

A WORD FROM THE CHAIR FRANÇOIS HOUILLER, CHAIRMAN AND CEO OF IFREMER

The French Oceanographic Fleet (FOF) is designated a very large research infrastructure (TGIR). It plays a distinguished role for the French scientific community and occupies a special place within IFREMER. The result of a long process of "unification", a period explored more thoroughly in Jean-Marie Flaud's interview, the FOF comprises since 1 January 2018 all the surface, underwater and experimental resources previously owned and deployed by the CNRS, IFREMER, IPEV and the IRD.

The French Oceanographic Fleet is a versatile infrastructure founded on a range of equipment and resources whose diversity and complementarity are essential for responding to the expectations of the scientific community: six deep-sea vessels which operate in the Mediterranean and the Atlantic, Indian and Pacific Oceans, five coastal vessels which operate in French waters, the CNRS's seven research station vessels which are distributed along France's seaboard, submersibles which can be deployed from support vessels to depths of 6,000 metres, and ship-borne scientific equipment. For the most part these resources are deployed by Genavir, an economic interest group comprising the CNRS, IFREMER, the IRD and IRSTEA.

The FOF is one of the research infrastructures operated by IFREMER, supporting other research infrastructures dedicated to the observation of the oceans, information systems, hydrodynamic tests and fish-farming experiments. It is remarkable for several reasons: along with EuroArgo, it is one of only two very large research infrastructures mentioned on the national roadmap defined by the Ministry of Higher Education, Research and Innovation (MESRI); in financial terms, it is by far the most important, not only in comparison with the other IFREMER infrastructures, but also when compared with the various French research infrastructures involved in environmental and earth sciences.

It is remarkable, too, for the diversity of its missions, its users and its partners: open to the entire French scientific community, it undertakes research cruises that have been assessed for their excellence and pertinence; in partnership with France's military navy (Marine nationale), it undertakes cruises on behalf of France's naval hydrographic and oceanographic service (SHOM); it undertakes surveys in support of public maritime policies at national and European levels; and it is the material resource for collaborative projects involving public or private bodies within the framework of special charters.

As one of the three largest scientific fleets in Europe, alongside those of Germany and the United Kingdom, the FOF has the capacity to intervene on all the world's oceans and maintains partnerships with various countries in Europe and North America.

Under the direction of Olivier Lefort and its Executive Committee (the latter chaired by the MESRI and composed of representatives from the CNRS, IFREMER, the IRD and France's network of marine universities), the French Oceanographic Fleet is currently operated by IFREMER on behalf and for the benefit of France's entire scientific community. This annual report is the first to account for the FOF's activities within the new context.

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FOREWORD OLIVIER LEFORT, DIRECTOR OF THE FRENCH OCEANOGRAPHIC FLEET

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The year 2018 was a remarkable one for the French Oceanographic Fleet (FOF): the unification of this very large research infrastructure (TGIR) became a reality, with the establishment of the FOF's management structure which now resides within IFREMER. It benefits all the parties involved, the people and the resources required for the smooth running and development of this infrastructure.

The governance structure has been established. Comprising representatives of the CNRS, IFREMER, the IRD and France's network of Marine Universities, the Executive Committee has convened four times, and the national assessment committees of the deep-sea and coastal fleet have been renewed for the next four years. The FOF's Scientific Council has been formed. Open to international members, it held its first meeting in December.

The year 2018 was marked by some highly symbolic cruises, in particular the deployment of the *Marion Dufresne* to the China Sea and the initial operations with the new seismic equipment which have generated promising results. Starting four years ago, the modernization of the FOF reached a significant milestone with the HROV *Ariane* and the new generation of seismic sources entering active service.

Lastly, the future is beginning to take shape with the Scientific Council's validation of an outline plan for the renewal of the FOF's vessels and the launch of a process to define the deep-water workclass submersibles of the future.

The reorganization of French Oceanographic Fleet is now complete and its staff determined to furnish all users with modern and high-performance tools that are suitable for the major projects of the national scientific community. . – saan saa ya shikiin assama aa iyo aa dadha shika shika adaa sharadaa shika shika shika shika shika aa shara

THE WORD OF THE MINISTRY

INTERVIEW WITH JEAN-MARIE FLAUD (MINISTRY OF HIGHER EDUCATION, RESEARCH AND INNOVATION), CHAIRMAN OF THE FOF EXECUTIVE COMMITTEE.



WHAT WERE THE MOTIVATIONS AND HOW WAS THE UNIFICATION OF THE FLEET LRI CONCEIVED?

The issue of how to optimise the Oceanographic Fleet had been the subject of debate and discussion for over twenty years. As time passed, awareness of the need for change grew stronger. In 2016, the mission letter sent to François Jacq by the Secretary of State for Higher Education and Research opened a new phase, to go beyond the progress made by the UMS Fleet joint service unit created in 2011. The aim of the mission was to propose concrete solutions enabling this new step to be taken, in the most pragmatic possible way. A team was formed, composed of well-known figures from various horizons. After meeting with the numerous interested stakeholders and setting up a monitoring arrangement with the UMS Fleet joint service unit operators (CNRS, IRD, IPEV, IFREMER), the mission team formed its conviction that the solution of a unified Fleet underpinned by IFREMER was the best option

to ensure its lasting use whilst preserving the highlevel technological tools it needs. Proposals made by the mission team were approved by the ministry and the organisations which use the Fleet, with the shared conviction that this change would certainly represent an added value.

WHAT WERE THE PRINCIPLES CHOSEN FOR THIS UNIFICATION?

