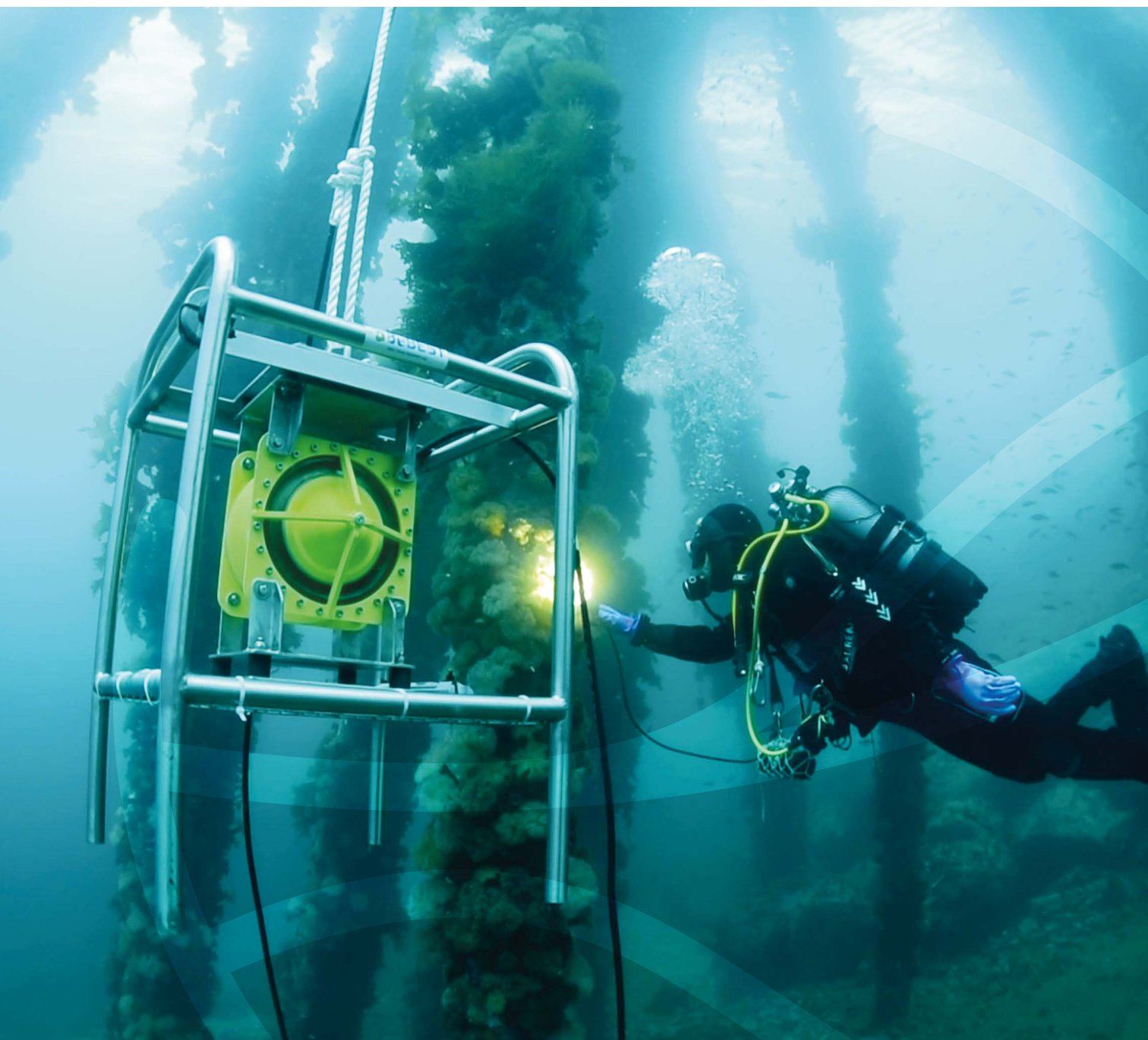




The interdisciplinary
graduate school
for the blue planet

2018-2023 REPORT



At a time when we need to preserve and learn more about our maritime environment, ISblue, the interdisciplinary graduate school for the blue planet, represents the ambition of those involved in research and higher education at the tip of Brittany to join forces in a common project.

Since its launch in 2018 thanks to support from the France 2030 programme, ISblue has established itself as a new place for innovation in interdisciplinary research and training, stimulated by the 21st century challenges of climate change and biodiversity crisis. ISblue has become a real vector for the development of projects and synergies driven by its research laboratories, often in interaction with its socio-economic partners, and open to the international arena. There have been many innovations at the crossroads of marine science and technology and we describe some of the success stories in this report. Support for activities at sea is also a key aspect of ISblue's activities. These are essential for our students to come face to face with the realities of the marine environment and to get involved.

ISblue is a catalyst for new approaches to master's, engineering and doctoral courses, all of which have been enriched and transformed by numerous exchanges among the teaching teams, making it possible, for example, to use virtual reality as a new training tool. Interaction with the socio-economic world is also being developed through the ISblue HUB's support of student projects in line with the realities and operational needs of the marine environment and the need to preserve it.

Through its actions, ISblue is now establishing itself as a major player in the international context of the United Nations Decade of Ocean Sciences for Sustainable Development (2021-2030). The advances made by ISblue over its first five years, detailed in these pages, represent the seeds of new discoveries and innovations that will be developed in the second phase of ISblue.

This new phase will doubtless lead to many others, enabling us to work for the common good and to enrich and renew the training of new generations of marine environment specialists skilled in understanding and supporting the transition to sustainable systems!

The ISblue management team

Cover photo : Laurent Chauvaud (LEMAR/BeBEST) dives under the quays of Saint-Pierre and Miquelon to deploy a sound source as part of the France-Quebec 'Auditif' project supported by ISblue.



A UNIVERSITY RESEARCH SCHOOL

ISblue, the interdisciplinary graduate school for the blue planet, aims to train new generations of researchers, experts and engineers capable of meeting the multiple challenges facing the ocean and coastal areas. This requires both a mastery of top level tools and concepts in one's specialty and the ability to work across disciplines. Whether we consider the role of the ocean in the climate system, seismic and erosion risks at the land-ocean interface, the impact of anthropogenic changes on coastal ecosystems and societies, or the development of artificial intelligence and drones for observing the global ocean, these challenges all require interdisciplinary approaches as well as strengthened international collaboration.

ISblue is funded for 10 years as a University Research School (École Universitaire de Recherche: EUR) as part of the investments for the future and France 2030 programmes, benefited from the experience of LabexMER, which joined the EUR in 2018.

The tip of Brittany is home to the largest concentration of marine science and technology researchers in France, as well as master's and engineering courses in this domain. Research and training are rooted in a rich socio-economic context, driven by the Pôle Mer Bretagne Atlantique cluster and Campus Mondial de la Mer. In this favourable environment, ISblue brings together two universities, four engineering schools and three research organisations around an ambitious research and training project:

- Université de Bretagne Occidentale (UBO) & Université de Bretagne Sud (UBS)
- École Navale, ENIB, ENSTA Bretagne & IMT Atlantique
- CNRS, Ifremer & IRD

ISblue is supported by 13 research units that cover all aspects of marine science and technology. Of these, 11 focus on the ocean and coastal areas. The IRDL and Lab-STICC include 'marine' centres in the fields of engineering, materials science, information and data.



▲ ISblue's 13 member laboratories work in an interdisciplinary manner on five research themes.

KEY FIGURES



Funding:
21.8M€/10 years



500 Research and teaching **staff**



29 PhDs co-funded



277 Doctoral students
270 Master's students
370 Engineering students



415 publications over 4 years

A COLLECTIVE TO CREATE NEW SYNERGIES

ISblue is run by a Governing Board consisting of representatives from the nine members, with UBO as the chair, the coordinating institution of the EUR. This board meets twice a year to examine strategic orientations and budgets. The operational committee comprises researchers and lecturer-researchers representing the EUR's five research themes and five major subject areas. The Operational Committee meets four times a year to develop strategy. Its members take part in project selection panels. The management team consists of a director and three deputy directors, reflecting the diversity of ISblue (universities, engineering schools and research organisations).

To guide its strategy and its ambitions for international visibility, ISblue benefits from the recommendations of an international interdisciplinary scientific council, made up of 12 scientists from 10 different countries. This board met in 2019 and 2022 in Brest, and in 2021 online.

ISblue is hosted and managed by the European Institute for Marine Studies (Institut Universitaire Européen de la Mer: IUEM), an internal school of UBO and Observatory of the Sciences of the Universe accredited by the CNRS and IRD. The ISblue Operational Team is based on the premises of the IUEM and the Pôle-Numérique Brest-Iroise, close to Ifremer's Brest centre, ENIB and IMT Atlantique.

MULTIPLE SKILLS AT THE SERVICE OF ISBLUE

- A team of five people in the IUEM administrative department oversees the management of administration and finance.
- Communication contributes to ISblue's reputation by organising scientific meetings for the community of lecturer-researchers, researchers and students. ISblue is present at national and international fairs and events, as well as on its website and social networks.
- ISblue benefits from IUEM's international relations department.
- ISblue relies on the École Doctorale des Sciences de la Mer to implement its policy at doctoral level.
- Five engineers, who specialise in educational engineering, digital training, virtual reality, and science communication in the media, carry out the training strategy.



A PROGRAMME OF RESEARCH

FIVE INTERDISCIPLINARY THEMES

ISblue's research is organised into five interdisciplinary themes, which generate new knowledge, cutting-edge observations, technological innovations and new training modules. These five themes structure ISblue's strategy of excellence in terms of interdisciplinarity and internationalisation.

