation/recolonisation mechanisms on active and inactive sites, the extent of hydrothermal influence on fauna and sediment chemistry on the deep seafloor and existing functional links. Ultimately, this knowledge could help to limit the environmental impacts of the exploitation of deep-sea resources and enable restoration actions to be undertaken. ■

* Marine Ecological Restoration in Changing European Seas



Innovative pulleys and ropes

Ifremer's laboratory studying Behaviour of structures at sea is specialised in knowledge about composite materials, elastomers, ropes and adhesives used at sea, as well as their weathering.

The Ino-Rope company develops innovative products for sailing and yachting, racing and cruising alike. In particular, the firm proposes pulley blocks with a textile axis, combining ultra-slippery HMPE (High Modulus PolyEthylene) fibres and an aluminium ring treated to provide very low friction.

These HMPE polyethylene fibres and ropes display exceptional properties (low weight, very high resistance) and have replaced steel cables in many marine applications. However, the behaviour of these fibres is complex and little feedback is available for them. Ifremer has used ropes with these fibres since 2010 for handling

operations in deep water aboard the research vessel *Pourquoi pas ?*.

To adapt these highly reliable Ino-Rope blocks to other fields of application and improve their performance even more, Ino-Rope sought to collaborate with Ifremer and ENSTA Bretagne in the context of a Cifre-funded PhD thesis. The aim of this study is to optimise the yield and performance of these materials, for textile blocks or ropes used in handling, and thus to know how they will behave and predict their lifespan.



An «Ino-Rope» textile-axis pulley stock

Converting energy from marine currents into electricity

Ifremer receives regular requests for its test facilities and its expertise in hydrodynamics to be applied to marine renewable energy uses.

For several years now, the Institute has been closely involved in research and development studies to perfect the EEL tidal device's technology.

The EEL Energy company aims to develop and operate a tidal energy converter with an undulating membrane to produce electricity from marine or river currents.

Currently, Ifremer teams are working on the project with EEL Energy and Hutchinson, to develop a demonstrator

with potential power of about one megawatt. The goal is to produce a full-scale prototype in 2020.

The teams have conducted experimental and numerical studies and simulated the mechanical and hydrodynamic behaviour of the entire device. The fatigue scaling for the membrane was obtained thanks to mechanical testing carried out at Ifremer's Brittany centre. Developments from analytical and numerical models were validated after trials were run on a 1:20 scaled mockup in the wave and flume tank of Ifremer's English Channel-North Sea centre. Producing electrical power from medium power (about a kilowatt) converters was also tested on a 1:6 scaled prototype, but with non-negligible confinement effects. The results obtained were sufficiently promising for the first sea trials to be launched in December 2017. These towed trials in the Bay of Brest are a key step in the project and will be incorporated into the development of the prototype which has already entered the design phase. ■



Testing the undulating membrane prototype at a scale of 1:6 in the Bay of Brest

8

COMMUNICATIONS

The ties between science and society are at the heart of Ifremer's preoccupations. Specifically, promoting scientific culture in the marine sciences is one of the Institute's priorities.

Exhibitions and conferences

Ifremer took part in several large-scale exhibitions, by loaning photo images and providing scientific advice for *Aventures océanographiques* at the Porte Dorée tropical aquarium in Paris, and *Milieus extrêmes* at Espace Mendès-France in Poitiers.



Science festival, Brest
© Ifremer/J. Burdallet

Several partnership agreements were also signed with Universcience, the *Cité de la Mer* in Cherbourg and Nausicaa in Boulogne-sur-mer, for permanent exhibitions which will begin in 2018.

As has been the case for many years, Ifremer organised a cycle of conferences at the Ifremer Brittany centre on topics of interest to the public: biodiversity, global warming, fisheries, the deep sea, etc. Emphasis was also placed on scientific mediation and outreach to schoolchildren, hosting numerous classes of primary and secondary school students. In this way, Ifremer's Brittany centre welcomed one-hundred-ninety high school students and their teachers to promote "marine sciences for women" on International Women's Day on 8 March. In October, the Marine geosciences research unit presented the richness of underwater geology to six classes, through workshops during the MarFluid symposium. ■

The Lumexplore Junior contest

In the context of the Lumexplore festival for scientific and environmental exploration, Ifremer worked with the Society of French explorers and with Eden, a theatre in La Ciotat, to create the Lumexplore Junior contest, with the participation of the Montpellier, Aix-Marseille and Nice school-district authorities.

Teams of high-school and middle-school students were asked to produce a short film about scientific and environmental issues. The aim of this educational initiative is to stimulate youngsters' callings for the scientific and technological fields or for reporting, authoring or producing films about explorations. ■



Lumexplore Junior contest in La Ciotat
© Ifremer/P. Gontier

Sustained contribution to audio-visual media

2017 was a particularly rich year for audio-visual presence and productions.

Along with our scientists taking part in numerous shootings for TV shows or news programmes on the major national channels (TF1, France 5, and in programmes like *Télématin* on France 2, *Thalassa* on France 3, *Xenius* on Arte), Ifremer also took part in two series of videos to promote the profession of researcher:

- A series called "What makes you search?" fluctuating between the arts and science, tracing back to the origins of researchers' vocations, was written and produced by Geneviève ANHOURY and broadcast via *Le Monde* and the *Universcience* web TV.
- During the Science festival, a programme called "*L'étincelle*" (the spark) was broadcast daily on France 3, depicting scientists who explain what was the catalyst for their research work!

A two-part documentary on "*A journey through the Gulf Stream*" by the German director Rolf LAMBERT, aired on the Arte TV channel in March 2017. Our Institute, its researchers and vehicles are prominently featured in it.

In-house, the audiovisual centre has also launched a web series called "*It's Sea Time*", devoted to the daily activities of scientists at Ifremer, with some thirty reports filmed on the Brittany, Atlantic and Mediterranean seafarers. And finally, the Videocor 1 research cruise (May 2017) also showcased its images, since this mission made it possible to acquire exceptional photos and videos of cold-water coral ecosystems in the Mediterranean. ■

Deep sea, microplastics and microalgae at the heart of participatory sciences

The "Deep-Sea Spy" game launched by the Deep-sea environment laboratory, invites internet users to discover the hydrothermal fauna living at depths of nearly 2,000 metres.