Four principles were selected: unifying the budget, defining the specifications for fleet utilisation, setting up a dedicated organisation within IFREMER, along with dedicated governance, and the unification of scheduling. This meant that the Fleet budget became a single budget allocated to IFREMER by the ministry, and monitored separately, within IFREMER's budget. For the FOF scheduling to take account of existing constraints and the interests of users, specifications for the scheduling were drawn up. The executive committee guarantees it will be complied with, decisions are taken unanimously through consensus between the different members.

WHAT LESSONS HAVE YOU LEARNED FROM THE FIRST YEAR OF OPERATION?

We had a short time frame, but the entire framework is now in place. The 2018 schedule displays some very fine scientific cruises, while the more fundamental work, like the renewal plans for the Fleet and underwater vehicles has begun and has been submitted to the FOF's scientific board. We have expressed the wish that the FOF unification will allow for multiannual scheduling, to give the scientific community a better vision of the schedule for coming years. The engagement will be met in 2019, by grouping several scientific cruises in the Pacific, a fine illustration!

ORGANIZATION OF THE FRENCH OCEANOGRAPHIC FLEET

Since 1 January 2018 IFREMER receives a single subsidy from the Ministry of Higher Education, Research and Innovation for operating the FOF. On the basis of the financial resources available, IFREMER is committed to achieving annual scientific research times of 450 days for the deep-sea fleet and 960 days for the coastal vessels. A department (DFO) dedicated to operating the TGIR French Oceanographic Fleet was established within IFREMER. It covers all the technical resources specific to the FOF, ensuring their scheduling and development.

The DFO's structure comprises a naval operations unit, two engineering units (Ships and Ship-borne Systems – NSE, Submersible Systems – SM), and a management team. It operates a Quality assurance policy. This new department's governance structure enables it to comply with scheduling specifications and bring together in a well-balanced manner all the parties concerned:

- Executive Committee to which the FOF management reports. It is chaired by the ministry in charge of research. It is composed of representatives from the CNRS, the IRD, IFREMER, and the universities using its services (France's network of Marine Universities). The Committee's decisions are taken unanimously by consensus among its various members.
- Scientific governance (Scientific Council comprising twelve members) and assessment bodies (National Committee of the Deep-sea Fleet – CNFH, National Committee for the Coastal Fleet – CNFC, and Local Assessment Committees – CLC) are responsible for assessing the scientific merit of cruise proposals.



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INITIAL DECISIONS OF THE EXECUTIVE COMMITTEE OF THE OCEANOGRAPHIC FLEET

The executive committee of French Oceanographic Fleet convened four times in 2018.

It fixed the composition of the Scientific Council of the French Oceanographic Fleet, its membership being open to other European countries, which convened for the first time on 18–19 December 2018. It also validated the new terms of office and membership of the assessment committees, whose terms had expired at the end of 2018. Guarantor of the FOF's proper functioning and the service rendered to its users, it approved in October 2018 the FOF's preliminary schedule and budget for 2019, as proposed by the FOF's management.

Strategic decisions, such as renewing ships or equipment, also fall within the scope of the Executive Committee of the French Oceanographic Fleet. In early 2018 the Ministry of Higher Education, Research and Innovation asked the FOF's management to propose a plan for the development of the Oceanographic Fleet up to the year 2035, to cover not only the ships but also the Fleet's submersible systems and semi-heavy equipment. This plan, based on the works undertaken in 2017 by the preceding scientific and technical advisory council, was approved by the new scientific council of the Fleet in December 2018, saw its principal objectives confirmed by the executive committee of the Fleet at the end of 2018, and will be officially communicated to the Ministry of Higher Education, Research and Innovation in 2019.

- In connection with the future of the deep-water workclass devices, the *Nautile* is scheduled to be withdrawn from service in 2025, to coincide with a new ROV entering the Fleet, and the *Victor 6000* is to be modernized. Following the opinion of the FOF's Scientific Council in December 2018, the preparation of this scenario, which should see the new deep-water ROV enter service by 2024, continues throughout 2019 with a consultation phase to identify the needs of the scientific community. *Victor 6000* will be modernized in phases, in order to benefit from certain technological modules that it will share with the new ROV. Its modernization will, as a consequence, be completed according to the same schedule.
- The plan includes the modernization of the Pourquoi Pas? in 2022, to ensure the availability of suitable scientific equipment (including multi-beam echo sounders) for the continuation of the scientific activities of the most recent large multidisciplinary vessel. It brings forward the replacing of *L'Atalante* to 2030.
- By the year 2034, the plan for renewing coastal and near-shore vessels includes the provision of a near-shore vessel and a coastal vessel for each of France's coasts, and brings forward the prompt decommissioning of the *Alis* in the western Pacific. It also notes the urgent replacement of the *Thalia* in French waters and the need to retain a near-shore capacity in the southwestern Pacific beyond the decommissioning of these vessels in 2022.

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THE SCIENTIFIC COUNCIL'S POINT OF VIEW

The Scientific Council of the French Oceanographic Fleet convened for the first time on 18–19 December 2018. It took the opportunity to give its opinion on the decisions taken for 2019.

The Council holds an extremely favourable view of the FOF's new organization, which it believes can be nothing but beneficial to France's entire marine sciences community, stakeholders and public-sector decision-makers in terms of harmonizing practices, greater transparency in allocating cruise slots, optimizing the use of the Oceanographic Fleet, strengthening capacities and international visibility. Bolstering the operations of this very large research infrastructure, by aligning them more suitably with scientific needs, on the one hand, and by improving financing and the capacity for technological development of the Fleet, on the other, is certain to accelerate the impact of the research undertaken.