Theme 1 - Climate regulation by the ocean: ocean circulation, sea ice, fluxes at the air-sea interface, the carbon cycle and chemical elements in the ocean, new global maritime trade routes.

Theme 2 - Interactions between land and ocean: geological, physical and biological processes on the seabed, deep-sea ecosystems, seismic and tectonic risks, mineral resources, legal and regulatory frameworks for seabed activities.

Theme 3 - Sustainability of coastal systems: sedimentary processes, erosion, resilience of ecosystems and societies to risks (rising sea levels, pollution, overexploitation), new activities linked to sustainability (renewable marine energies, eco-design), integrated coastal zone management.

Theme 4 - The living ocean and ecosystem services: how marine organisms and ecosystems function in the face of anthropogenic pressures, governance of marine resources (fisheries, aquaculture, biological resources), biotechnologies, ecosystem services.

Theme 5 - Long-term observation systems for knowledge of the ocean: new sensors, drone-based observation systems (surface, coastal, underwater), data mining, using artificial intelligence to increase the value of observations, integrated observatories, low-cost and participatory observation.



▲ The Pôle de Spectrométrie Océan (PSO), a shared facility, enables the ISblue community to carry out large-scale projects in the geosciences and biology. Here, a PSO engineer is training a master's student in the preparation of samples for mass spectrometry analysis.

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FUNDING TAILORED TO THE NEEDS OF RESEARCH

ISblue supports research through calls for projects open to the community, with four objectives:

- Encouraging the emergence of new research at the disciplinary interfaces, through leadership within the research themes and through emerging projects
- Supporting new research at sea and in the field, and making 'access to the sea' a more attractive proposition for teams
- Raising the international profile of our teams by hosting young researchers and co-funding PhDs
- Providing significant support for flagship projects that are emblematic of ISblue in terms of their originality, influence and impact on the international community, and their ability to feed into training programmes

Key research figures(2018-2023)

	Number	Amount
Emerging projects	30	330 k€
Research projects at sea	36	490 k€
Emblematic flagship projects	6	2460 k€
International post-docs	24	2530 k€
Co-financed PhDs	29	2770 k€



EDUCATIONAL OBJECTIVES

A NEW TRAINING DYNAMIC

The aim of University Research Schools is to train students to master's and PhD levels in an environment as close as possible to the research laboratories. Brittany has a wealth of high-level courses in all areas of marine science and technology. ISblue is based on the master's programmes in the field of Marine and Coastal Sciences (8 master's courses at the IUEM), on the maritime courses offered by the engineering schools, and on the École Doctorale des Sciences de la Mer et du Littoral (EDSML), which is home to 84% of the EUR's doctoral students.

ISblue improves these courses and makes them more attractive by sharing experience between institutions, developing new teaching methods and creating new joint courses. ISblue strengthens the interdisciplinarity of training modules, develops digital teaching, supports internationalisation initiatives and implements new training courses on the challenges of climate change and ecological and societal transition. Finally, the ISblue HUB contributes to the professionalisation of students and offers them the opportunity to carry out projects in conjunction with private companies and socio-economic actors.

Masters in Marine and Coastal Sciences	
●	Marine biology
●	Chemistry of the marine environment
●	Maritime activities law
●	Applied economics
●	Expertise and management of the coastal environment
●●	Earth, planetary and environmental sciences
●●●	Marine physics
●●	Marine biotechnologies
●●●●	Design engineering, marine engineering course
Engineering specialities	
●	Hydrography and oceanography
●	Naval and offshore architecture
●	Mechanics and energy in a naval environment
●	Maritime engineering, robotics applied to the maritime environment
Specialised Masters	
●●●●	Expert in marine renewable energy
●●●●	Cybersecurity of maritime and port systems
●	Maritime project management
●	Marine engineering, naval architecture and offshore
●	UBO / IUEM
●	IMT Atlantique
●	ENIB
●	UBS
●	ENSTA Bretagne
●	École Navale

▲ Training courses within the ISblue perimeter and the concerned institutions.

A WEALTH OF OPPORTUNITIES

For the past five years, ISblue has been offering a wide range of opportunities to lecturer-researchers, researchers, teachers and learners:

- Pedagogical support for implementing the skills-based approach and active teaching (serious games, projects, creative marathons, etc.);
- Support for the creation of digital modules, such as SPOCs (small private online courses) or hybrid courses (digital/classroom-based);
- Financial support for training projects (training for the ecological and societal transition, field training, international training, interdisciplinary training, arts and sciences, etc.);
- International mobility of master's and doctoral students (including to French overseas departments and territories);
- Support for international conferences and summer schools;
- Strengthening the link between research and training by funding master's courses;
- Helping to develop training courses by identifying companies' needs.

Key training figures (2018-2023)

	Number	Amount
Training projects	99	1 160 k€
Master's internships	97	310 k€
Conferences or summer schools	37	250 k€
International master's mobility	122	170 k€
International mobility and co-supervision of doctoral students	158	340 k€
Guest professors	21	285 k€



▲ The ISblue student community getting together for a start-of-year evening with a range of stands on the theme of ocean sustainability.

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OBJECTIVES AND AMBITIONS

PROMOTING INTERDISCIPLINARY RESEARCH



Ocean and society: healthy together **p.12**



Artificial intelligence: exploring an ocean of data **p.14**

Natural and human trajectories **p.16**



Sustainability of marine and coastal socio-ecosystems **p.18**

DEVELOPING AND IMPROVING TRAINING COURSES

Ecological and societal transition: an educational challenge **p.22**



Interdisciplinary and cross-disciplinary skills **p.24**



Educating society **p.26**



Training through digital technology and virtual reality **p.28**

STRENGTHENING INTERNATIONAL ATTRACTIVENESS

Discoveries at the heart of the ocean **p.10**



International outlook: attractiveness **p.36**



International outlook: mobility **p.38**



CATALYSING SYNERGIES ON THE SITE

Research with a regional focus **p.20**

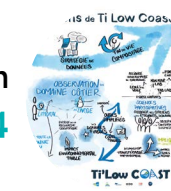


Universities and engineering schools: transforming education together **p.30**

ISblue HUB: a vehicle for professionalisation **p.32**



Connecting education and research with socio-economic actors **p.34**





▲ The research vessel Marion Dufresne, passing in front of the Kerguelen archipelago during the SWINGS mission in 2021.

© Virginie SANIAL

DISCOVERIES AT THE HEART OF THE OCEAN

The ISblue teams are conducting ambitious campaigns at sea to observe the ocean and deep seabed in situ. ISblue supports this work by facilitating the embarkation of young researchers on research cruises and by funding trials of new technologies.

OBSERVING THE MOVEMENTS OF THE SEABED

To better understand the seismic risks on islands and in coastal areas, we need to look at the movements of the ocean floor. Fluid circulation plays a major role in plate tectonic processes, particularly in subduction zones where fluids influence seismicity. The Manta-Ray-MV project aims to quantify fluid circulation in the Lesser Antilles subduction zone using piezometers deployed on the ocean floor at fluid seepage sites. One piezometer was deployed during the campaign and will be recovered in March 2024 by a vessel chartered with project funding. Variations in temperature and pressure in the data will indicate the rate of fluid flow, making it possible to study the relationship between fluid migration and seismicity in the region.

SEARCHING FOR RARE ELEMENTS

SWINGS (South West Indian Geotraces Section) is an oceanographic mission that took place in the Indian sector of the Southern Ocean from 13 January to 8 March 2021 and is part of the international GEOTRACES programme. During these 56 days at sea, Catherine Jeandel (LEGOS, Toulouse) and H  l  ne Planquette (LEMAR, Plouzan  ) coordinated the work of 48 scientists with the main objective of understanding how this oceanic region contributes to the subtraction of atmospheric CO₂. The support provided by ISblue enabled more scientists from Brest to join those on board. The 8,000 samples collected will make it possible to study more precisely how macro- and micronutrients, particularly trace metals, essential to the development of life, are brought in, transformed, transported by currents and deposited in the abysses.

A multi-proxy approach (radium isotopes, dissolved and particulate trace metals, prokaryotes) has revealed the existence of a new hydrothermal source, probably of the ultramafic type, at the level of the Southwest Indian Ridge.

Particular attention is currently being paid to the transport of trace metals, notably by the Agulhas Return Current and by a branch of the Antarctic Circumpolar Current at Fawn Trough, south of the Polar Front. These studies will provide a better understanding of the monitoring of the different ecosystems encountered during this transect of almost 12,000 km.

OCEAN AND SOCIETY: HEALTHY TOGETHER

The well-being of marine ecosystems is closely intertwined with the well-being of the people who rely on these resources for their livelihood. Two emblematic ISblue flagship projects, OMEGA and MARESISTOME, are studying the biology and ecology of exploited marine resources - fish and bivalves - to preserve or improve the health of consumers and ecosystems.

OMEGA

OMEGA aims to understand the effects that a reduction in the availability of omega 3 could have on the world's populations of small pelagic fish - such as anchovies, sardines and sardinellas - and on human populations. Omega 3s play a crucial role in maintaining vital functions such as heart, brain and immune function, as they are major constituents of the cell membranes of animals, including humans.

In the first area of this research, in situ sampling and historical data were used to build a database on the omega-3 composition of small pelagic fish from the world's main fisheries. Secondly, sardine farming was developed experimentally in the Bay of Biscay to test the effects of a dietary deficiency in omega 3 on fish physiology and behaviour. All the data was integrated into a third axis to model the evolution of these populations and their omega 3 quality. A fourth area, based on unique expertise in the economics of marine resources, has enabled the construction of a database tracing the potential influence of fishing methods on the omega-3 content of small pelagic fish. The importance of the omega-3 content for buyers of small pelagics is also being examined, through an analysis of canned sardine prices. The representations of their nutritional qualities by consumers of fish are the subject of a fifth area of research using psycho-sociological approaches to food. These show that the general public's knowledge of omega 3s is very patchy. Based on the results of research area 5, a sixth area of research is devoted to public outreach, including active participation in events for the general public such as the Fête de la Science and school activities, including participatory workshops with schoolchildren.