The aim is to annotate the thousands of images taken by seafloor observatories and thus contribute to the laboratory's research (see chapter on the Deep Sea). More than 10,000 players have already participated to date!

A participatory science operation dubbed "*Enquête de sable*" (sand quest) attracted nearly three-hundred participants to the

Events for the grand public: honouring the researchers!

During the night of Friday 29 September at Océanopolis in Brest, nearly 4,000 visitors came to discover the diverse world of research during the twelfth European Researchers' Night.

The theme this year was "*Impossible?*". Two stands were manned by PhD students and researchers from the Coastal benthic ecology and Microbiology of extreme environments laboratories to present studies concerning the crepidula slipper limpet (a gastropod mollusc proliferating along the North Atlantic coast) and microorganisms in the abyssal plains.

Paris, Brest, Dinard, Lorient, Nantes, Boulogne-sur-mer, La Seyne-sur-mer, Martinique, Tahiti, New Caledonia, and so

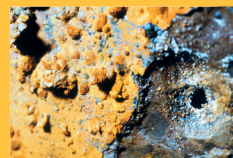
on... Once again, this year Ifremer's scientists were actively involved in the nationwide science festival event called *Fête de la science*. They succeeded in sharing and making their studies easier to understand, as well as transmitting their passion to the general public. For instance, in Brest, the Marine geosciences unit was mobilised at the Quartz conference centre, where over 7,000 science buffs and curious visitors came over the four days of the event. In Paris, for the second consecutive year, Ifremer joined forces with *L'Esprit sorcier* and fifteen other research institutions to occupy the *Cité des Sciences et de l'Industrie* centre. During three days of festivities and learning, the researchers presented their experiments, research topics and some mysterious objects to the public. ■



Marine-related books at Editions Quae

Ifremer is one of the four founding bodies, along with Cirad, INRA and Irstea, of the Quae publishing house.

Amongst the books (in French) published in 2017 illustrating the marine environment's wide range of facets are: *A challenge for the planet*, *Atlas of the Molène archipelago* (geology), *Biodegradation of materials*, *What risks for health and the environment?* In the "*Clés pour comprendre*" (Keys to understanding) Collection: *Oysters*, *Sea turtles*, *Green tides*.



990,910

NUMBER OF VISITS
TO INSTITUTIONAL WEBSITE



9,418

FOLLOWERS



5,437

SUBSCRIBERS

beaches of Roquebrune-sur-Argens, Lacanau and Fouesnant in July 2017. Holiday-makers were asked to help the scientists find the tiniest particles of plastic present in the sand, with aim of testing a simple protocol to collect microplastics on beaches.

The scientific mission *Hermiona* on marine plankton, launched in 2015 and entrusted to students at the maritime high school in La Rochelle by Ifremer, has now yielded its secrets. The samples collected have highlighted species not often seen and new species still to be described. ■

9

SUPPORTING AND BACKING RESEARCH

In 2017, Ifremer pursued its action for greater efficiency and consistency in practices within the Institute, its quality management system and its ethics and professional ethics plan. 2017 was also a year of major changes in terms of management and finance.

Social dialogue

The two collective agreements signed were milestones for the year 2017.

Wage agreement

In addition to the continuation of previous arrangements related to general measures, career advancement and promotions, Ifremer implemented a new wage measure for the year 2017, further reinforcing the will to boost our compensation policy. This involved an extraordinary bonus of 750 euros (gross), attributed to employees who demonstrated an exceptional involvement, contribution, performance or outcome during the year 2016. Over one-hundred salaried employees received this bonus.

The agreement related to terms of consultation of unions and staff representatives within the Ifremer/Genavir economic and social unit

The Institute's social partners seized the opportunity provided by the so-called "Rebsamen act" law of 17 August 2015 concerning social dialogue and employment to organise - by negotiating a company agreement - the terms of consultation of staff representative bodies. In this context, the time limits for consultation were negotiated by the Central works council and local organisations (local CE and CHSCT), as were the principles for distributing the roles between central and local organisations.

In 2017, Ifremer also organised elections to renew several staff representative bodies, using an electronic voting system for the first time. It was deployed for those voting in metropolitan France, in overseas France and for teams and crews on cruises aboard research vessels at the time.

Thus, in the Ifremer/Genavir economic and social unit framework, this led to the new election of fifty-two representatives in various works councils and and fifty-nine staff representatives.

Likewise, the three seats for full-member (and three for alternate) staff representatives on the Institute's scientific committee were renewed.

The Institute will continue this outplacement assistance and do everything possible in 2018, with the perspective of finding a solution for one and all by providing financial and human support, to meet the 1st January 2019 deadline. ■

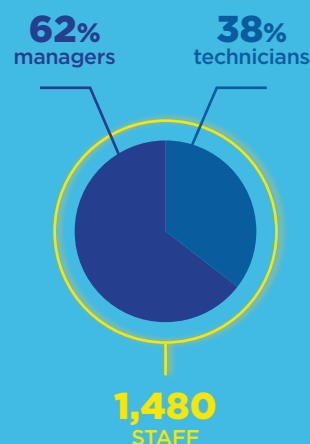


Ifremer's workforce

The Institute's total staff as of 31 December 2017 was 1,480 salaried employees, including 161 on fixed-term contracts. The breakdown between managerial and technical staff is 62% managers and 38% technicians.

Of the new hires, 69% are at management level and 53% are women.

The proportion of women, making up 46% of the total population at the Institute, remains similar to that of the previous year, thanks to exact parity in management hiring and a majority of women hired as technicians.



Hiring and related resources

While necessarily seeking to control payroll expenditure, after several years of tighter restrictions, Ifremer was able to hire a large number of recruits on open-ended contracts in 2017.