The Council appreciated being given access to clear and well-documented indicators of the Fleet's activities, as well as the bibliometrics produced in 2015. It discussed, however, the absence of indicators that report on the FOF's impact, recommending that the excellent research carried out by the Fleet be more thoroughly documented, and offers its support to the Fleet's management in this area.

The Scientific Council examined the project for renewing the National Committee of the Deep-sea Fleet (CNFH), the National Committee for the Coastal Fleet (CNFC) and the Local Assessment Committees (CLE). It approves of the balance obtained for the composition of the national and local committees in terms of disciplines, represented organizations and geographic work zones for the CNFC, and recognizes with satisfaction the efforts which have been deployed to ensure gender balance among the full and deputy members, as well as in the allocation of chairs and vice-chairs. The Scientific Council also approves the Fleet renewal plan as presented to it, in particular the section concerning new coastal and near-shore vessels,

as well as the schedule for implementing this plan. The Council judges this plan to comply with the decisions taken in 2017, following the works of the preceding technical and scientific steering committee, and the Fleet's mission. However the Council notes that ocean observation is relying increasingly on a multi-platform and multi-device approach, which means that the use of autonomous instruments needs to be taken into account for the completion of these ships. The Council suggests putting into perspective not only the ships but also all the tools to be proposed in the future, in response to the new scenarios of scientific use that are expected to come into play.

Lastly, concerning the scenario of two deep-water ROVs which was decided by the Ministry of Higher Education, Research and Innovation and the Fleet's Executive Board: the Council is aware of the positive results of Phase o as to the feasibility of an innovative deep-water ROV system featuring new technical capacities, satisfying new scenarios and scientific applications, and enabling in the long-term scientific teams to dive on deep-water sites virtually. The Council encourages the continuation of the works. In general, the Council considers that any technical innovation must be guided by a strategic and scientific vision, and recommends the strengthening of the two-way dialogue between scientists, engineers, technicians and funding bodies during the planning phase of the two-ROV scenario which is about to open.

2018 IN FIGURES



115 CRUISES



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RESOURCES OF THE FRENCH OCEANOGRAPHIC FLEET

The major part of the Fleet's ships, including underwater systems and mobile equipment, is deployed by Genavir, an economic interest group comprising the CNRS, IFREMER, the IRD and IRSTEA. The exceptions are the *Marion Dufresne*, which is operated by Louis Dreyfus Austral Seas (LDAS), and the research station vessels and two coastal vessels *Côtes de la Manche* and *Téthys*, which are operated by the CNRS.

DEEP-SEA VESSELS

one of the few ships able to collect sediment cores of more than seventy metres long. The major refit in 2015 increased considerably the *Marion Dufresne*'s resources in terms of scientific equipment, echo sounders and laboratories, as well as improving her capacity for sampling and her coring system. New capabilities will be integrating the ship in late 2019. She will be able to deploy the *Penfeld* penetrometer, the *Victor 6000* ROV, and all of the Fleet's seismic devices.

MARION DUFRESNE



© IFREMER. Olivier Quédec

The *Marion Dufresne* is a multipurpose ship which entered service in 1995. Her main activities involve oceanographic research on all seas that are not covered with ice, under the responsibility of IFREMER, and logistics to France's subantarctic islands (Crozet, Kerguelen, Amsterdam/Saint-Paul) under the responsibility of France's Antarctic Overseas Territories (TAAF). The *Marion Dufresne* is one of the largest research vessels in the world (120 m long) and covers all oceanographic fields except fisheries. Her capabilities for sediment coring and paleoclimatology are internationally recognized. The *Marion Dufresne*'s giant corer *Calypso* makes her

POURQUOI PAS ?



© IFREMER. Olivier Dugornay

Built in 2005 in Saint-Nazaire, the ship is 107 metres long and was co-financed by the French Navy (Marine nationale), which uses her on average 130 days a year, mostly for hydrographic and oceanographic work (SHOM). She is a multidisciplinary ship, fitted with deep-water multibeam echo sounders and many other pieces of acoustic equipment. She is able to deploy two submersible systems or pieces of heavy equipment on the same cruise. Embarking up to forty scientists and technicians, the *Pourquoi pas*? is used for numerous multidisciplinary cruises in all fields of environmental science. Her principal operating zone is the Atlantic and the Mediterranean Sea, with occasional trips into the Indian Ocean.

L'ATALANTE



© IFREMER. Olivier Dugornay

The Fleet's first modern vessel, *L'Atalante* (85 metres) was delivered in 1989 and modernized in 2009. She is a multidisciplinary vessel featuring a complete range of scientific equipment, numerous laboratories, and the capacity to deploy *Victor 6000*, *Nautile* and the new seismic facility. *L'Atalante* can carry up to thirty technicians and scientists for cruises of up to forty-five days. She is the Fleet's only deep-sea vessel to be deployed across all the world's oceans and cruises the Pacific on average one year in every four.

THALASSA



© IFREMER. Olivier Dugornay

The *Thalassa*, delivered in 1996, is seventy-five metres long and concentrates on population ecology and the assessment of fisheries in the Channel, the Bay of Biscay and the North Sea. Fitted out with fishery echo sounders and trawling systems, she was originally intended to be a multi-purpose vessel for undertaking research cruises relating to physical oceanography. Following her refit in 2017 the *Thalassa* can now undertake geoscientific cruises and deploy the HROV *Ariane*. She can accommodate up to twenty-five scientists and technicians, and works mostly in the Atlantic and the Mediterranean.