All the results generated by the project will provide essential elements for understanding the evolution of the global supply of omega 3s for the human population and the effects of global change on upwelling ecosystems, which are the most productive ecosystems in the world, with small pelagics being a key compartment.

► Small pelagic fish, including anchovies, sardines and sardinellas, account for around 1/4 of global fishing, and are the main source of omega 3 for humans. A basket of anchovies on a beach in Senegal

© GraphicNode, Unsplash.com



MARESISTOME

The MARESISTOME project aims to study the role of the coastal environment in the emergence and spread of antibiotic resistance, using clams as a model. To combat the increase in antibiotic resistance, an overall approach to human, animal and environmental health is needed, which is known as One Health. However, the role of the marine environment in antibiotic resistance is still largely unknown. To address this issue, the MARESISTOME project brings together an interdisciplinary panel of experts to address four specific objectives.

The first aim is to assess the presence and dynamics of antibiotic resistance genes and resistant bacteria in coastal waters and in the microbiota of clams from protected areas and those strongly influenced by humans, in order to determine the environmental factors likely to influence their spread. Secondly, the project aims to verify whether the ingestion of contaminated bivalves induces the transfer of resistance genes into the food chain. Thirdly, the project proposes innovative biotechnological strategies in aquaculture to mitigate the emergence and spread of resistance for sustainable aquaculture. Fourthly, an initial assessment of the state of knowledge of various actors (doctors, pharmacists, farmers, shellfish farmers, associations, public services, etc.) on the issues linked to the spread of antibiotic resistance in the marine environment will also be carried out.

The MARESISTOME project brings together areas of expertise that are rarely associated, but which are essential for a better understanding of antibiotic resistance in the marine environment. It also contributes to the training of students through work placements, an international workshop and a course module in the form of a Mutualised Interdisciplinary Project (Projet Interdisciplinaire Mutualisé: PIM) for ISblue master's students

ECOSYSTEM HEALTH FROM LAND TO SEA

The emerging project **ESTUARIES** integrates multidisciplinary environmental signatures: geography to identify land use; hydrobiology to monitor physico-chemical parameters of the water; chemistry to measure the pollutants present in the water, sediments and fish; and biology to study fitness biomarkers and apply molecular '-omics' tools on a model species, the European flounder (*Platichthys flesus*). The project has enabled progress to be made in characterising the ecological quality of estuarine ecosystems, in collaboration with CEDRE, local authorities and water managers.

ARTIFICIAL INTELLIGENCE: EXPLORING AN OCEAN OF DATA

Artificial Intelligence (AI) refers to advanced learning and data mining methods. As these have considerable potential to increase our knowledge of the oceans, ISblue supports the development of AI across the full spectrum of research.

BLUE REVOLUTION

The Blue Revolution project aims to develop AI-based observation and classification methods for benthic meiofauna (small organisms living in marine sediments) in order to generate annotated quantitative data and improve knowledge and mapping of these species. The project has made it possible to validate the use of a whole range of instruments (holographic microscopy, fluorescence microscopy) for in- and ex-situ imaging of meiofauna, from low resolution 2D to high resolution 3D. Neural networks have been constructed from pre-trained models for the automatic identification of benthic species from 2D microscopic images. A 1D model has also been proposed for species recognition using DNA sequence analysis. Models based on 2D and 3D deep networks have been developed for recognition from confocal fluorescence videos. To compensate for gaps in the data, the use of GANs (Generative Adversarial Networks) has enabled the generation of synthetic images of nematodes and copepods that appear as realistic as real images. To help train the taxonomists of tomorrow, three training workshops were organised on the use of imaging and AI for the taxonomy of benthic meiofauna.

High-throughput imaging coupled with AI is opening up a new way to rapidly characterise benthic communities. Future developments in the field will aim to increase the acquisition rates of imaging devices and to combine different learning models to improve the description of benthic diversity in order to monitor a wide range of anthropogenic impacts.

▼ Benthic meiofauna (small animals living in marine sediments) are one of the most diverse groups of organisms on the planet and are ideal ecological indicators and sentinels of ecosystem health.

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FROM PROOF OF CONCEPT TO OPERATIONAL OCEANOGRAPHY AND FUTURE SCENARIOS

ISblue is contributing to the OceanIX chair (physics-informed AI for observation-driven Ocean AnalytiX), which is developing new methods that jointly exploit knowledge of ocean physics and statistical learning. The first area of research has demonstrated that AI can replace the parameterisation of certain unresolved processes in numerical simulations of the ocean.

A second area of research concerns the reconstruction of sea states from partial observations. Many satellites scan the surface of the globe but rarely pass over the same point, so they do not resolve temporal variability. The new 4DVarNet software was first tested on synthetic data and then on real data. It demonstrated its ability to reconstruct a sea surface height field more accurately and cheaply than existing data assimilation methods. As part of a value-added approach, a collaboration is being developed with the company CLS (Collecte Localisation Satellites) for its operational implementation.

A third particularly fruitful area is the use of AI as an emulator of phytoplankton variability on a global scale. This work has been the subject of an emerging ISblue project, followed by co-funding for a PhD. The challenge was to reconstruct time series of phytoplankton concentration at the ocean surface over several decades despite direct satellite observations only covering a recent period of time.

AI has made it possible to meet this challenge, using relationships between phytoplankton and physical ocean parameters that have been observed for a long time. A refinement of the method takes into account the contrasting characteristics of phytoplankton ecosystems in different regions of the ocean. This work, which has now received more funding from the

ANR, will enable a more systematic exploration of the future of marine ecosystems under different climate scenarios.

YOUNG DOCTORAL STUDENTS TRAINED IN MARINE APPLICATIONS OF AI

In four years, with the support of the Brittany region, ISblue has co-funded 12 PhD projects on the development of AI methods and their application to the ocean. AI is used to process images of the seabed and coastal ecosystems, reduce uncertainties in climate projections, discriminate events in time series using unsupervised machine learning, automatically detect signals and geolocate from underwater acoustic observations, and reconstruct the origin of organic matter observed using sediment traps in the deep ocean. ISblue has also supported the dissemination of AI tools and concepts through 'AI & Ocean' doctoral courses.

NATURAL AND HUMAN TRAJECTORIES

Today's coastal societies are facing considerable environmental change. The reconstitution of ancient environments and the study of past human societies provide valuable insights into the vulnerability and resilience of civilisations. Two of ISblue's flagship projects are conducting this research, which concerns both sides of the Atlantic.

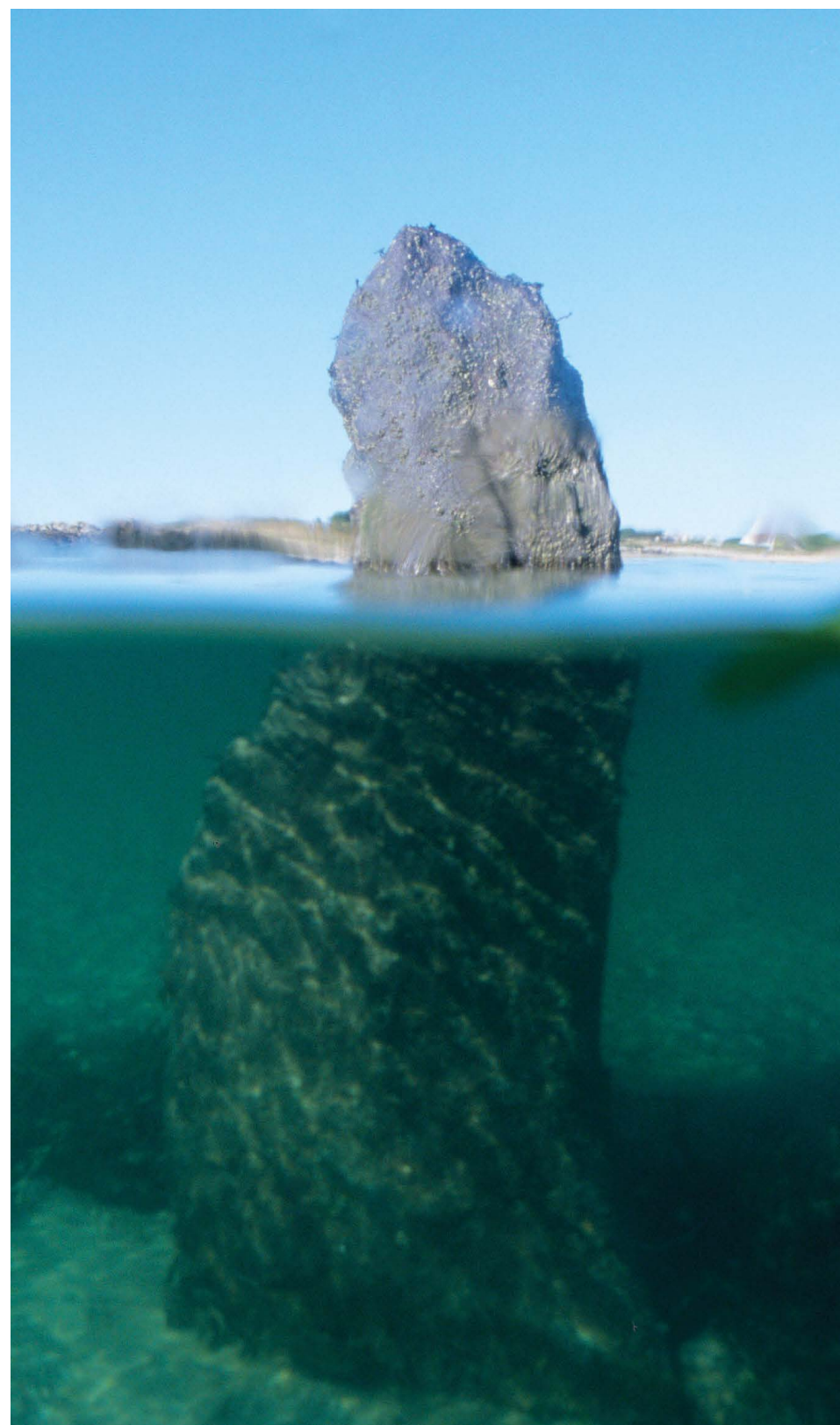
SEALEX

The SeaLex project aims to make a significant contribution to the contemporary societal debate on the impacts of climate change on coastal human populations. It is developing a retrospective approach to the long-term trajectories of socio-ecosystems, particularly in terms of adaptability and social resilience, from the beginning of the Holocene to the present day, in several relevant areas of the North Atlantic Ocean. The work carried out has led to the construction of a database of coastal archaeological sites based on documentary archives, surveys and detection methods.