Effectively, ninety-nine new hires (69% of them at management level) joined Ifremer. These recruitments mainly involved the Institute's core business, with 62% scientists, of whom 46% are researchers.

A significant percentage of new support staff was also hired (38% of total recruitment), especially to prepare the transfer of the headquarters and support the DAJF financial and legal affairs department in its new organisation.

Along with this external recruiting, Ifremer continued to promote internal mobility, by increasing the possibilities for its employees to further their careers. Twenty-two employees thus took advantage of an in-house move to another position.

Hiring process and the new "Careers at Ifremer" website

Revision of the hiring system was launched in early 2017, with the aim of making the process transparent, fast, fair and professional.

To this end, the recruitment campaign for the year 2017 was accompanied by a new hiring guide designed for managers and all internal recruiters, along with centralising the hiring budget and broadening of job advertisement channels in France and abroad.

Since June 2017, there is a new page on the Institute's internet site for Careers at Ifremer: ifremer.jobs.net (consulted by 30% of Ifremer website visitors). It is part of the drive to optimise the recruitment phase and bolster Ifremer's brand as an employer.

The new functions provided by its Careers website enable Ifremer to:

- better interact with applicants and make recruitment and follow-up processes more efficient;
- simplify the submission of job applications;
- create new pages, like a special section for unsolicited applications for internships or a link to the section devoted to research grants. ■

2017, a year of major changes in administration, management and financial affairs

Three significant developments marked the 2017 financial year:

- setting up public-sector budget and accounts management (GBCP);
- overhauling the organisation of the administrative, legal and financial division (DAJF);
- bringing the budget and financial information system for the Institute (integrated management software suite or ERP) into force.

Implementation of an integrated management software suite (ERP)

After several years of preparation, the budget and financial strand of Ifremer's ERP software was put into service at the start of the 2017 financial year. It is based on the following functions:

- fully integrated procurement cycle: from expression of need to payment of supplier;
- budget management (estimated and actual) of projects conducted by the Institute;
- budget management (estimated and actual) of structures (research departments, centres, line management);
- the Institute's accounting and bookkeeping.

At the close of the financial year, the system was operational overall, even though some functions must be further improved, and the full benefit of this new system will become tangible in 2018 and beyond.

Setting up this tool deeply modified the Institute's administrative practices: so that all expenditures must follow a strictly marked out and controlled circuit, adopted by

all employees, in keeping with their level and responsibilities. The implementation was difficult in the first nine months of the year, and a few complicated cases still need to be resolved in 2018.

We should note the significant efforts made by all of the employees at the Institute to adopt and utilise this new tool, thanks as well to the ergonomic and easy-to-use portal set up to this end.

Setting up of the public sector budget and accounts management (GBCP)

This new tool also enables the Institute to be managed in compliance with the rules set out in the Decree N° 2012-1246 related to GBCP public sector budgets and accounts management.

The initial budget for 2017 was partially drawn up using the new format. Reporting of activities was done entirely in accordance with the new criteria. This made it possible to begin steering the commitment authorisations (AE) and payment appropriations (CP) for the Institute during the financial year, making it possible to draw up the initial budget for 2018 entirely in GBCP format.

The redesign of the legal and financial affairs

Finally, to support and activate these new tools, on 1st January 2017, the divisions for financial affairs and legal affairs were merged into a single structure adapted to the new requirements. ■

55

PEOPLE ON SANDWICH COURSES FOR QUALIFICATIONS AND DEGREES

27

CIVIC SERVICE VOLUNTEERS IN OVERSEAS FRANCE

Sustainable development and corporate social responsibility

In 2017, the sustainable development approach found two highly tangible touch points: firstly, in the construction project for the Institute's headquarters at the Brittany centre and secondly, in analysing the Institute's publications with respect to the concepts of sustainable development and corporate social responsibility (CSR).

As concerns the real-estate project for the headquarters, the main contractor has committed to keeping the following four fields of corporate social responsibility in balance: social (functions, quality of use, social codes), economic (investment costs, direct and indirect costs, overall cost), environmental (resources, energy, waste and emissions, comfort, health and hygiene quality) and societal (working conditions, vocational inclusion clause).

As for the contribution made by Ifremer's research studies to sustainable development and the Institute's corporate social responsibility through its publications, it can be noted that over 21% of articles published this year by the Institute (indexed by the Web of Science) can be associated with the field of sustainable development, and the proportion of these publications associated with the concepts of governance, the environment, economics and social aspects falling under CSR was close to 30%. In this framework, as is the case in Europe and worldwide, the themes of economics and biodiversity are predominant. ■



Support for employees in the context of the headquarters transfer

The mobility agreement specifically related to the transfer of Ifremer's headquarters to the Institute's Brittany site, signed in 2016 with the unions, was fully implemented over the year 2017.

The support from a specialist firm given to the employees concerned by a job search, as well as active coordination by the HR network of public sector institutions (particularly in the field of higher edu-

cation and research) have already enabled nearly thirty colleagues to find new positions either within Ifremer, or in public sector bodies or other companies.

The Institute will continue this outplacement assistance and do everything possible in 2018, with the perspective of finding a solution for one and all by providing financial and human support, to meet the 1st January 2019 deadline.

Interview

Léa EDIN

Ifremer, support hub,
financial project management team, DAJF



Ifremer is strongly committed to training tomorrow's young talent. Of course, research is a growth sector, with twenty-five salaried post-doc fellows and eighty-four salaried PhD students present at the end of 2017. In overseas France, as of 31 December 2017, the Institute also hosted twenty-seven civic service volunteers. Finally, at the height of the year, Ifremer trained up to fifty-five people on sandwich courses for degrees and qualifications ranging from higher certificate of vocational training to graduate engineering diploma.

Ifremer, support hub, financial project management team, DAJF

What is your background and what were your choices for a professional project?

— Following a degree from the University institute of technology (IUT) in company and administration management, I majored in finance-accounting for a Bachelor's degree awarded in 2014 by the IAE university school of management in Brest, then did a Master's degree in Information systems and management control (SICG).