OVERSEAS VESSELS

ANTEA



© IRD. Morell, Marc

The *Antea*, a thirty-five metre multipurpose research vessel built in 1996 in Les Sables d'Olonne, operates in the Mediterranean Sea, the Indian Ocean and the Tropical Atlantic. She undertakes oceanographic missions involving physics, chemistry and fisheries, as well as scanning the water column. Her speciality, similar to the *Alis*, is her capacity to sail long distances and undertake missions in distant regions.

ALIS



© IRD

This multipurpose scientific research vessel is twenty-nine metres long and entered service in 1987. Based in Noumea, she operates in the South-West Pacific Ocean from French Polynesia to Papua New Guinea. She undertakes missions related to physics, chemistry, biology, fishing, water column scanning and sea-floor mapping. Her hyperbaric chamber enables teams to undertake diving missions.

COASTAL VESSELS

CÔTES DE LA MANCHE



© CNRS/ INSU

The *Côtes de la Manche* entered service in 1997. She undertakes scientific research missions of up to ten days, mostly in the Channel and the Atlantic, in the fields of marine geosciences, biological and physical oceanography, biogeochemistry and ocean chemistry. She contributes to long-term observations of the marine environment, as well as research and trial missions in various fields of marine technology. She also undertakes training missions for universities.

L'EUROPE



© IFREMER. Olivier Dugornay

L'Europe is a 29.60 m catamaran built in 1993 in Les Sables d'Olonne and operates in the Mediterranean Sea. She is designed to undertake a variety of research missions related in particular to fishing and the coastal environment. She can carry out deep conventional trawling (down to 1300 m), pelagic and experimental trawling, deploy static traps (gill nets, longlines, pots, etc.), and undertake works related to seismology, sedimentology and hydrology (sampling).

HALIOTIS



© IFREMER. Olivier Dugornay

The oceanographic launch *Haliotis* provides a platform for mapping, based primarily on acoustic imaging, to obtain precise and reliable information on the character and morphology of very shallow coastal waters. Deployed from a trailer and operated by a crew of two along the entire French coast and in Corsica, as well as overseas, the *Haliotis* provides essential support to coastal vessels.

TÉTHYS II



© CNRS/ INSU

The oceanographic vessel *Téthys II* is 24.90 m long and entered service in 1996. She undertakes scientific research missions mainly in the Mediterranean Sea. This coastal vessel is fitted with instruments to satisfy the needs of researchers in the following fields: marine geosciences, physical and biological oceanography, biogeochemistry and ocean chemistry. She contributes to long-term observations of the marine environment, as well as research and trial missions in various fields of marine technology. She can also undertake training missions for universities.

THALIA



© CNRS/ INSU

This research vessel is 24.5 m long, was built in 1978 in Cherbourg, and operates in the Channel and the Bay of Biscay. She is a versatile vessel used for cruises in the coastal environment and to assess fish stocks. She is equipped for mapping with shallow-water multibeam echo sounders, taking hydrological measurements, recording underwater video, sampling by grab and dredge, as well as undertaking acoustic and seismic trials.

STATION VESSELS

ALBERT LUCAS



© CNRS/ INSU

The *Albert Lucas* is fitted out for coastal fishing and operates up to 20 miles from the coast, mostly in Brest roads and the Iroise sea. She is mobilized for various activities relating to observation, research and teaching in the fields of biology, marine ecology, biogeochemistry and oceanography.

ANTÉDON II



© CNRS/ INSU

The Antédon II specializes in coastal oceanography in a zone which stretches from Fos-sur-mer to La Ciotat. Her time is split between long-term observation missions on permanent study sites (SOMLIT-SOFCOM), training missions, and implementing instruments for scientific projects and technological trials.

NEOMYSIS



© CNRS/ INSU

The *Neomysis* operates up to 20 miles from the coast, mostly within a 30 mile radius of Roscoff (between Aber Wrac'h and Lannion Bay). She is mobilized for various activities relating to observation, research and teaching in the fields of biology, marine ecology, biogeochemistry and oceanography, as well as for collecting biological material for the CRBM.

NÉRÉIS II



© CNRS/ INSU

The *Néréis* focuses her activities on the Côte Vermeille, from the coast to the MOLA point directly above the Lacaze Duthiers canyon, 20 miles off Banyuls in the Roussillon Sea. She undertakes missions related to research, observation, teaching, aquariology, promoting science, and marine technology, the latter involving the maintenance of instrumentation buoys deployed by Banyuls Oceanographic Observatory.

SAGITTA III



© CNRS/ INSU

The *Sagitta III* operates up to 20 miles from the coast, mostly in Villefranche roads and around the Boussole buoy. She is mobilized for various activities relating to observation, research and teaching in the fields of biology, marine ecology, biogeochemistry, seismology and oceanography.

SÉPIA II



© CNRS/ INSU

The *Sépia* is fitted out for coastal fishing and operates up to 20 miles from the coast, mostly in a maritime zone which extends from Dieppe to the Belgian border, while sometimes making crossings to the English coast. She is mobilized for various activities relating to observation, research and teaching in the fields of biology, marine ecology, biogeochemistry and bio-optics. The ship also assesses the impact nuclear power stations and chemical industries have on marine waters and the seafloor.

PLANULA IV



© CNRS/ INSU

The *Planula IV* operates exclusively in Arcachon Bay; the conditions in the entrance channels exclude all missions on the open sea. Three quarters of her time is spent on research and observation, and the remaining quarter on teaching activities (themed courses and introduction to oceanography). Underwater devices regularly used aboard the *Planula IV* include dredges, grabs, plankton nets, bottles, probes and a SPI (sediment profile imager).

