

THE UNDERWATER DIMENSION

A guide on underwater research activities and related
academic paths at University of 'Milano-Bicocca'

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INTERNATIONAL MASTER COURSE IN 'MARINE SCIENCES'

UNIVERSITY OF 'MILANO-BICOCCA' - 'THE MALDIVES NATIONAL UNIVERSITY'

The **international** master course in 'Marine Sciences' is a **2-year master degree** programme envisaged for both **Italian and foreign students** and jointly offered by University of 'Milano-Bicocca' and 'The Maldives National University'.

Future professionals in the marine sector will need to navigate with agility through the complexity of the disciplines they will encounter. This programme aims at creating an **international network of alumni** who, despite coming from different scientific backgrounds and pursuing various careers after graduation, work closely together for two years, engaging in dialogue, and learning each other's scientific languages.

This explains why the international master course in 'Marine Sciences' has been structured as a highly **inter-disciplinary programme**, encompassing subjects from the **natural sciences**, such as the physics of the sea, marine geology and geomorphology, marine ecology and biology, as well as **humanities**, including the law of the sea, geopolitics of the sea, and human geography of small islands.

The programme includes **practical activities** conducted in state-of-the-art laboratories and at sea, both in Italy and abroad. It also involves underwater-related activities at the **research centers** of University of 'Milano-Bicocca' in Italy and the Maldives (MarHE Center), internships with the **national industry**, and collaborations with **foreign institutions** and **international organizations**.

All classes and seminars are held in English by an **international faculty** of lecturers, scientists and researchers, and the course entitles graduated students to apply for admission to **second level masters** or **PhD schools**.

UNDERWATER-RELATED DISCIPLINES

The international master course in 'Marine Sciences' encompasses the study of various disciplines related to the **underwater dimension**. It is approached with a practical orientation, fostering continuous interdisciplinary exchange. The main underwater-related disciplines addressed in the course are the following:



Marine Geology

INNOVATIVE TECHNOLOGIES FOR SEABED IMAGING, MAPPING AND CHARACTERIZATION

GEOMORPHOLOGY AND GEOBIOLOGY OF MARINE BIOCONSTRUCTIONS

GEOHAZARDS AND UNDERWATER ANTHROPOGENIC IMPACTS

UNDERWATER ENVIRONMENTAL HISTORY

OCEAN-BASED CARBON DIOXIDE REMOVAL

This branch of the programme includes courses in:

- APPLIED GEOMORPHOLOGY AND HABITAT (6 credits)
- FUNDAMENTALS OF MARINE PHYSICAL GEOGRAPHY (6 credits)
- GEOBIOLOGY (6 credits)
- BIOFACIES (6 credits)
- APPLIED MARINE GEOLOGY (6 credits)
- PALEOCEANOGRAPHY AND PALEOCLIMATOLOGY (6 credits)

In general, the study of marine geology at 'Milano-Bicocca' is pursued through research, analysis, and dissemination of results related to:

- bioconstruction and habitat engineers as environmental recorders
- biogenic carbonate production and storage
- marine habitat characterization, identification, and mapping
- conservation paleobiology
- geochemical proxies for the interpretation of recent past environments
- geomorphology of continental margins and coastal regions
- systematics, ecology and paleoecology of living and fossil calcareous red algae, benthic mollusks, foraminifera, micro and nannoplankton
- biogenic carbonate habitats: rhodolith beds, biogenic nodules (macroids) beds, coralligenous, cold-water corals
- holocene and historical evolution of the seafloor and marine habitats under environmental changes and human impacts
- mitigation of marine acidification and global warming

All courses are also part of the **M.Sc. in 'Geological Sciences and Geotechnologies'** (curriculum in 'Marine Geology') at 'Milano-Bicocca'.



Marine Biology and Marine Ecology

CORAL REEF RESTORATION

TROPICAL MARINE ECOLOGY

CORAL HEALTH AND DISEASE ASSESSMENT

This branch of the programme includes courses in:

- BIODIVERSITY AND MARINE ECOLOGY (12 credits)
- CHEMISTRY OF THE MARINE ENVIRONMENT (6 credits)
- FUNDAMENTALS OF MARINE BIOLOGY (6 credits)
- MARINE ENVIRONMENTAL MICROBIOLOGY (6 credits)
- MARINE INVERTEBRATE ZOOLOGY (6 credits)
- MARINE VERTEBRATE ZOOLOGY (6 credits)
- MANAGEMENT OF AQUATIC RESOURCES: FISHERIES (6 credits)
- COASTAL AND MARINE BOTANY (6 credits)
- MARINE MOLECULAR BIOLOGY (6 credits)
- UNDERWATER SCIENTIFIC METHODOLOGIES FOR ECOLOGICAL STUDIES AND MONITORING (6 credits)