Throughout my studies, I had the opportunity to do internships both abroad and in France, in private and public sectors. They enabled me to clarify my choice of training and the direction I wanted my professional life to take.

Why did you choose to do a sandwich course, and why at Ifremer?

— My aim was to begin work with a more professional grounding than that of most graduates, and at the same time having done an assignment in a well-structured and well-known company. What with my various internships and my work-link sandwich year, the experience I accrued was a big advantage!

In 2014, for my Bachelor's degree work placement, I looked for an organisation that would above all give me interesting assignments.

Because I'm from Brittany, and in fact from the city of Brest, for me «Ifremer» was an obvious choice amongst the firms to contact. Ifremer is internationally famous, with employees whose expertise is recognised. So, I knew that the assignments they could give me could only be enriching, both professionally and for my own culture.

After my BS internship in the Institute's financial affairs service, I was encouraged to apply for my first-year Master's internship, so naturally, I sent an unsolicited application via the HR department's website to do my professionalisation contract.

What assignments were you given at Ifremer? Did they meet your expectations? And do you feel they met the expectations of your host organisation?

— At the start of my contract in 2015, the Financial affairs division was right in the middle of finalising the new SAP management tool: I joined the working group drawing up the purchasing nomenclature and I was also entrusted with the financial management of the Institute's fixed assets and drawing up the multi-annual real-estate strategy plan (SPSI) fact sheets for the different centres.

Being young, I brought my energy and, being curious, I asked lots of questions, which wasn't easy for my tutor, whom I thank once again for the advice and a listening ear. In the end, I'd say the satisfaction was great, and that it was mutual.

What is your situation today?

— I arrived in the Institute in the middle of the period of administrative reorganisation, and the transfer of headquarters, with planned job openings towards the end of my contract. So, I applied for a position as administrative and financial manager of projects. After a fixed-term contract that was supposed to run for one year, starting in September 2016, to my great satisfaction, I was finally hired on an open-ended contract as of February 2017!

I don't regret choosing Ifremer for my work placement as of 2014, and then for my work-link sandwich contract. The latter is really a "win-win" exchange: first of all for the company, who can train the future employee in the way its work and has the time to determine his or her potential, and then for the student, who is familiarised with working life. In my case, when I was hired within the organisation, I was immediately operational.

Today, my administrative colleagues appreciate my drive and the employees appreciate my serious approach and my involvement in the projects I manage. I am very happy to be part of the Ifremer "family".

Quality

After five years of existence, Ifremer's quality system was simplified in 2017 to adapt to new requirements. Indeed, transitioning the system to meet the new 2015 version of the ISO 9001 standard, which was decided in April 2016, was implemented on the basis of these objectives: simplification, identification of risks and opportunities and increased involvement of the management.

The new quality system's organisation is now based on fourteen processes, including one management process, eight performance processes and five support processes. Each of their descriptions has been updated to take account of the in-house changes noted since 2011 and the new frame of reference requirements, in particular, identifying threats and the related opportunities. The quality system indicators were reviewed and there are now fewer of them; thus enabling the 2014-2018 objective contract goals to be covered.

The quality policy orientations

The quality policy statement now identifies four orientations:

- ensure reliability and traceability of the Institute's activities;
- promote more stringent management, based on integrated and joint management methods, of scientific, technical and functional projects;
- better anticipate, particularly through the threats approach, the changes needed to constantly improve efficiency;
- strengthen harmonisation and sharing of practices on all sites and in every component of the Institute.

The new ISO 9001: 2015 standard

The external supervision audit took place in November 2017, based on the new ISO 9001: 2015 standard. The outcomes were judged to be highly satisfactory by the auditor commissioned by Afnor, who emphasized the mastery of processes, the commitment of the general management and the numerous tools deployed within the system.

No item of non-compliance was noted. The four sensitive points raised by the previous audit were considered closed. Two new sensitive points related to documentary management were flagged within the new frame of reference and nineteen pathways for progress were identified. In parallel, twenty-three strong points in Ifremer's quality system were noted. Consequently, Ifremer has kept its certification. The logo now appears on the Institute's internal and external communications publications and media. ■



Ethics and the professional code

In 2017, the Institute, within the AllEnv alliance, began to discuss, seeking to explore the need to set up an inter-organisational committee for ethical oversight approval (similar to an IRB: International Review Board), which would make it possible to certify research projects before they are submitted. In the environmental sciences, this has become a crucial step to be able to bid in funding agencies' calls for projects and publish scientific results with a growing number of publishing houses.

The INRA-Cirad-Ifremer joint consultative ethics committee finalised an initial referral concerning the ethical implications of the 2015 agreements, the United Nations sustainable development programme (with its seventeen sustainable development goals - SDGs), and the Paris agreement on the climate. The second referral dealing with the ethical implications arising from new plant-genetics improvement techniques is currently being finalised.

Ifremer professional ethics charter

In terms of professional ethics and integrity, Ifremer's approach is described in the Professional ethics charter for research at Ifremer, which has been in effect since 1st

January 2017. It aims above all to remind all those who contribute to the Institute's activities of their responsibilities: those of decision- and policy-makers in managing the Institute, those of supervisory staff (including supervisors for students) and those of researchers in conducting and publishing their scientific studies, including their expert appraisals and reports.

In addition to this charter, Ifremer has created new documents of reference.