HEAVY AND MOBILE EQUIPMENT

THE GIANT CORER CALYPSO



© IFREMER. Stéphane HOURDEZ

The *Calypso* corer of the *Marion Dufresne* and the *Pourquoi pas*? is a piston corer used for taking very long samples of undisturbed sediment. Deployed using an aramid cable which is almost weightless in water, the corer's operating depth is limited to the cable's length.

THE SUBMARINE NAUTILE



© IFREMER. Stéphane Lesbats

The *Nautile* is a manned submarine designed for observation and manipulation down to a depth of 6,000 metres. She is used for reconnoitring specific zones, taking physical measurements, collecting samples and manipulating special tools, and searching for, locating, investigating and assisting in the raising of wrecks. She is operated by a crew of three: a pilot, a co-pilot and a scientist.

THE REMOTELY OPERATED ROBOT VICTOR 6000



© IFREMER. Michel Gouillou

The ROV Victor 6000 has been used at sea since entering service in 1999. Designed for scientific research in the field of oceanography, Victor 6000 is a modular and remotely operated deep-water system fitted with instruments. It can generate high-quality optical imaging, as well as carry and operate a diverse range of scientific equipment and tools. Its high-resolution optical imaging system (photo and video) ensures an optimal visual perception of the environment. Victor 6000 can also generate optical 3D reconstructions of the area under observation. It can undertake surveillance and identification cruises in study zones, and study zones that require video and acoustic inspection. It can harvest data and carry out manipulation, take physicochemical measurements in situ, and sample water or sediments. It is also a high-performance platform for developing technology.

THE HROV ARIANE



© IFREMER. Olivier Dugornay

The hybrid ROV *Ariane* represents the next generation of remotely operated submersibles that carry their own energy source in the form of batteries. Its only link to the surface is a fibre-optic cable. The *Ariane* is deployed from the coastal vessels of the French Oceanographic Fleet, in particular *L'Europe*, the *Antea* and the *Côtes de la Manche*. It undertakes dives to 2,500 m for short missions requiring manipulation, sampling, inspection or optical and acoustic mapping. Fitted with HD video cameras and a pan and tilt digital camera, the *Ariane* can undertake high-quality optical inspections and generate high-resolution photogrammetry (or 3D optical mapping).

THE PENETROMETER PENFELD



© IFREMER. Stéphane Lesbats

The penetrometer *Penfeld* is a geotechnical measuring device. Once in position on the seabed, it takes measurements in the sediment using a rod fitted with instruments. The penetrometer's maximum working depth is 6000 m. It features a rod which penetrates the sediment to a depth of 30 m. The rod is 36 mm in diameter and is wound around a 2.20 m diameter drum. It is straightened during penetration using the coiled tubing technique. A bearing cable connects the device to the vessel. It is powered by pressure-equalizing lead batteries.

SEISMIC EQUIPMENT



© IFREMER

Seismic systems for marine surveying are widely used to explore the oceanic crust at depths ranging from several metres to several kilometres. The pool of seismic equipment has been entirely modernized. Three systems – SMT, HR and SISRAP – are now available. These devices comprise an impulsive source (compressors and air guns) combined with a set of receiving sensors positioned along cables up to 6 km long towed by the ship. The many configurations available for the systems are able to satisfy the demands of most scientific cruises which focus on environments as varied as the coast or the deep sea, and whose aims in terms of resolution and penetration depth are extremely varied.

THE AUV ASTER^x ET IDEF^x



© IFREMER

The submersibles *Aster^x* and *Idef^x* are autonomous underwater vehicles (AUV) designed for the scientific reconnaissance of continental shelves to a depth of 2,850 metres. They perform dives without any physical connection to the surface vessel and do not require an operator. They have at their disposal a catalogue of payloads, including multibeam echo sounders, sub-bottom profilers, current profilers, CTD, magnetometers and other "user" embarked equipment, which can be leveraged thanks to adaptable interfaces. Used to improve the efficiency of remotely operated (Victor 6000) and manned (*Nautile*) submersibles, they represent a significant gain in efficiency by generating high-resolution charts and data relating to the diving targets of "heavy" equipment.

ENGINEERING, RESEARCH AND DEVELOPMENT

MAJOR DEVELOPMENTS ACHIEVED IN 2018

The year 2018 was marked by significant and technological developments which contributed to the quality of the tools placed at the disposal of the community. For a start, the seismic equipment pool was renewed in order to satisfy the needs of the scientific community. Works were undertaken on the vessels, such as modifications to the stern gantry of the Marion Dufresne. Submersibles were also improved: the ROV Victor was given a 4 K video camera, the Nautile's major refit was achieved with success and ensures her availability until 2025, and the fine-tuning of the latest modules for the HROV Ariane was completed. Changes to practices were also on the table. A telepresence solution was subjected to a series of trials in real conditions and showed potential for educational purposes.

IMPROVEMENTS TO THE MARION DUFRESNE

Despite an initial phase of works enabling IPEV to install a new stern gantry, the *Marion Dufresne* is not yet able to deploy the *Victor 6000* or the *Penfeld*. With a view to carrying out compliance works in September 2019, studies were undertaken in 2018 to determine the feasibility of deploying the *Penfeld* and the *Victor 6000*. Quite significant modifications to the stern gantry were required. In particular the addition of a holding ring to immobilize the vehicles, a system for taking up the slack/absorbing shocks on the hoisting winch cable, and a set of blocks to ensure the proper lead of the hoisting cable of the *Penfeld* once it has left the ship's deck. Similarly, the studies concerning the integration of the seismic equipment are ongoing and will result in the vessel's capacity to deploy new seismic systems after the refit in late 2019.