In collaboration with the ARMERIE research chair (UBO-INRAP), three archaeological digs were carried out on the Molène and Saint-Pierre and Miquelon archipelagos. The shell middens of these places provide an ideal object of research for analysing the lifestyles of past populations, using archaeozoological, botanical, sclerochronological and ancient DNA approaches. This work has made it possible to identify extreme climatic events of the past, determine their geomorphological impact and assess their potential consequences for past human societies. The role of ocean circulation in these extremes has been studied on the basis of retrospective numerical simulations using a regional physical oceanography model for the current period, 3,000 years ago, 5,000 years ago and 9,000 years ago.

The SeaLex project has served as fertile ground for funded projects (ANR GEOPRAS), three PhDs and synergies with:

- other national and foreign teams;
- local (nature parks), national (INRAP) and international actors;
- UNESCO, for cultural heritage management;
- university training.



► A menhir now sitting in the water, evidence of a past when sea levels were much lower than they are today.

© René OGOR, Men Ozach

EVOL'IROISE

An innovative outreach tool for students and the general public, Ocean Touch is a large-format interactive touch-screen display that takes a fresh approach to the scientific poster, while overcoming the constraints inherent to the printed medium. The first scenario developed, called Evol'Iroise, allows visitors to immerse themselves in the research being carried out on the Brest roadstead and islands of the Iroise Sea to discover how they have changed since the last ice age. Rising sea levels, upheavals in coastal landscapes and changes in human society are described using language accessible to a wide audience, enhanced by original, interactive data displays and films. Several other scenarios have since been added to the system, which has been used in a wide range of contexts (trade fairs, courses and events for the general public).

PACTE

The PACTE project aims to reconstruct the trajectory of the socio-ecosystem of the Brest roadstead in response to a range of climatic changes and anthropogenic pressures at the outlets of its main tributary rivers, the Aulne and Elorn, over at least the last two centuries. The main objective is to reconstruct a chrono-systemic timeline of the evolution of the socio-ecosystem of the Brest roadstead by deploying an integrated study strategy combining:

- retro-observation using estuarine sedimentary archives;
- analysis of historical records of use and occupation of catchment areas, maritime activities and major climatic events;
- modelling the physico-biogeochemical trajectory of the land-sea aquatic continuum.

Bathymetric and seismic observations of the structure and sediment fill of the Aulne and Elorn estuaries will be used to feed the numerical models and choose sediment core sampling zones in the two estuaries. Retrospective analysis of environmental changes will be carried out using different palaeoecological approaches (microfossil analysis and statistical analysis of time series). The HistoRade project aims to retrace the trajectory of this socio-ecosystem between the eighteenth and twenty-first centuries. A hydro-biogeochemical model of the catchment area and river will also be implemented and coupled to a model of the Bay of Brest.

SUSTAINABILITY OF MARINE AND COASTAL SOCIO-ECOSYSTEMS

Coastlines are fragile, dynamic and heterogeneous environments with limited resilience to major natural or anthropogenic forcings. All the ecosystem services provided by the ocean, from fishing to tourism, need to adapt. ISblue supports the development of new approaches to research in support of management, combining environmental sciences with human and social sciences rooted in the emerging field of sustainability sciences.



▲ Within the Iroise Marine Natural Park, staff from the Office Français de la Biodiversité have been monitoring the status of species and habitats since 2017 and helping maritime professionals to reduce the impact of their activities.

Sébastien BRÉGEON | OFB

HOPOPOP

The main objective of the flagship project HOPOPoP is to foster the development of transdisciplinary and interdisciplinary approaches to sustainable marine socio-ecological systems (SES). This project emphasises the establishment of a collaborative transdisciplinary platform that promotes international reflection and fosters strong, innovative connections between science, education, practical actions, and society. This platform aims to unite scientists from diverse fields with local socio-economic stakeholders in order to develop integrated approaches and future scenarios for marine socio-ecological systems, using the Iroise Sea as an illustrative example. Integrated and participatory modelling approaches for the socio-ecological system, virtual reality and serious games are being developed in the project. These will encourage interaction between stakeholders, social learning and the search for sustainable trajectories for marine SES, by promoting interactivity and the use of models as intermediary objects.

The information needed to build these approaches and scenarios is obtained by studying the dynamics and evolution of the socio-ecological system of the Iroise Sea (in particular the interactions between living resources and coastal and recreational fishing activities). Knowledge-sharing workshops have helped to identify the key sustainability issues in the Iroise and to construct an initial representation of the interactions based on the ComMod (Companion Modelling) approach, which identifies the Actors, Resources, Dynamics and Interactions of a socio-ecosystem. International workshops and an international scientific committee will help to increase ISblue's leadership role concerning questions on the management of complex socio-ecological systems.

INTER- AND TRANSDISCIPLINARITY

Ensuring the sustainability of marine and coastal socio-ecosystems in the face of global change requires inter- and transdisciplinary research. To support these initiatives, 18 seminars and webinars have been organised for the entire ISblue community: researchers, lecturer-researchers and students.

With regard to the sustainability of coastal systems, these presentations explored all the dimensions inherent to theme 3 of ISblue: sustainable human activities on the coast, renewable energy production, mobility, ecology and observation of coastal risks in all their complexity.

Theme 4 - the living ocean and ecosystem services - has initiated a series of webinars in partnership with the Zone-Atelier Brest-Iroise (ZABri) on coastal and marine sustainability sciences. The aim is for the community to learn about and share the work and approaches developed by others in the field of sustainability science. By sharing research practices, views and approaches, the webinars aim to encourage the emergence of new collaborations, new research groups and new project ideas. This cycle of webinars combines presentations of work carried out in the field of coastal and marine sustainability sciences by members of the ISblue community or by guest researchers.

THE LAW TO FIGHT PLASTIC POLLUTION

Is the law, as it exists today, able to protect the ocean? To answer this question, the aim of Odeline Billant's PhD, supervised by Marie Bonnin, was to develop a method for analysing the law by using digital and quantitative tools to analyse its potential to offer protection. The experimental analysis of the regulations on plastic bags adopted by seven Atlantic countries highlighted the lack of scope and effectiveness of the legal texts, due to the large number of exceptions provided for and the insufficient regulation of biodegradable bags. Moreover, the diversity of approaches adopted raises questions about best practices on the eve of the negotiation of an international treaty on plastics.

RESEARCH WITH A REGIONAL FOCUS

A REMARKABLE SITE FOR THE STUDY OF MARINE SOCIO-ECOSYSTEMS

Situated at the tip of Brittany, the ISblue University Research School benefits from remarkable coastal and marine sites nearby. The Iroise Sea, Brest roadstead and its catchment areas make up the Brest Iroise Workshop Area (ZABrI), recognised by the CNRS as part of the national network of workshop zones and the European research infrastructure e-LTER (long term ecosystem, critical zone and socio-ecological research). Research within the ZABrI focuses on coastal socio-ecosystems, with a view to integrated management, sustainable development and transformation. Four emblematic flagship projects have chosen to use the ZABrI as a natural laboratory for their research. SeaLex, PACTE and HOPOP treat the Brest roadstead and Iroise Sea in a time continuum from the last millennia to future scenarios. These projects benefit from experience gained in ZABrI of co-constructing scientific questions and close collaboration with non-academic partners (Iroise Natural Marine Park, marine protected areas, local authorities, associations, professional groups, catchment area managers, etc.). The MARESISTOME project will also draw on observations made within ZABrI. ISblue is helping to strengthen interdisciplinary research along the land-sea continuum, particularly through the GLAZ project, supported by local authorities, institutions and organisations as part of the State-Region planning contract.

▼ The kelp forests of the Mer d'Iroise, exceptional in Europe, are remarkable habitats that provide food and shelter for a large number of species.

© Erwan AMICE | CNRS



PARTICIPATORY SCIENCE FOR MONITORING COASTAL HAZARDS

CoastAppli is a mobile participatory science application that enables a number of simple and accessible protocols to be implemented for monitoring coastal erosion and marine submersion hazards. The aim is to collect reliable, consistent and accurate long-term data to monitor changes in coastal dynamics, while simultaneously educating coastal users. The data is intended to help local authorities make appropriate, sustainable coastal management choices. The application was developed as part of an ISblue educational project that, over a 3-year period, brought together the technical programming skills of five students from ITM Atlantique and the thematic knowledge of coastal hazards and risks of ten students from IUEM's Expertise and Management of the Coastal Environment master's programme. In partnership with the OSIRISC observatory and Litto'Risques, the objective is now to extend CoastAppli to several municipalities in Finistère.