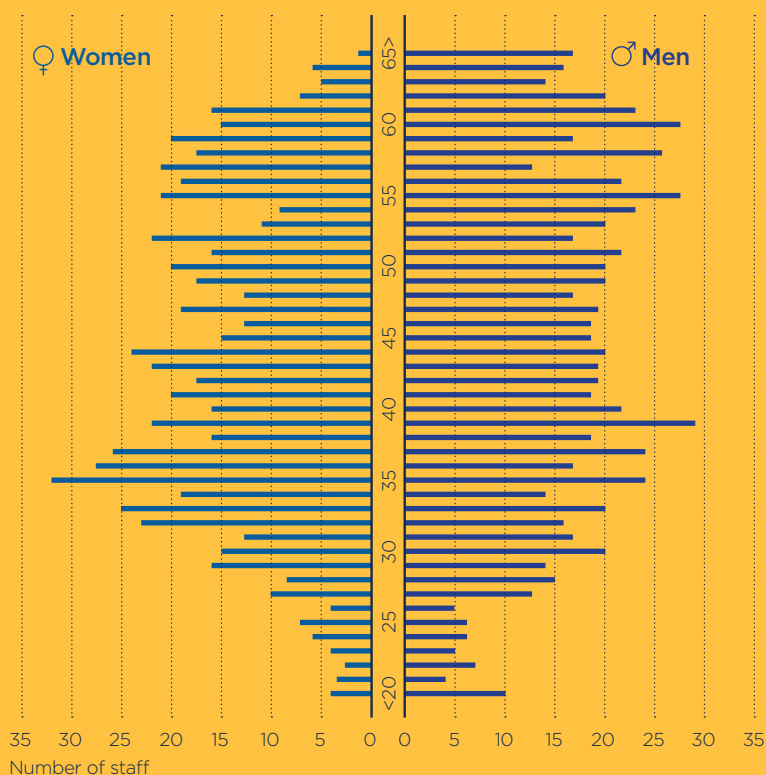
- The charter for PhD students describes the commitments by Ifremer PhD supervisors or co-supervisors with respect to students under contract or whose thesis is co-funded by the Institute, as well as the commitments undertaken by the PhD students themselves.
- The criteria for the signature of documents reminds researchers of the qualities that the author of a publication is expected to fulfil, i.e., a significant intellectual contribution made to designing the project and the acquisition of its results, a contribution made to writing the article and the ability to defend all or part of the article's contents and ensure its accuracy.

• The charter for expert assessment reports and opinions has been significantly redrafted to incorporate professional ethics requirements as well as the outcomes of reflection carried out in the framework of the P9 (Producing expert reports and supplying opinions) quality process. A certificate indicating the absence of connections and interests has been enacted.

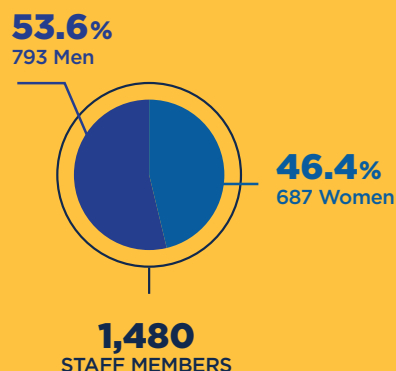
To raise staff awareness about all these actions, these reference documents have been presented to the heads of research units in the scientific departments, who must ensure that they are disseminated to their teams. A dedicated intranet site has also been put on line.

The delegate for professional ethics and integrity, reporting to the Chairman of the Institute, ensures the design, implementation and the monitoring of this approach, outside of the ethics committee which is within the remit of the scientific management. She can be consulted by the Institute's personnel to investigate any question related to professional ethics or scientific integrity. ■

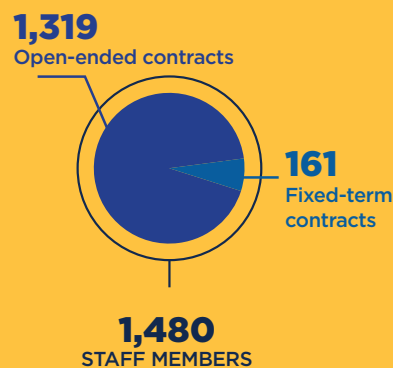
— AGE PYRAMID



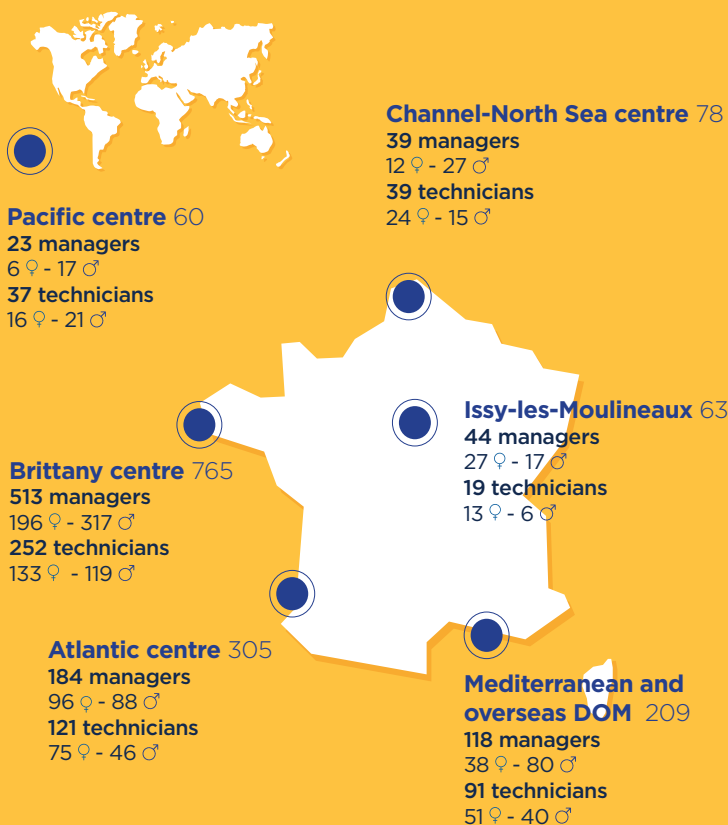
— BREAKDOWN MEN / WOMEN



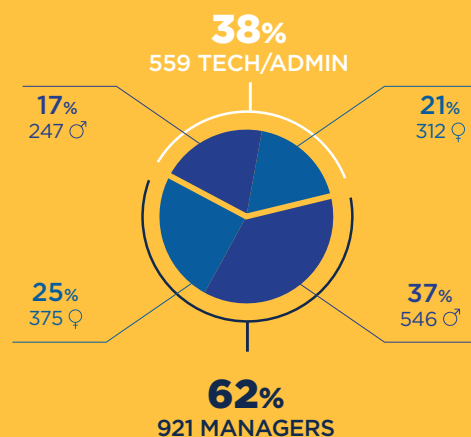
— TOTAL WORKFORCE / BREAKDOWN FIXED-TERM / OPEN-ENDED



— BREAKDOWN BY IFREMER CENTRE



— BREAKDOWN OF WORKFORCE BY GENDER AND BY CATEGORY



89
NEW HIRES
69% managers
31 ♀ - 30 ♂
31% technicians
16 ♀ - 12 ♂

Budget and financial figures

Financial year 2017

Setting up public-sector budget and accounts management (GBCP) at Ifremer, as of the financial year 2017, led to new indicators being monitored (summed up in the table for budget authorisations).