Modifications to the stern gantry of the *Marion Dufresne* © IFREMER

MODERNIZATION OF THE THALASSA

Following the propulsion problems which appeared in early November, the end of 2017 was very disrupted by the time it took the supplier to identify the source of the problem and correct it. This resulted in the near-complete cancellation of the **Evohe 2017** cruise.

A definitive solution was implemented and tested during December and early January 2018. Thanks to these works, the **IBTS** mission scheduled for 23 January to 12 February 2018 was able to go ahead as planned. As part of the modernization works, a series of technical trials was conducted in late April to measure radiated noise and confirm that, in return for a few improvements, the vessel is now compliant with the requirements of ICES 209, the underwater radiated noise standard of European fisheries research.

The acceptance at sea of the deep-water echo sounder EM304 was carried out in September. In general terms, the echo sounders own sound levels are excellent: the specified range was achieved (5.5 times the depth down to 1,500 m and in the region of 8 km below that, at least down to 4,500 m) and relative bathymetric accuracy complies with the specifications. The survey of the *Boehlen* shipwreck was carried out with the new shallowwater echo sounder EM2040 and its new "extra detection" option (more detection per beam), which generated some fine results in relation to its capacity for automatic detection in the water column.



Survey of the Boehlen © IFREMER

RENEWAL OF THE SEISMIC EQUIPMENT

The project to renew the seismic equipment was launched in late 2013, the aim being to place high-performance seismic equipment at the disposal of the scientific community.

The new equipment was developed over a period of five years, involving study phases, its purchase, its integration into the ships, and validating trials at sea. The total amount invested in the project for the period 2014–18 was €8,505,000 (including €1,500,000 from the ERDF and €2,400,000 from Brittany Council (CPER).

The final stage in the modernization of the seismic equipment concluded in 2018 with trials and the subsequent commissioning of the new seismic source SMT. The quality of the acoustic signal has been greatly improved thanks to a more precise synchronization of the air guns and the very stable geometry of the rig. This source was used for the first time during the **ILAB SPARC** cruise in late 2018. Initial processing of the data has shown that the signals emitted by this new source were detected by the Ocean Bottom Seismometers (OBS) at a distance of 750 kilometres, a feat which has never previously been achieved. These results should enable scientists to create better profiles of the oceanic crust, as well as the upper layer of the mantle, and improve their understanding of the phenomena which occur there.

Three entirely modernized systems – SMT, HR and SISRAP – are now available:

- SMT system. A 2D system comprising a 6,000 m streamer and a seismic source optimized for the acquisition of seismic reflection and refraction.
- HR system. A 2D or 3D system comprising two streamers which are 600 m long and can be configured differently in accordance with the scientific goals and the size of the support vessel (3D or 2D with a 600 m to 1,200 m streamer).
- SISRAP system. A 2D system comprising a 300 m streamer towed at 8–10 knots.

The many configurations available for the SMT, HR and SISRAP systems are able to satisfy the demands of a very large number of scientific cruises which focus on environments as varied as the coast or the deep sea, and whose aims in terms of resolution and penetration depth are extremely varied. These systems entered service in phases and have already been used on several cruises, producing data which has been published in scientific journals. Feedback from the scientific teams has been very positive (TECTA, GHASS...).

Numerous proposals received from the two latest calls for tenders by the CNFH (National Committee of the Deep-sea Fleet) demonstrate the expectation among the scientific community for this new seismic equipment (eleven proposals for 2019 and 9 proposals for 2020).

VICTOR 6000 IN 2018

5 cruises 38 dives 636 diving hours to depths of between 1,700 and 3,100 metres

An experimental 4K video camera was integrated for the scientific cruises in the summer of 2018 on *Victor 6000*. The resolution and sensitivity of the images sent up through the cable were better than the HD video camera installed, and available in 4K on a screen set up in the scientific operations room of *L'Atalante*. Feedback from scientists using the system has been very positive. The system, comprising the broadcast and recording of very high resolution video, will be permanently integrated as part of the system's modernization.

NAUTILE IN 2018

2 cruises 23 dives Average depth 3,400 metres

A major and comprehensive refit was carried out in 2018 to ensure the uninterrupted availability of a deep-water workclass submersible prior to the arrival of a new ROV in 2024-25. The major refit began in April 2018 and ended in late January 2019 so that it would be ready for a series of technical qualification tests. The major refit ensures that all the maintenance operations, including the complete dismantling of the submersible, can be undertaken: non-destructive inspections of the hemispheres and the viewports-hatches, manufacturing and fitting of the new equatorial seal. Obsolescent equipment was also replaced: surface IT system, battery chargers, new set of LED lighting and video cameras. The interior of the personnel sphere was partially rearranged, new propulsion controllers were installed, and the sonar was updated.



Assembling the *Nautile* in the final phase of the major refit. © IFREMER



New forward face of the *Nautile* with new LED floodlights © IFREMER

DEEP-WATER AUV PROJECT CORAL

Progress is being made in the CORAL project (6,000-metre AUV) in accordance with the contract agreed with the company ECA Robotics which is supplying the vehicle.

The review of the detailed studies took place in November 2018 and led to the validation of the proposed design. Analytical calculations confirmed that the design of the enclosures and structures complies with the demands of the required mechanical resistance. The size of the actuators and the inboard power supply were also validated. All the components of the vehicle are currently being either manufactured or integrated. The aim is for the shore-based acceptance of the vehicle to take place some time in 2019. The most recent meeting of thescientific working group finalized a shared strategy for procuring the sensors and scientific equipment which will be integrated into the AUV as part of the second phase of the CORAL project.