ISBLUE, A DRIVER OF ATTRACTIVITY FOR THE REGION

Attracting and training researchers at the highest international level is a major objective for the Brittany region. In its first phase, ISblue benefited from 28 co-financed PhDs, earmarked for the EUR by the region. ISblue has thus been able to support PhD projects with international co-management or co-supervision. The ISblue international post-doctoral programme has also been supported by the region in 2019 and 2020. The experience gained by the ISblue research units in attracting young international researchers has met with remarkable success within the framework of the Marie Curie COFUND Bienvenue European programme coordinated by the Brittany region. In two years, 17 young researchers (a third of the candidates selected by the international jury from the whole region) have joined ISblue laboratories to carry out their work in marine sciences and technologies. Finally, ISblue is encouraging teams to organise major international conferences in West Brittany (DEB2019, NereisPark, Deep Sea Microbiology, etc.) by allocating €10-20k to the largest events.



EDUCATION



▲ The plenary session reporting on the debates and agreements reached during the COP simulation organised by ISblue in 2022.

© Sébastien HERVÉ | UBO

ECOLOGICAL AND SOCIETAL TRANSITION: AN EDUCATIONAL CHALLENGE

The EUR ISblue universities and schools are aware of the immense challenges posed by climate change, the biodiversity crisis and environmental degradation. Oceans and coasts are at the heart of these major challenges, and every year more of our students ask us how we are taking them into account: the mechanisms at work, the socio-environmental issues they raise and the responses that scientists are developing.

Over these first five years, ISblue has supported interdisciplinary training projects, encouraging students to become more aware, more committed and more involved, both collectively and individually. Different aspects have been explored, leading today to the pooling of initiatives taken by ISblue establishments, to a better highlighting of the challenges in the range of courses on offer, and to the development of an Open Badge recognition system validating the new skills acquired by students concerning the socio-environmental dimension of maritime sciences in a world in transition. This approach is possible thanks to the strong links that exist between the research carried out in the institutions and the master's and doctoral training. ISblue strongly encourages the inclusion of training initiatives in all research projects dealing with transitions.

LEARNING ABOUT INTERNATIONAL NEGOTIATIONS

ISblue COP, an innovative teaching project, is a simulation of a Conference of the Parties (COP) by UBO students: the 300 students from the IUEM's eight Marine and Coastal Sciences (SML) master's courses and Geography bachelor's degrees. In the form of a role-playing game, the students take on the roles of the various actors at the COP, with the aim of proposing solutions to the challenges of transition via a joint agreement. Finding arguments and negotiating around the transition are just some of the challenges that the students have to face in this serious game.

INTERDISCIPLINARY AND CROSS-DISCIPLINARY SKILLS

ISblue courses cover all disciplines in marine science and technology. A major objective of the EUR is to strengthen the interdisciplinary culture and the ability of students to work together to experiment with new teaching methods and to generalise skills-based approaches within the courses.

MASTER'S STUDENTS FROM SEVERAL DISCIPLINES WORKING TOGETHER

At UBS, the AVOS-3D project brought together geoscience students from the Marine and Coastal Sciences master's programme and students from the IT master's programme. The aim was to improve 3D visualisation of complex objects, scientific media communication skills and group work. For three months, in collaboration with local partners, the students were able to experiment as a team with methods derived from Design Thinking to manage the development of digital application prototypes on coastal environment themes. The AVOS-3D project led to the creation of around ten digital application prototypes (websites, games, etc.). The momentum was then maintained with the students' participation in the Ocean Hackathon in Brest and the creation of a new application to promote the consumption of seaweed.



COMMON INTERDISCIPLINARY PROJECTS

Mutualised Interdisciplinary Projects (PIMs) are projects that bring together students from master's courses or engineering schools from across the whole of ISblue to work on cross-disciplinary themes. They do this each year for an intensive week in January and another in June. The PIMs are led by researchers and lecturer-researchers from the ISblue community. They are designed to enable students to work across disciplines, develop their interpersonal skills and prepare them for the socio-professional world associated with marine and coastal sciences.

This framework for learning and experimentation in a micro-project format is a place where all the students in the ISblue community can meet and exchange ideas, get to know each other and network. Each module brings together students from different disciplines to take advantage of the diversity of their backgrounds, knowledge and disciplinary contributions. Students choose their module from a catalogue of projects with a wide range of themes. Some PIMs are devoted solely to issues of ecological, social and digital transition. Others include actors from the socio-economic world to work on project methodologies and address issues of integration into the workplace. PIMs enable complex, cross-disciplinary issues to be tackled, while promoting active, collaborative learning formats.

INTERPERSONAL SKILLS TO MEET THE CHALLENGE OF SUSTAINABLE DEVELOPMENT

The PIM InterDEV gives ISblue students the opportunity to develop their interpersonal skills and use Design Thinking methods to respond to sustainability issues put forward by the socio-economic actors of Brest roadstead. Based on the identification of user needs, the students develop a viable and realistic solution concept in one week, taking into account all the issues involved in sustainable development.

◀ Presentation of an interactive 3D model of Brest roadstead produced as part of a PIM in partnership with the association SMAUG.

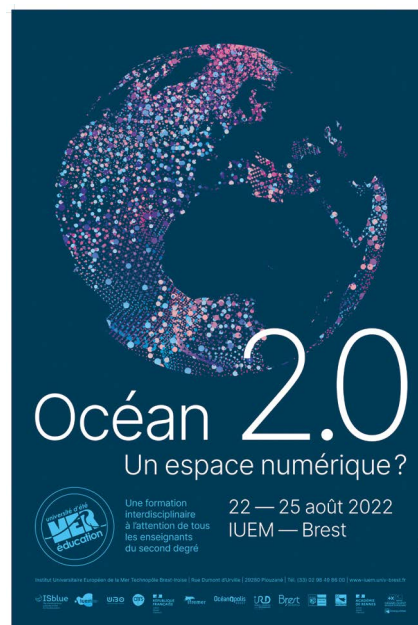
© Paula JACQUES | UBO

EDUCATING SOCIETY

As a University Research School, ISblue offers master's and PhD courses, but it also has a mission to help educate the general public about ocean and coastal issues and the advances made possible by new technologies. Training courses for professionals and scientific outreach activities are being developed with this in mind.

TRAINING TEACHERS IN INTERDISCIPLINARITY

The Mer et Éducation summer school is an event initiated by ISblue and co-organised with UBO, Océanopolis, Ifremer and Académie de Rennes. This training course in marine and coastal sciences for secondary school teachers takes place every year in the last week of August. Its aim is to bring secondary school teachers from all disciplines (science, mathematics, economics, languages, technology, etc.) into contact with science and scientists through lectures, workshops and visits, and to provide them with the knowledge they need to develop interdisciplinary teaching projects based on marine sciences. Every year, around fifty teachers focus on a different theme and meet the leaders of interdisciplinary research projects: ocean exploration in 2021, 'Ocean 2.0: a digital space' in 2022 and 'Ocean and Society: healthy together' in 2023.



▲ Posters for the 2021, 2022 and 2023 editions of the Mer et Éducation summer school, which each year trains secondary school teachers in research topics related to the ocean and coastal areas.

TRAINING JOURNALISTS IN SCIENTIFIC ISSUES

To meet the needs of journalists, expressed for many years, for training in marine science and technology, ISblue has provided a 2-day summer school in Brest, since 2019 at IUEM. This training course, for around thirty French-speaking journalists from different areas of the media, is designed in partnership with the École Supérieure de Journalisme de Lille (ESJL), the Club de la Presse de Bretagne (CPB), Océanopolis and the Institut France Québec Maritime (IFQM).

The course provides an innovative, multidisciplinary perspective on subjects chosen each year in consultation with researchers and journalists. The role of the ocean in climate change, the work of the IPCC, extreme events, the consequences and challenges for present and future societies, and cutting-edge ocean exploration techniques have all been covered. Over the next few years, the course will be further developed as part of the Mer et Medias (Sea and Media) University Diploma.



▲ Group photo of participants at the Mer et Journalisme 2022 Summer School.

© Sébastien HERVÉ | UBO

LIVING TOGETHER AND COMMUNICATING SCIENCE: AN 'ARTS & SCIENCES' WORKSHOP

This series of annual cross-disciplinary workshops brings together scientists, artists and a group of ISblue students around the theme of deep-sea ecosystems, so that their research, know-how and personal experiences can intersect, interweave and shed unexpected new light on the issues raised. The work includes writing, acting and sound recording/editing sessions, in an unusual location for three days of human adventure akin to that of a campaign at sea. Taking a variety of forms, the 'arts & sciences' projects have the common aim not only of sharing approaches but also of going beyond them and creating new ways of communicating with the public. The workshops are organised by researchers from Ifremer's Deep Environment Laboratory and the Brest-based theatre company Teatr Piba.

TRAINING THROUGH DIGITAL TECHNOLOGY AND VIRTUAL REALITY

While presential and field training represent strengths of ISblue, a distance-learning offer is needed to attract international students and a wider variety of audiences. A new-shared digital platform, called the Blue learning SPOT, will host ISblue's new online courses from the start of the 2023 academic year, and will be a hub of activity thanks to a social network of learners. ISblue also aims to use the new virtual reality techniques developed at the European Center for Virtual Reality (CERV) at ENIB for all its courses.