In general, the study of marine ecology at 'Milano-Bicocca' is pursued through research, analysis, and dissemination of results related to:

- analyses of biological aspects of ocean ecosystems and the physical processes that regulate them
- invertebrate and vertebrate biodiversity studies
- new marine symbioses and their role
- in depth study about the ecology of coral reefs, seagrass meadows and mangroves
- anthropogenic impacts on marine habitats
- study and development of new passive and active conservation strategies
- marine habitats restoration and rehabilitation
- ecophysiology of marine organisms under stress
- impacts of plastic pollution of the marine realm
- bioprospecting
- emerging marine diseases
- mitigation of climate change impacts through new technologies
- educate and train new generations on the underwater dimension

On-site workshops on coral reef restoration, coral reef fishes, and mapping technologies in coral-reef environments are hosted at the **MaRHE Center** of 'Milano-Bicocca' in the Maldives.

Physics of the Sea

OCEAN TEMPERATURES AFFECTING METEOROLOGICAL PHENOMENA

INTERACTIONS BETWEEN PHYSICAL PROCESSES AND MARINE PRODUCTIVITY AROUND SMALL ISLANDS

CLIMATIC AND OCEANOGRAPHIC CONTROLS ON CORAL BLEACHING

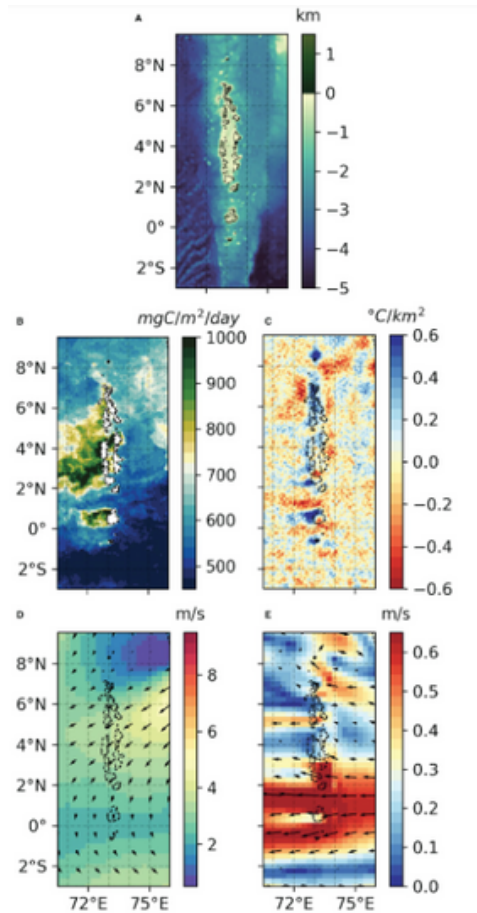
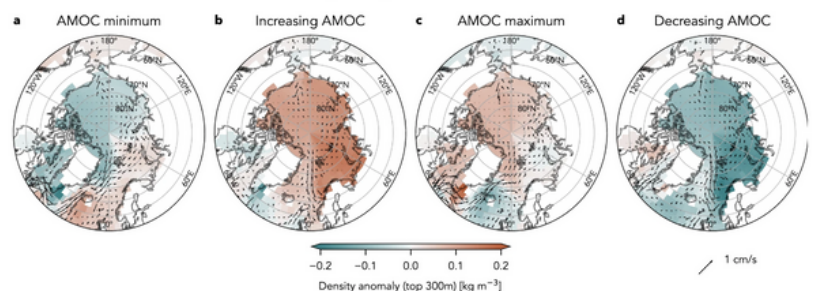


FIGURE 5 Maldives (A) Topography, (B) NPP, (C) SST Laplacian, (D) Wind Speed, (E) SODA3 currents, February 2013. Black dashed line represents the 100 m depth isoline.