Project members organized a CORAL open day on 5 July in collaboration with the robotics group of the Mediterranean business cluster *Pôle Mer Méditerranée*. The aim was to communicate on the progress being made and to inform the representatives of services in the south of France of the economic aspects at work within the CORAL Alliance organized by IFREMER. Project members were also invited to the Marine Autonomy and Technology Showcase (MATS) in Southampton (UK) to present the challenges facing this new AUV.



Presentation of the CORAL Project.

INITIAL MOBILIZATION OF THE ARIANE ON THE ANTEA

Scheduled for 1–10 September 2018, the **ESSHROV**-**AN-2018** was the first outing of the HROV *Ariane* on the *Antea*. After a preliminary phase to install the HROV on the ship, an initial test dive was made in Brest roads. There followed four other dives to validate the operating procedure of the HROV from the vessel: two off Ushant in shallow waters, and then two down to 2,500 m in the Lampaul Canyon. At the same time, operators were able to carry out additional tests on the *Ariane* in its "mapping" configuration. The first scientific use of the HROV took place in late September during the **CYLICE-ECO** cruise.



Deploying the Ariane in Brest roads. © IFREMER



Mapping the wreck of the cargo ship *Boccaccio* off Ushant (the *Ariane's* 100th dive). © IFREMER

COASTAL AUVs

In October the AUV *Aster*^x carried out the following works in the second **TURBIDENT** cruise for the French National Research Agency (ANR): measuring currents that connect the subsurface layer of the water column to the bottom, along radial lines, in order to understand surface processes and improve digital forecasting models. *Aster*^x deployed an ADCP 1200 Hz pointing upwards to complement a standard ADCP (300 kHz, used for navigation) pointing downwards. Nine dives allowed the operators to collect 275 km of radial lines. The cruise was a continuation of the works carried out in recent years to develop environmental current-measuring techniques using AUVs.

TELEPRESENCE

The **TELEPRESENCE** cruise took place on 1–7 December 2018 and saw the HROV *Ariane* deployed from *L'Europe*. The aim was primarily to validate the pertinence of the telepresence concept on vessels of the French Oceanographic Fleet.

Telepresence should enable the greatest number of scientists and students to take part, from the shore, in the exploratory dives of remotely controlled submersibles. Information technologies are enabling us to optimize research cruises, to circumvent the limited number of available berths on the ships. Eventually this service will be offered routinely on eligible ships of the French Oceanographic Fleet.

During the cruise of the same name, telepresence was used between the ship and the conference room of the Geoazur Institute in Nice (France). Data from the *Ariane* was projected live, while the shore-based scientific team held a videoconference with the shipboard team. As a result, the mission turned into a veritable educational tool, integrating students on the master's degree research programme of Geoazur University (Master 3G) in the first semester. Scientific objectives were twofold and related to the study of tectonic and sedimentary changes occurring on the Ligurian Margin.

The project also enabled the ship to share a complete dive of the *Ariane* on the Nioulargue Bank with all the IFREMER staff on 3 December 2018 via IFREMER's intranet.

THE SOFTWARE SUITE TECHSAS NG

Ease of use and adaptability across various devices (mobile, tablet) have been the major sticking points for TECHSAS NG in recent years.

The new version of the data acquisition and visualization software for vessels at sea is now functioning. It makes data accessible to all seagoing personnel via a webpage. Its new interface also enables operators to monitor the proper acquisition of data from the sensors. At the same time, the replacement of the ship's log (CASINO+) was initiated. The Techsas application was also deployed on the *Marion Dufresne* in 2018.

This facility, which will be finalized in 2019, enables operators to bank data acquired by the vessel in SISMER. Scientific data produced in the NetCDF format is now standard between the vessels *Marion Dufresne II*, *Pourquoi pas*?, *L'Atalante*, *Thalassa* and *L'Europe*.



New interface of TECHSAS NG © IFREMER

NEWS OF THE FLEET MANAGEMENT'S R&D PROJECTS

The Oceanographic Fleet's management (DFO) can only supply national scientific teams with highperformance tools if it has the capacity to conduct in-house R&D projects that will contribute to the performance of resources either by bringing to the table new knowledge or by inferring developments. As such, we can highlight the signing in December 2017 of the new cooperation agreement with DGA-Techniques Navales, which was followed by an inaugural meeting on 14 February 2018 to detail the avenues for cooperation, being for the most part focused on robotic autonomy and organizational considerations. A workshop on the prospects for underwater technology took place on 20-21 February in partnership with the German Marine Research Consortium (KDM) as part of the JPI Oceans initiative. Approximately thirty-five participants convened to identify the most promising technological venues for oceanographic sciences. In addition, several projects were either launched or achieved significant milestones.

PROJECT H2020 EUMARINEROBOTS

The DFO is one of the partners in the project *EuMarineRobots* (H2020-Infrastructures) and took part in the launch of the project on 1–2 March 2018 in Porto University. As an "emerging community", the consortium brings together renowned European laboratories in underwater robotics (IST Lisbon, Giron University, Herriot Watt University Edinburgh...) and robot operators in oceanographic fields (Marum, NOCS, Marine Institute...) and for the military (CMRE-NATO), to propose a set of actions such as Trans-National Access (TNA) and Joint Research Activity (JRA). Under the TNA, IFREMER will provide access to the HROV *Ariane* and the AUV *Aster*^{*} for technical trials.