Commitment authorisations (AE) in 2017 were established at 208.3 million euros, making up 92% of the forecast amounts overall. Payment appropriations (CP) were used to the amount of 193.2 million euros, i.e. 87% of the forecast. Income cleared reached 197.5 million euros, i.e. 94% of the forecast.

The financial year was marked by some budget commitments being shifting to the 2018 financial year (construction of the headquarters in Brest, work on the site of La Tremblade, etc.) because more time was needed than was foreseen for the competitive bidding procedures; a difference in staff-related figures between realisation and forecast due to initial estimations which were not entirely compatible with the GBCP approach at the moment they were produced. The gap with respect to payment appropriations can be explained in part by the delays in payment of invoices and by overly ambitious forecasts. Revenues here mean income duly received and should

not be compared with the earnings on the income statement.

Therefore, the budgetary balance shows a surplus of 4.3 million euros for 2017.

The budget performance is shown by a surplus of 18.9 million euros and 10.2 million euros being added to the working capital. Corresponding figures for the 2016 financial year were respectively 24.56 million euros and 10.9 million euros. ■

— Budget authorisations

EXPENDITURE	2017 forecast		2017 performance	
	AE	CP	AE	CP
Staff	110,979,883	110,979,883	107,968,057	107,968,057
including employer's contributions to (CAS)				
Pension net lending	771,000	771,000	762,636	762,636
Operations	76,983,738	74,055,537	73 199,747	58,657,160
Intervention	-	-	-	-
Investments	39,194,474	38,204,705	27,121,960	26,537,396
Total expenditure	227,158,095	223,240,125	208,289,764	193,162,612
Fiscal balance (surplus)		-		4,318,264

REVENUE	2017 forecast		2017 performance	
Overall revenue		196,979,975		187,822,713
Subsidies for provision of public services		154,409,455		147,760,455
Other State funding		8,747,319		12,873,356
Tax allocations		-		-
Other public funding		23,454,945		17,182,418
Own resources		10,368,256		10,006,485
Earmarked revenue*		13,168,986		9,658,162
Earmarked State funding		5,665,986		1,284,000
Other earmarked public funding		7,503,000		8 374,162
Earmarked equity		-		-
Total revenue		210,148,961		197,480,876
Fiscal balance (deficit)		13,091,164		-

Budget	Staff		Operations		Investments		Total	
	AE	CP	AE	CP	AE	CP	AE	CP
SCIENCES	79,383,025	79,383,025	21,972,290	13,577,173	8,239,744	7,864,614	109,595,058	100,824,812
SUPPORT	18,845,187	18,845,187	16,968,982	13,589,720	2,564,153	3,970,071	38,378,322	36,404,978
OTHER	-	-	-	-	-	-	-	-
FLEET	9,739,845	9,739,845	34,258,475	31,490,266	16,318,064	14,702,711	60,316,384	55,932,823
Total	107,968,057	107,968,057	73,199,747	58,657,160	27,121,960	26,537,396	208 289 764	193,162,612
FISCAL BALANCE (surplus)								4,318,264

10

FINANCIAL AND ACCOUNTING REPORTS

— Balance at closing before allocation of profit or loss (euros)

BALANCE SHEET - ASSETS					
	2017			2016	Evolution
	Gross	Depreciation & amortisations	Net	Net	
FIXED ASSETS					
Intangible assets					
Initial expenses	13,270.16	13,270.16	0.00	0.00	-
Research and development costs	0.00	0.00	0.00	0.00	-
Concessions and similar rights, patents, licences, trademarks, processes, software, entitlements and securities	38,541,198.46	32,433,897.46	6,107,301.00	7,342,748.59	-16.8%
Purchased goodwill	0.00	0.00	0.00	0.00	-
Other intangible assets	208,522.16	208,522.16	0.00	0.00	-
Intangible assets in progress	5,980,724.06	0.00	5,980,724.06	4,384,602.03	36.4%
Advances and prepayments on fixed asset orders	5,003,325.16	0.00	5,003,325.16	4,287,546.85	16.7%
Total - intangible assets	49,747,040.00	32 655 689.78	17,091,350.22	16,014,897.47	6.7%
Tangible assets					
Land, developments and improvements	8,411,966.64	1,587,747.58	6,824,219.06	7,204,389.34	-5.3%
Buildings	118,726,381.73	75,011,826.73	43,714,555.00	47,071,675.63	-7.1%
Technical facilities, equipment and tools	333,805,858.76	251,993,560.76	81,812,298.00	91,809,318.86	-10.9%
Collections	872,856.49	0.00	872,856.49	872,856.49	0%
Historical and cultural property	0.00	0.00	0.00	0.00	-
Other tangible fixed assets	34,747,162.34	32,907,630.34	1,839,532.00	2,770,979.73	-33.6%
Fixed assets under concession	0.00	0.00	0.00	0.00	-
Tangible assets in progress	8,496,395.41	0.00	8,496,395.41	7,484,954.31	13.5%
Advances and prepayments on fixed asset orders	53,429,645.34	0.00	53,429,645.34	24,679,795.76	116.5%
Tangible assets (living biological assets)	0.00	0.00	0.00	0.00	-
Total - tangible assets	558,490,266.71	361,500,765.41	196,989,501.30	181,893,970.12	8.3%