IMMERSEA LAB

ImmerSea LAB was created as a result of a collective reflection between scientists, teachers and engineers. It is a structuring approach to the use of virtual environments (virtual reality and augmented reality) in the marine and coastal sciences. From the creation of scientific communication scenarios to the construction of courses for initial training, ImmerSea LAB is an experimental space that aims to offer teaching and technical tools adapted to the needs of training and disciplinary expertise. Thanks to the pedagogical advantages offered by these technologies, they give users access to a diversity of interactions and environments that are difficult to access in reality (deep seabed or coastal areas impacted by climate change, for example).

Based on the research carried out by the ISblue partner institutes and the wealth of scientific data available, ImmerSea LAB encourages multidisciplinary connections through student collaboration with scientists and trainers. A variety of formats are used: student projects, internships, courses or ISblue PIMs (such as ImmerSea RADE), which together offer an active and innovative teaching approach based on virtual environments. ImmerSea LAB is currently supported by La Fondation Dassault Systèmes, which provides technical, pedagogical and project management support.

► Demonstrating the use of virtual reality for marine science at the Marine Imaging Workshop (MIW, October 2022).

© Olivier DUGORNAY | Ifremer



SILICA SCHOOL

Silica, from stardust to the living world

Silicon dioxide (SiO₂) is composed of the two most abundant elements on our planet. This course explores the past, present and future role of silica in living organisms, in the ocean and in the carbon cycle. This is an English-language course supported by an international consortium.

Target audience: ISblue and international students

Online: October 2020

Practical details: 32 hours of classes over 2 months each year

Number of students: 40-50 per year (80% international)

SPOC PHOTOLITTO

Introduction to coastal photogrammetry

From the theoretical basis of stereo photogrammetry methods to the processing of acquired data.

Three paths: Drone/Acquisition, Processing/Restitution or Complete Path.

Target audience: Professionals and ISblue students

Online: October 2023

Practical details: course available all year round, session run with a leader in January of each year

Number of students: 50 per year

SPOC FLOTRISCO

Coastal societies faced with coastal risks

The aim of this SPOC is to train future coastal risk management practitioners and students in the concepts of systemic coastal vulnerability, based on knowledge and understanding of hazards, stakes, management and social representations of coastal risks.

Target audience: risk management stakeholders

Online: October 2023

Practical details: courses available all year round

Number of students: 50 per year

IMMERSEA RADE

Over the past 12,000 years, the Brest roadstead has undergone a number of changes as a result of natural climate dynamics and the development of human activities. Conducted within the ImmerSea LAB, the PIM ImmerSea RADE set out to build scenarios of the evolution of this coastal environment using virtual environments (with the 3DEXPERIENCE platform). The students were as much part of the adventure as the researchers. Future editions will provide new visualisations and enhance the content of the project.

UNIVERSITIES AND ENGINEERING SCHOOLS: TRANSFORMING EDUCATION TOGETHER

ISblue's member institutions - two universities and four engineering schools - are developing new courses in synergy, with the support of the EUR. ISblue facilitates the sharing of field-based training and the experimentation of new practices within one institution, with the potential for wider adoption across the ISblue community.

A NEW COURSE IN OCEAN DATA SCIENCE

Data science has become an important discipline, linked to advances in computing power and artificial intelligence. Neural networks and machine learning enable us to tackle scientific problems of much greater complexity than before, and to extract information from very large databases.

Physical oceanography is making increasing use of these techniques to analyse large datasets from in situ, satellite or numerical models. There is a pressing need for training in artificial intelligence applications.

To meet these challenges, UBO, ENSTA Bretagne and IMT Atlantique have created the international Ocean Data Science course within the master's degree in Ocean and Coastal Physics. Designed and tested using ISblue, this course, taught in English, was officially opened in 2021, and has trained 20 students from the three institutions in its first two sessions.

Collaboration between the engineering schools and university enabled this course to be set up quickly. Its programme draws on the skills of the three institutions: traditional methods in physical oceanography (remote sensing, digital modelling and data assimilation), massive data mining, neural networks and learning methods.



ROBOTS TAKE THE PLUNGE

The Guerlédan project brings together hydrography and robotics students from ENSTA Bretagne and IUEM with students in the Ocean Data Science master's programme at IMT Atlantique for two weeks in the field: one in October and the other in February, with further joint sessions between these two weeks. The aim is to get students to work on practical problems that will enable them to use autonomous robots or hydrographic and oceanographic equipment.

Thanks to the subjects proposed by the different teachers as well as the industrial and academic partners, the students carry out a complete study ranging from the installation of systems to the production of data, including the adaptation of equipment and data processing. One of the aims of the course is to give students the autonomy and initiative they need for their end-of-study placements, as well as for their future careers as engineers or researchers. They also offer educational workshops to primary school pupils, who spend half a day learning about robotics and oceanography.

◀ Students on the Ocean Data Science course taking part in a two-week hydrography/robotics course on Lac de Guerlédan.

© Simon ROHOU | ENSTA Bretagne

HOLI-D BLUE

Holi-D Blue is a training and research project that aims to develop a holistic approach to training engineering and university students to understand and respond to environmental and societal issues in the maritime sector.

In practice, this involves the creation of a cross- and interdisciplinary path, integrated into the initial training curriculum of postgraduate students, starting with ENSTA Bretagne for the test scheme.

The principle of HOLI-D Blue is to integrate socio-environmental knowledge into existing curricula in order to put it into concrete perspective and encourage the development of dedicated skills (forward-looking analysis, systemic approach, co-construction, critical thinking, etc.) by building links between the students' different learning environments. In this way, not only teaching, but also community involvement, internships, student projects and pre-professional training are organised in a systemic approach that encourages cross-disciplinarity, experimentation and exchange with socio-economic actors.

At the end of the experimental phase, the aim of this project is to share and pool the results obtained (in terms of training programmes, support for professionalisation, teaching and scientific tools) with the entire ISblue community involved developing training courses related to the environment and the socio-ecological transition of maritime areas.

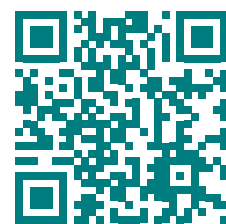
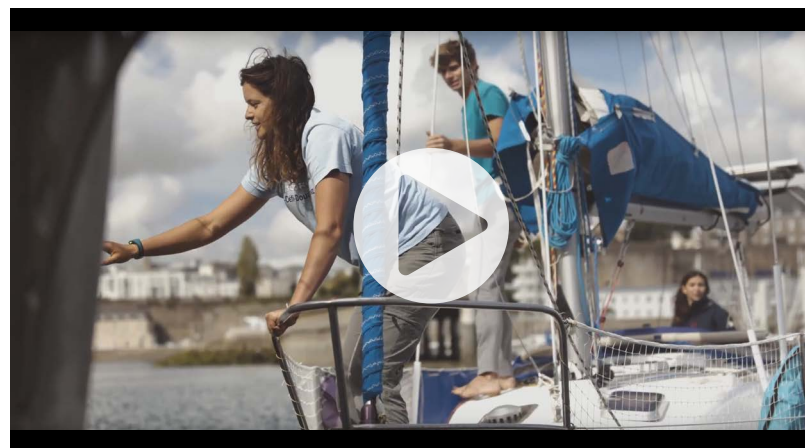
ISBLUE HUB : A VEHICLE FOR PROFESSIONALISATION

The ISblue HUB encourages students to get involved and prepare for their careers by helping them to carry out innovative, interdisciplinary projects in conjunction with local socio-economic actors. Students can respond to a permanent call for projects with an annual budget of €50k. Over two years, 14 projects have been supported out of 26 applications, with an average €4,000 for each project. Project leaders benefit from tailor-made support. The projects enhance the employability of graduates through the acquisition of soft skills, the development of their entrepreneurial approach and by skills mentoring within the HUB.

REALISING PROJECTS

'Into the Wakes' is a scientific expedition to cross the Atlantic under sail (10,000 nautical miles), combining social and scientific issues. The expedition, led by two students from ENSTA Bretagne, takes the form of a scientific laboratory, with sensors on board to measure the temperature, pressure and salinity of the water. This initiative brings together ISblue, the start-up OCEANOVOX, the Astrolabe Expéditions association and the ENSTA Bretagne ENSTAQUA student club as part of their Sparkling Sea project, which was also a winner in the HUB call for projects, aimed at gaining a better understanding of the oceans.

This project also establishes structuring partnerships with a social vocation. These partnerships aim to combat discrimination and promote access to education for all: a partnership with the Franco-Moroccan association Afoulki has been set up to work towards getting children into school and supporting young women in their education and independence. The two students have regularly offered video exchanges in the form of questions and answers, sharing their experience with pupils in a UPE2A (educational unit for newly arrived allophone pupils) class to help them gain better knowledge of the French language.



CREATING TOGETHER

The HUB offers IUEM students in the SML master's programme and IMT Atlantique engineering students the chance to take part in the 'LittObs' workshops (a participatory research programme coordinated by the Astrolabe Expéditions association, aimed at deploying a network of coastal oceanographic observatories with the help of local stakeholders). The students are supervised by the manager of the TéléFab FabLab and tutored by the lecturer-researchers as they build oceanographic instruments that will be incorporated into the LittObs network. This interdisciplinary project began in Brest roadstead and the Iroise Sea and is now aiming for deployment in southern Brittany and the Mediterranean.



▲ Places for creativity and collaboration, FabLabs are indispensable partners for HUB projects.

© Christophe DESBOIS | ENIB

MEETING UP

Every month, the HUB invites students to the Pôle Numérique Brest Iroise for a friendly discussion to encourage the development of collaborative projects.

Every month, the HUB invites students to the Pôle Numérique Brest Iroise for a friendly discussion to encourage the development of collaborative projects.