INTERREG PROJECT MATRAC

The project *Matrac*, which got underway in March 2018, is a research programme relating to the security of port and coastal zones. As part of the project, the Submersible Systems Unit (SM) will be working on methods for monitoring the environment, using the *Vortex* vehicle to test a strategy for intelligent autonomous missions based on the detection of targets and autonomous sampling. These functions could subsequently be offered to monitoring programmes and, eventually, be integrated into the real-time controllers of deep-water submersibles (such as the AUV 6000 *Coral*).

REM2040-2018

The **REM2040-2018** cruise on the *Thalia* enabled scientists to acquire an initial set of multi-frequency data on the trench off Ushant using the new EK-80 echo sounder. This will enable scientists to improve the updating of the EM710 and ME70 multibeam data acquired elsewhere, to calibrate the new EK-80s in detail on a wide range of frequencies, and to improve the methods for multi-angle and multifrequency acquisition with the simultaneous deployment of three EK-80 arrays on a boom. The datasets acquired this way will enable significant progress in works to calibrate the echo sounders and to improve our understanding of backscattering from the seabed.

PROJECT FUI ABYSOUND

The **DIVACOU18-Leg2** cruise on *L'Europe* is part of the project FUI ABYSOUND (2017–2020) managed by Naval Group.



ABYSSOUND array on the stern gantry of L'Europe. © IFREMER

The array developed under the project is designed to measure the noise generated by underwater mining or oil-drilling operations. The DFO is responsible for the sea trials. The aim of this cruise is to test and assess the feasibility of deploying the large prototype array in shallow waters, and to verify the acquisition and recording systems of the electronic containers associated with the array, thanks to the implementation of two sound sources with managed noise. Assessment of the entire system in depths of approximately 1,000 metres is scheduled for 2019 on *L'Europe*.

HYPERSPECTRAL IMAGING TRIALS ON THE ROBOT *VORTEX* IN THE IROISE SEA

Under the scientific coordination of Touria Bajjouk (IFREMER-ODE-DYNECO-LEBCO) the experimental underwater vehicle *Vortex* has been adapted for deploying and testing a hyperspectral video camera on sites of biological interest in Brest roads. This initiative is part of the wider project *Life MARHA* (Marine Habitats) in which researchers in marine biology coordinated by Touria Bajjouk study the use of hyperspectral optical data for classifying, surveying and characterizing underwater habitats.

Initial trials in Brest roads took place over five days at sea with, in attendance, representatives of the Iroise Marine Nature Park, scientists from the DYNECO laboratory and a marine biologist from the Norwegian company Ecotone which developed the hyperspectral video camera used.

Engineers of the DFO deployed the *Vortex* in AUV mode, fitting it with a radio buoy at the surface to allow the scientists to follow in real time the data acquired by the hyperspectral video camera. The *Vortex* dived on six sites in conditions typical of the zone (2-knot current, 30-knot wind, poor visibility of the seabed). Several optical mapping positioning tools available on the *Vortex* were used in conjunction with the hyperspectral video camera to map and georeference the data of the coastal habitats in Brest roads. The acquired data are currently being processed by the DFO in collaboration with the Ecotone company.



The experimental AUV *Vortex* flies over habitats of interest in Brest roads at 1 m above the seafloor. © IFREMER



Representatives from the Iroise Marine Nature Park and ODE-DYNECO scientists observe the operations. © IFREMER

C R U I S E S 2 0 1 8

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MISSIONS

- 🕅 Defense partnership
- IP Public service
- 🚯 Scientific cruises
- ME Technical trials mission

VESSELS

- MARION DUFRESNE
- POURQUOI PAS ?
- L'ATALANTE
- 🔵 THALASSA

ORGANISATIONS

CNRS Centre national de la recherche scientifique
Genavir Groupement pour la gestion de navires de recherche
Ifremer Institut français de recherche pour l'exploitation de la mer
IPGP Institut de physique du globe de Paris
IRD Institut de recherche pour le développement
MNHN . Museum national d'histoire naturelle
NIOZ Netherland institute for sea research
SHOM Service hydrographique et océanographique de la Marine
SU Sorbonne Université
UBO Université de Bretagne Occidentale
UPS Université Paris-Sud

L'ATALANTE NIOZ OFEG-NIOZ

L'ATALANTE CNRS MOOSE

ME

L'ATALANTE Ifremer ESS_SISM

PM

L'ATALANTE

L'ATALANTE Ifremer ESSROV18

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L'ATALANTE **Marine Nationale** RAMOGE

POURQUOI PAS ? SU SEFASIL

L'ATALANTE

Genavir ESS-DEC-ATA-18 ESS-GRAV-ATA-18

> PM L'ATALANTE SHOM PROTEVS-PERLE

MARION DUFRESNE UPS HYDROSED

MARION DUFRESNE UBO EAGER

SU WESTMEDFLUX

MARION DUFRESNE UBO MD 216 / MOUILLAGE OHA-SIS-BIO

MARION DUFRESNE CNRS VT158/OHA-SIS-BIO-10

MARION DUFRESNE MNHN/SU VT 159 / REPCCOAI

MARION DUFRESNE ~ **CNRS/UBO** VT161/HADOCC

MARION DUFRESNE

MARION DUFRESNE

OBSAUSTRAL

MARION DUFRESNE

VT 157 / OISO-28

CNRS/UBO

SU

Genavir

ESS_DEC

MARION DUFRESNE CNRS VT 160 / FOAM

MARION DUFRESNE CNRS MOBYDICK-THEMISTO

CRUISES 2018



OVERSEAS AND COASTAL FLEET







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