Investments					
Securities	560,591.68	72,899.60	487,692.08	386,478.08	26.2%
Other forms of investment (Quae)	125,000.00	0.00	125,000.00	125,000.00	0%
Receivables attached to holdings	0.00	0.00	0.00	0.00	-
Capitalised securities	0.00	0.00	0.00	0.00	-
Loans	5,860,301.28	0.00	5,860,301.28	5,855,245.80	0.1%
Deposits and guarantees paid	640,399.76	0.00	640,399.76	640,399.76	0%
Total - investments	7,186,292.72	72,899.60	7,113,393.12	7,007,123.64	1.5%
Total - fixed assets	615,423,599.43	394,229,354.79	221,194,244.64	204,915,991.23	7.9%

CURRENT ASSETS					
Total - inventories and work in progress	0.00	0.00	0.00	0.00	-
Total advances and prepayments on orders	393,147.90	0.00	393,147.90	3,728,494.89	-89.5%

ACCOUNTS RECEIVABLE					
Customer and related accounts receivable	9,768,534.17	1,585,987.63	8,182,546.54	9,636,197.64	-15.1%
Claims on public bodies (the State, other public entities), international organisations and the European Commission	56,198,992.81	0.00	56,198,992.81	32,503,453.19	72.9%
Claims on taxpayers (income from allocated taxation)	0.00	0.00	0.00	0.00	-
Claims corresponding to operations on behalf of third parties (intervention arrangements)	0.00	0.00	0.00	0.00	-
Claims on other debtors	227,821.91	0.00	227,821.91	248,621.04	-8.4%
Total debts	66,195,348.89	1,585,987.63	64,609,361.26	42,388,271.87	52.4%

Available funds					
Shares (listed securities)	0.00	0.00	0.00	0.00	-
Other securities	0.00	0.00	0.00	0.00	-
Banking	46,303,976.02	0.00	46,303,976.02	46,025,699.47	0.6%
Incl. private banks	41,683.74	0.00	41,683.74	1,275,457.66	-96.7%
Incl. General directorate of Public finance	46,262,292.28	0.00	46,262,292.28	44,750,241.81	3.4%
Cash account	19.56	0.00	19.56	0.00	-
Authorisation to incur expenditure	43,449.87	0.00	43,449.87	48,978.48	-11.3%
Authorisation to receive funds	0.00	0.00	0.00	0.00	-
Total - available funds	46,347,445.45	0.00	46,347,445.45	46,074,677.95	0.6%

Adjustments					
Prepaid expenses	0.00	0.00	0.00	14,941.14	-100%
Unrealised exchanged losses	-0.23	0.00	-0.23	-0.23	0%
Total - adjustments	-0.23	0.00	-0.23	14,940.91	-100%
Total - current assets	112,935,942.01	1,585,987.63	111,349,954.38	92,206,385.62	20.8%

Total - assets	728,359,541.44	395,815,342.42	332,544,199.02	297,122,376.85	11.9%
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— Balance at closing before allocation of profit or loss (euros)

BALANCE SHEET - LIABILITIES			
	Financial year 2017	Financial year 2016	Trend
EQUITY CAPITAL			
Capital			
Funding received			
State funding not related to assets	0.00	0.00	-
State funding related to assets	131,072,975.14	132,791,467.98	-1.3%
Asset funding by third parties other than the State	25,944,995.59	15,558,739.12	66.8%
including carry forward of funding on balance sheet	381,198,024.49	355,070,918.26	7.4%
Total - funding received	157,017,970.73	148,350,207.10	5.8%
Total - reevaluation differential	16,299,666.98	18,760,830.03	-13.1%

Reserves			
Legal reserve	0.00	0.00	-
Regulated reserves	0.00	0.00	-
Other reserves	35,510,661.75	18,487,753.60	92.1%
Including optional reserves	35,510,661.75	18,487,753.60	92.1%
Total - reserves	35,510,661.75	18,487,753.60	92.1%
Balance brought forward	11,172,693.73	1,172,693.73	852.7%
Result for financial year (profit or loss)	18,923,659.73	24,561,745.10	-23%

Regulated provisions	0.00	0.00	-
Total - equity capital	238,924,652.92	211,333,229.56	13.1%

PROVISIONS			
Provisions for contingencies	2,200,820.00	1,631,000.00	34.9%
Provisions for expenses	15,741,582.87	17,423,298.12	-9.7%
Incl. Provisions for pensions and similar obligations	12,894,957.10	12,691,128.08	1.6%
Incl. Provisions for loss of employment allowance and severance payments	1,868,828.91	3,754,373.18	-50.2%
Incl. Other provisions for other charges	977,796.86	977,796.86	0%
Total - provisions	17,942,402.87	19,054,298.12	-5.8%

LIABILITIES			
Financial debts			
Loans and related liabilities	31,323.00	31,323.00	0%
Including deposits and guarantees received - deposits	31,323.00	31,323.00	0%
Holding-related liabilities	3,448.41	3,448.41	0%
Including liabilities related to joint venture companies - Tahiti	3,448.41	3,448.41	0%
Total - financial debts	34,771.41	34,771.41	0%
Non-financial debts			
Trade accounts payable and related accounts	26,116,404.83	15,701,055.87	66.3%
Tax and social security payable	24,058,645.18	31,611,137.97	-23.9%
Incl. Payroll and related accounts	10,350,140.49	12,014,028.62	-13.8%
Incl. Social security and social organisations	9,994,899.53	10,079,168.24	-0.8%
Advances and prepayments	22,337,132.45	16,370,183.57	36.5%
Debts corresponding to operations on behalf of third parties (intervention arrangements)	169,567.54	622,286.67	-72.8%
Other non-financial debts	2,706,174.37	2,319,298.66	16.7%
Total non-financial debts	75,387,924.37	66,623,962.74	13.2%
Cash position			
Cash liabilities elements	478.69	7,355.47	-93.5%
Total cash position	478.69	7,355.47	-93.5%
Adjustments			
Deferred income	253,968.54	68,759.55	269.4%
Accruals and deferrals	0.00	0.00	-
Total - adjustments	253,968.54	68,759.55	269.4%
Total - debts	75,677,143.01	66,734,849.17	13.4%
Total unrealised exchange profit	0.23	0.00	
Total - liabilities	332,544,199.03	297,122,376.85	11.9%