"Thanks to frequent discussions with Christophe (HUB Manager), we have matured our idea and structured an SML student project that is purposefully interdisciplinary, since it is in partnership with engineering students. The first experiment will be carried out during the PIM in June 2023."

Six IUEM Marine Biology master's students



© Christophe DESBOIS | ENIB

CONNECTING EDUCATION AND RESEARCH WITH SOCIO-ECONOMIC ACTORS

The HUB initiates and supports new projects in association with the region's socio-economic actors, both for research (in line with ISblue research themes) and for training (as part of the EUR's annual call for training projects).

ECO-DESIGN FOR SUSTAINABLE OBSERVATION

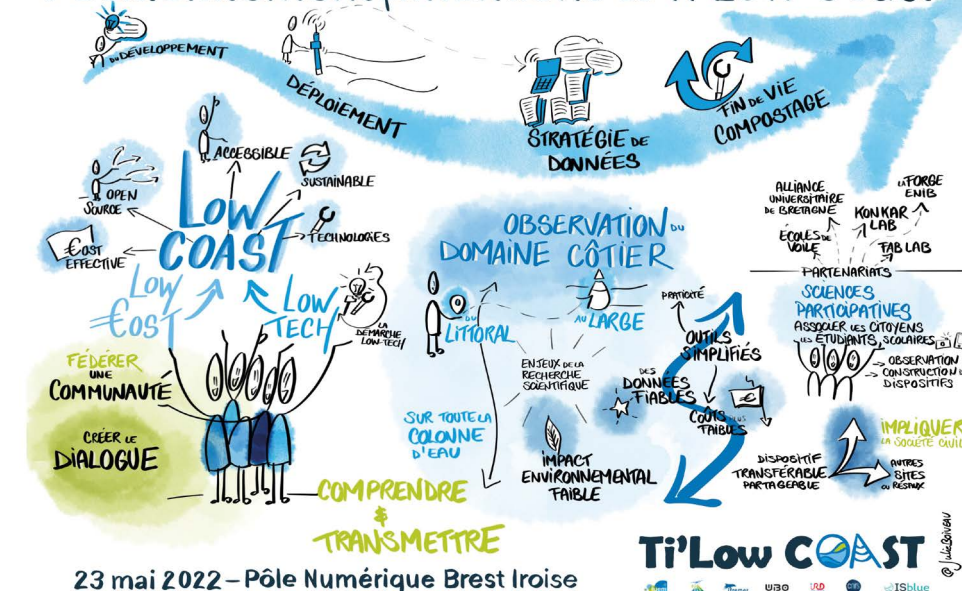
This training project is based on the innovations of the company Kairos, with the support of the Explore foundation. As part of a 5th year engineering school module at ENIB, the students have to design and build a marine drone prototype that meets a real need of ISblue's oceanographers. The originality of the project is that the proposed solution considers the environmental impact. The hull and rigid wing are made from Kairlin, a plant-based, compostable material (flax fibres and corn starch). ISblue HUB funding enabled the purchase of Kairlin, in collaboration with the company Kairos, who produce it, and sea trials of the prototype using the nautical resources of the Céladon association.



AN ANIMATED FILM TO RAISE AWARENESS ABOUT THE FRAGILITY OF THE DEEP SEA

The RESILIENCE project involved creating a short, animated film to raise public awareness about the impact of human activities on underwater ecosystems. The three directors and students took part in an Art & Science workshop funded by ISblue, where they met an Ifremer researcher and the PIBA theatre company. They then created a soundtrack to share their feelings and warn of the dangers of misunderstanding deep-sea environments. Wishing to reach a wider audience, they decided to add a visual dimension by calling on the services of an illustrator specialising in marine atmospheres. The animated film was presented at scientific outreach events such as the UBO Arts & Science festival RESSAC 2023, and the Génération Océan 2023 festival at the Cité de la Mer in Cherbourg.

Positionnement & Intentions de Ti Low Coast



► Graphic reproduction of the work produced during the Ti'Low Coast workshop.

© Julie BOIVÉAU

CO-CONSTRUCTING INNOVATIVE LOW-COST SOLUTIONS FOR OCEAN OBSERVATION

The HUB facilitates collaboration of ISblue researchers and engineers with all actors in the blue economy (public, private and maritime clusters). Meetings on the development of marine robotics are organised by ISblue themes 3 and 5 and the HUB, in conjunction with ISblue members, the Campus Mondial de la Mer and Pôle Mer Bretagne-Atlantique cluster. Two events, 'Marine robotics for observation' in September 2022 and 'The challenge of drones for coastal and ocean observation' in January 2023, brought together 90 participants, including eight companies.

A thematic group called 'Ti'Low COAST', initiated by the HUB and ISblue theme 5, has made it possible to initiate a multi-stakeholder co-construction involving academic players (CNRS / Ifremer / IRD / UBO) and a wide range of stakeholders. The group aims to take stock of the potential for integrating the low-cost concept into coastal ocean observation. Using an interdisciplinary approach that includes sustainability sciences, the aim is to characterise the low-cost technologies, techniques and strategies that have been integrated at all stages of the data production process, and to assess their relevance with a view to their integration into the ISblue community.



"The HUB enabled us to bring together more than a hundred stakeholders to develop a shared vision for our region, based on an inclusive and economic approach (one that is useful, accessible and sustainable). Bringing together more than 150 participants, three thematic sessions were held in 2022 in Brest, the first on 23 May presenting 16 low COAST projects on a local scale, followed by two other sessions in September at the IUEM as part of the IR ILICO programme for national scale impact".

Marion Jaud and Peggy Rimmelin-Maury,
coordinators of the Pôle Image et Instrumentation (P2i), IUEM.

INTERNATIONAL OUTLOOK: ATTRACTIVENESS

DEVELOPING INTERNATIONALISATION AND ATTRACTIVENESS

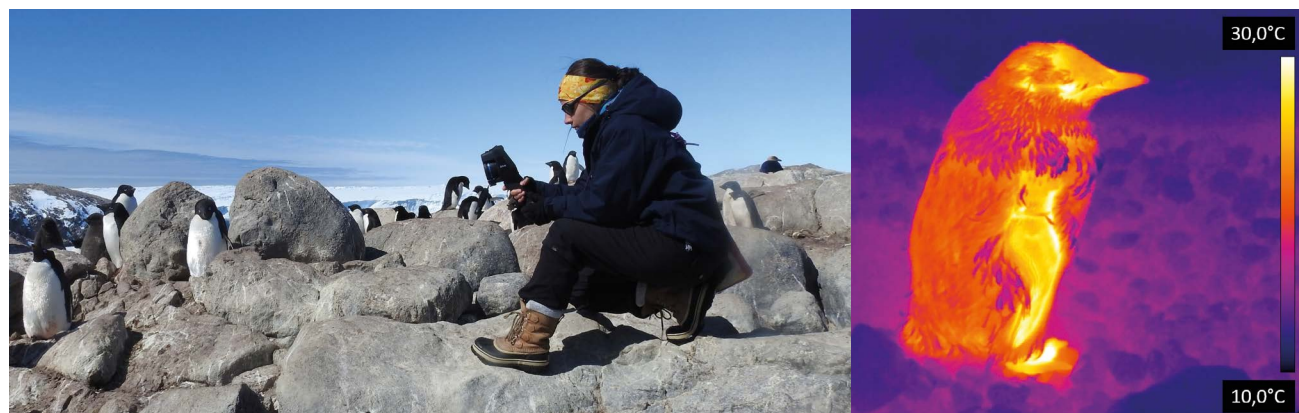
Boosting the international attractiveness of courses and laboratories is a major objective of the University Research Schools. In this context, the development of courses taught in English within the scope of ISblue courses is a strategy for attracting international students. Engineering courses and international master's programmes are offered in English: marine biotechnology, Master of Science in Marine Biological Resources IMBRSea, marine physics and the new ISblue 'ocean data science' path. Visiting professors supervise some Mutualised Interdisciplinary Projects (PIM) in English, including ones on aerosol chemistry and palaeo-sedimentology in January 2023.

WELCOMING TALENTED YOUNG RESEARCHERS

In partnership with Ifremer and UBO, ISblue offers young researchers with outstanding international careers the opportunity to develop their research projects within the site's teams.

Over five years (2018-2022), 21 post-docs have been recruited, out of 135 applications received. Half of the 12 young male and 9 young female researchers completed their PhDs abroad, and all have international experience. At the time of their recruitment, around 3 years after their PhDs, they had an average of 8.8 refereed publications.

Their stay in the ISblue laboratories offers them exceptional conditions for developing their projects over a two-year period. For ISblue researchers, the programme enables them to initiate international collaborations with these young colleagues that will continue beyond the duration of the post-doctoral projects.



▲ Agnès Lewden, an ISblue post-doctoral researcher at the LEMAR laboratory, is carrying out her research in Adélie Land and at Océanopolis. Using thermal cameras, she is trying to understand how climate change is affecting penguins.

© Téo BARRACHO | IPEV & Agnès LEWDEN | UBO

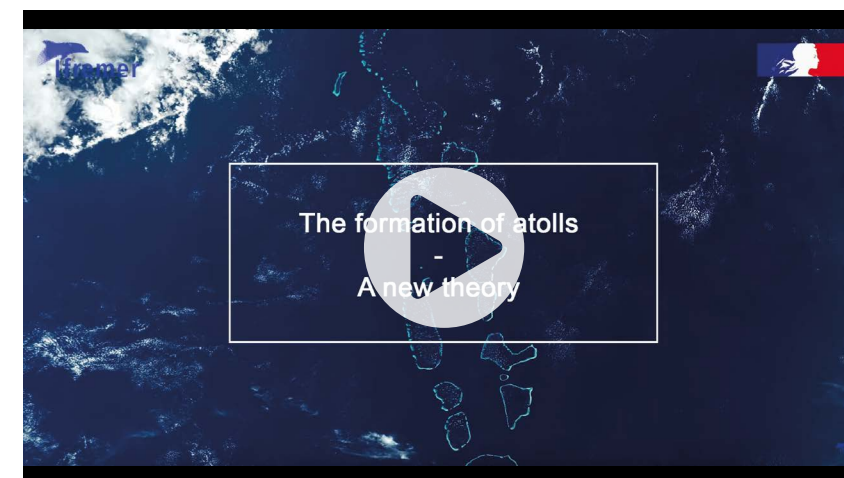
STRENGTHENING EXPERTISE AND INTERNATIONAL COLLABORATION

ISblue's visiting professors programme (19 visiting professors over 4 years) gives priority to supporting long or repeated stays that help to build long-term collaborations.

"At the invitation of Stephan Jorry, under the aegis of ISblue, I joined Ifremer and IUEM as a visiting professor. Over the last two years, for two to three months a year, I have taken part as a speaker in several ISblue seminars, taught at master's level, supervised several PhD students, written manuscripts and helped to develop future research projects, particularly on the Belize margin.

My recent stay at Ifremer helped to promote a recent paper that Stéphan and I published in 2021 on the origin of modern atolls. Because our proposal for an 'improved antecedent karst model' challenges Darwin's deeply entrenched 'volcanic structure subsidence theory' to explain the formation of modern atolls, our paper has generated interesting reactions in both the media and academia. Under the aegis of Ifremer and ISblue, Stephan and I have collaborated to produce a short video on this subject, which can be seen online."

André Droxler, Rice University (USA)



INTERNATIONAL OUTLOOK: MOBILITY

INTERNATIONAL TRAINING THROUGH MOBILITY

ISblue finances the mobility of master's and doctoral students, enabling ISblue students to go abroad and international students to spend time in ISblue research units. Over the last 5 years, 180 students have benefited in this way. One of the programme's original features is the support given to internships in the French overseas departments and territories (39 internships), in line with the strategies of the IRD and Ifremer.

"The aim of my internship was to obtain information essential for tackling the management and conservation issues facing bottlenose dolphins in the Guadeloupe archipelago. The internship gave me an introduction to photo-identification, both in the field and in analysis, and to the use of new software to process the results. What's more, a publication based on the work I have done is currently being written, giving me an introduction to the scientific writing process. This work placement in Guadeloupe has given me confidence in my career plans, which are to work in marine biology to promote the conservation of marine mammals."

Rachel HADERLE -
Mobility 2022, Master 1 in Marine Biology at UBO



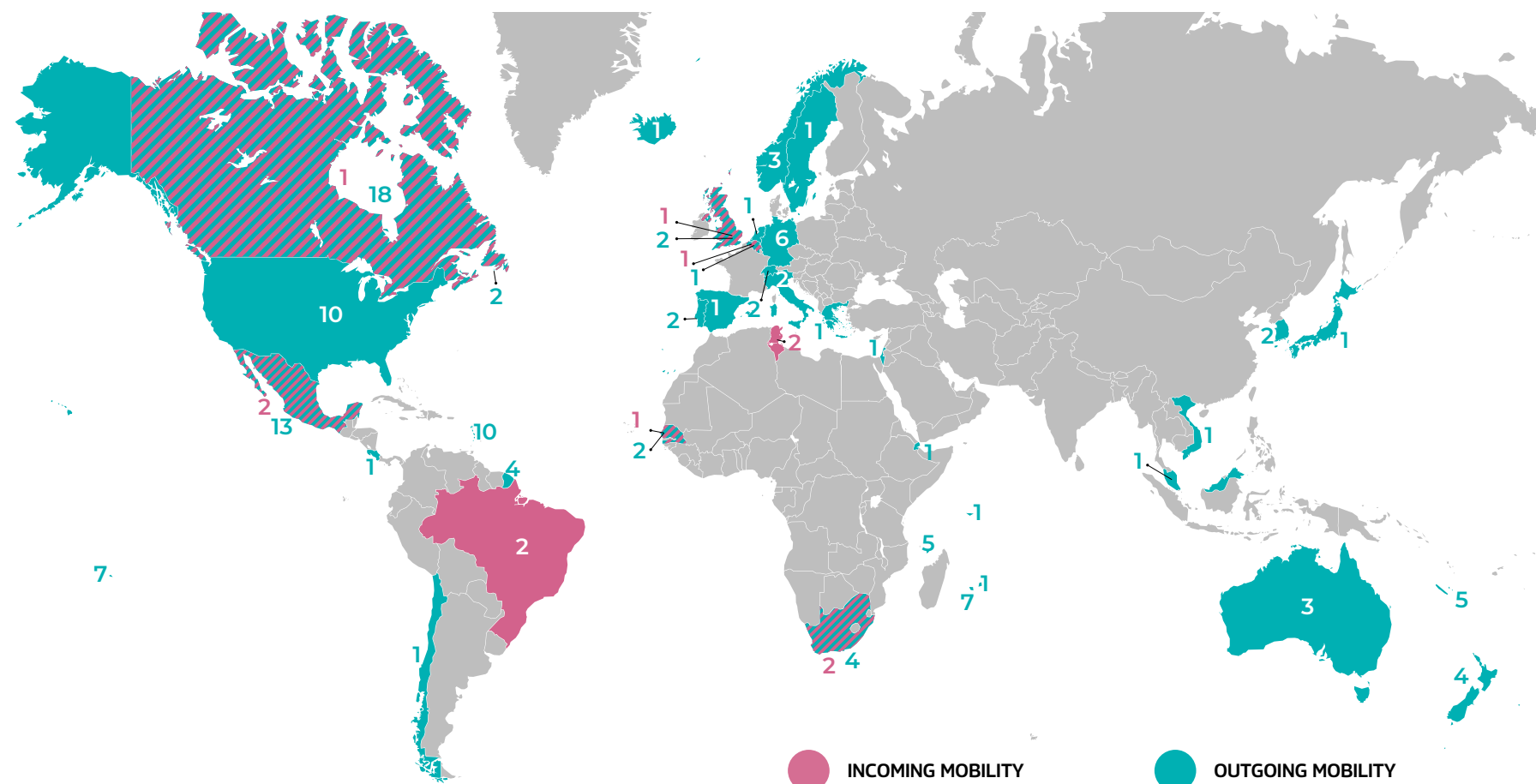
DOCTORAL STUDENTS CONDUCTING THEIR RESEARCH INTERNATIONALLY

The majority of ISblue doctoral students (84%) are part of the École Doctorale des Sciences de la Mer et du Littoral (EDSML); other doctoral schools on the site host doctoral students in marine engineering and technology from the IRDL and La-STICC research units. Thanks to ISblue, they all benefit from opportunities to carry out their work in collaboration with top international teams. ISblue has funded co-sponsorship of PhDs and joint supervision with foreign laboratories, as well as research visits abroad (124 projects over 5 years) and the hosting of PhD students from international teams in ISblue research units (33 projects). For these young researchers, the experience they gain, the new contacts they make and the wider network they develop provide opportunities for an international career.



"I spent just over 6 months at the Centre for Data Science (CDS), QUT, Brisbane, Australia, where one of my co-supervisors, Dr Paul Wu, works. My research focuses on modelling eelgrass beds using a hybrid method that combines a hydrodynamic model developed in France with a probabilistic dynamic Bayesian network model, developed in Australia. The main objective of the trip was to bring back a first version of the model coupled with spatial differentiation. I successfully met this objective. Other areas of work, such as the implementation of spatial processes and new nodes in the model, are still in progress. I have been included in two international working groups (Bayesian Research and Applications Group and Applied Mathematical Ecology Group) to which I have been able to present my work."

Carolynne CHERCHAM, Dyneco, Ifremer



◀ Map of ISblue-funded placements for master's students over 5 years: 129 outgoing placements and 12 incoming placements



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EDITORS

Christophe Claramunt, Jacques Deverchère, Anne Marie Treguier (ISblue Management), Laure de Montbron (Communications Officer)

GRAPHIC DESIGN AND LAYOUT

Sébastien Hervé

CONTRIBUTORS

ISblue team

Christophe Desbois, Paula Jacques, Maxime Kernec, Quentin Millière, Nadine Reniers, Riwalenn Ruault

Research unit and educational staff

Catherine Adam, Erwan Amice, Abdesslam Benzinou, Odeline Billant, Grégory Charrier, Laurent Chauvaud, Carolyne Chercham, Erwan Contal, André Droxler, Ronan Fablet, Erwan Gensac, Rachel Haderle, Alain Hénaff, Marion Jaud, Stephan Jorry, Frauke Klingelhofer, Gwenaëlle Le Blay, Pauline Letortu, Agnès Lewden, Claire Macher, Stéphanie Madec, Gwenola Martin-Bailly, Catherine Meur-Ferec, Irène Mopin, Amandine Nicolle, Charlotte Oerther, Laure Pecquerie, Aurélie Penaud, Hélène Planquette, Vianney Pichereau, Taina Postec, Peggy Rimmelín-Maury, Jozée Sarrazin, Pierre Stéphan, Jill Sutton, Paul Tréguer, Marie Vagner, Daniela Zeppilli.



ISblue

The interdisciplinary
graduate school
for the blue planet

TECHNOPOLE BREST-IROISE
RUE DUMONT D'URVILLE
29280 PLOUZANÉ

TEL : +33 2 90 91 56 27
WWW.ISBLUE.FR



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