Results (euros) - part 1	Financial year 2017	Financial year 2016	Trend
OPERATING AND INTERVENTION COSTS			
Operating expenses			
Purchases	0.00	101.50	-100%
Consumption of goods and supplies, performance of work and direct consumption of services by the organisation for its activity, as well as expenses related to changes in stocks and inventory	65,040,044.81	71,000,189.33	-8.4%
Staff expenses	96,150,114.96	97,441,998.31	-1.3%
Salaries, wages and other pay	64,276,858.81	65,669,497.48	-2.1%
Social contributions	26,970,852.57	26,865,458.48	0.4%
Profit-sharing and participation	0.00	0.00	-
Other staff costs	4,902,403.58	4,907,042.35	-0.1%
Other operating costs	10,495,906.65	11,208,066.03	-6.4%
Depreciation, amortisation and net book value of assets disposed of	16,741,125.59	18,746,948.12	-10.7%
Total operating costs	188,427,192.01	198,397,303.29	-5%

Intervention costs			
Arrangement to intervene on own behalf	1,429,356.72	459,393.71	211.1%
Transfer to households	0.00	0.00	-
Transfer to companies	0.00	0.00	-
Transfer to local and regional authorities	0.00	0.00	-
Transfer to other authorities	1,429,356.72	459,393.71	211.1%
Expenses due to application of the organisation's guarantee	0.00	0.00	-
Provisions and impairment	0.00	0.00	-
Total intervention costs	1,429,356.72	459,393.71	211.1%
Total operating and intervention costs	189,856,548.73	198,856,697.00	-4.5%

OPERATING INCOME			
Income without direct consideration (or subsidies and similar income)	177,797,957.20	181,227,954.55	-1.9%
Subsidies for provision of public services	154,384,174.00	155,586,583.00	-0.8%
Subsidies for operation from the State and other public bodies	23,386,783.20	25,591,371.55	-8.6%
Subsidies specifically allocated to financing certain intervention costs, from the State and other public bodies	0.00	0.00	-
Donations and legacies	27,000.00	50,000.00	-46%
Income from allocated taxation	0.00	0.00	-
Income with direct consideration (or direct income from activity)	14,616,431.54	25,191,839.13	-42%
Sale of goods or service provision	12,420,273.97	21,558,361.56	-42.4%
Gains from disposal of assets	310,000.00	36,779.34	742.9%
Other management income	1,064,292.42	1,675,936.89	-36.5%
Final inventory	821,865.15	1,920,761.34	-57.2%
Other income	16,079,634.86	16,779,186.80	-4.2%
Write-back on depreciation and provision (operating income)	2,968,426.46	2,052,388.62	44.6%
Write-back on financing related to an asset	13,111,208.40	14,726,798.18	-11%
Total operating income	208,494,023.60	223,198,980.48	-6.6%

Results (euros) - part 2	Financial year 2017	Financial year 2016	Trend
FINANCIAL EXPENSES			
Interest costs	14,751.65	0.00	-
Net loss from sale of securities	0.00	0.00	-
Foreign exchange loss	14,282.61	3,544.62	302.9%
Other financial charges	0.00	24,157.57	-100%
Depreciation and provisions expense	0.00	4,100.00	-100%
Total - financial expenses	29,034.26	31,802.19	-8.7%

FINANCIAL INCOME			
Income from shareholdings and loans	273,167.25	263,250.00,	3.8%
Net income on disposals of investments	0.00	0.00	-
Interest on performing debts	0.00	0.00	-
Income from sale of securities and cash position	0.00	0.00	-
Net proceeds from sale of securities	21,812.37	4,500.46	384.7%
Foreign exchange gains	0.00	281.10	-100%
Other investment income	87,480.00	8,232.25	962.6%
Write-back of financial depreciation and provision	0.00	0.00	-
Total - financial income	382,459.62	276,263.81	38.4%

CORPORATE INCOME TAX	67,241.00	25,000.00	169%
Gross profit or loss	18,923,659.23	24,561,745.10	-23%
Total - income	208,876,483.22	223,475,244.29	-6.5%
Total - expenses	189,885,582.99	198,888,499.19	-4.5%
Profit (+) or loss (-)	18,923,659.23	24,561,745.10	-23%

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AS OF 31 DECEMBER 2017

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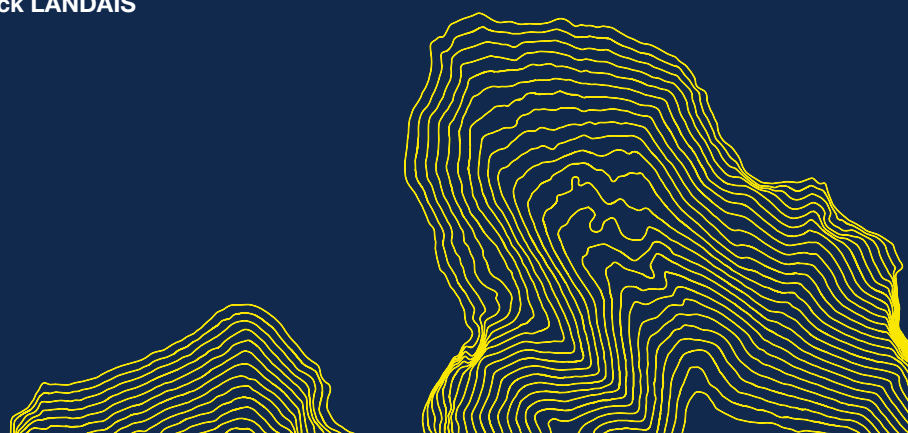
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