From: High-latitude precipitation as a driver of multicentennial variability of the AMOC in a climate model of intermediate complexity



Composites of density anomalies (gridded) and velocity anomalies (arrows) in the top 300 m of the ocean for four AMOC phases. Each composite is obtained from 21 consecutive years per oscillation cycle. The full Atlantic basin is shown in Fig. S5

This branch of the programme includes courses in:

- PHYSICS OF THE SEA (6 credits)
- OCEAN MONITORING AND DATA ANALYSIS (6 credits)

In general, the study of the physics of the sea at ‘Milano-Bicocca’ is pursued through research, analysis, and dissemination of results in a broader range of topics. Those specifically related to the underwater dimension include:

- interactions between ocean dynamics and marine ecosystems using observational data and high-resolution numerical modeling (recent attention has been focused on the Maldivian region and coral reefs, with a specific focus on marine heatwaves and ongoing climate change)
- impact of subsurface conditions, particularly temperature profiles, on extreme events such as tropical-like cyclones, both in the Mediterranean and elsewhere
- deep circulation in the Atlantic Ocean, with a particular emphasis on mechanisms responsible for its variability
- analysis of the surface imprint of motions within the ocean boundary layer



Law of the Sea

LEGAL REGIME OF MARINE SPACES AND UNDERWATER ACTIVITIES
 PROTECTION OF SUBMARINE CABLES AND PIPELINES
 EXPLOITATION OF THE NATURAL RESOURCES OF THE SEABED
 MARITIME LIMITS AND BOUNDARIES: LEGAL RULES AND CASE LAW
 MARINE GEOSPATIAL INFORMATION MANAGEMENT

This branch of the programme includes courses in:

- INTERNATIONAL LAW OF THE SEA (6 credits)
- OCEAN AFFAIRS LAW & POLICY (6 credits)

In general, the study of international law of the sea at 'Milano-Bicocca' is pursued through research, analysis, and dissemination of results in a broader range of topics. Those specifically related to the underwater dimension include several aspects addressed in the United Nations Convention on the Law of the Sea (UNCLOS), such as:

- legal regime of marine spaces
- legal and technical aspects related to maritime limits and boundaries
- legal and technical aspects related to marine scientific research and hydrographic surveys
- overlapping maritime claims and the settlement of maritime boundaries disputes
- legal status of waters forming straits used for international navigation
- legal status of ships and submarines
- legal status of submarine cables and pipelines
- protection of archaeological and historical objects found at sea

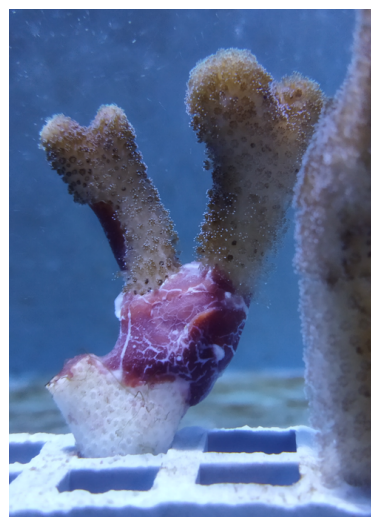
Additional areas of work currently include:

- Geographic Information System (GIS) and the law of the sea
- marine geospatial information management between legal, hydrographic, and cartographic aspects (in collaboration with **Istituto Idrografico della Marina**)
- practice in the act of deposit by coastal States of charts and lists of geographical coordinates with the United Nations Secretary-General (DOALOS)
- implication of emerging technologies on law of the sea issues
- contemporary developments at the interface of legal and technical considerations in the law of the sea
- legal status of unmanned underwater vehicles
- ocean diplomacy

CROSS-DISCIPLINARY OPPORTUNITIES RELATED TO THE UNDERWATER DIMENSION

Engineering, Characterization, and Degradation of Polymers in the Marine Environment

The course (6 credits) is offered within the international master course in 'Marine Sciences' under the aegis of the collaboration between the **University of 'Milano-Bicocca'** and **Istituto Italiano di Tecnologia (IIT)**. IIT researchers provides 'Marine Sciences' students with knowledge and understanding of: definition of polymer, types and synthesis of polymers and their main features; polymeric materials based on natural and synthetic polymers; engineering advanced and active polymeric material, characterization of polymeric materials such as morphological, thermal, and mechanical properties, interaction with water, and others; fabrication of polymeric materials such as solvent casting, spin coating, rod coating, electrospinning, extrusion, injection molding, blow molding, freeze drying, salt leaching, and others; engineered living materials; applications field of polymeric materials; definition of biodegradable, compostable, eco-friendly, green, and sustainable polymeric materials; plastics, bioplastics, micro-plastics, nano-plastics; and biodegradation and impact in the marine environment.

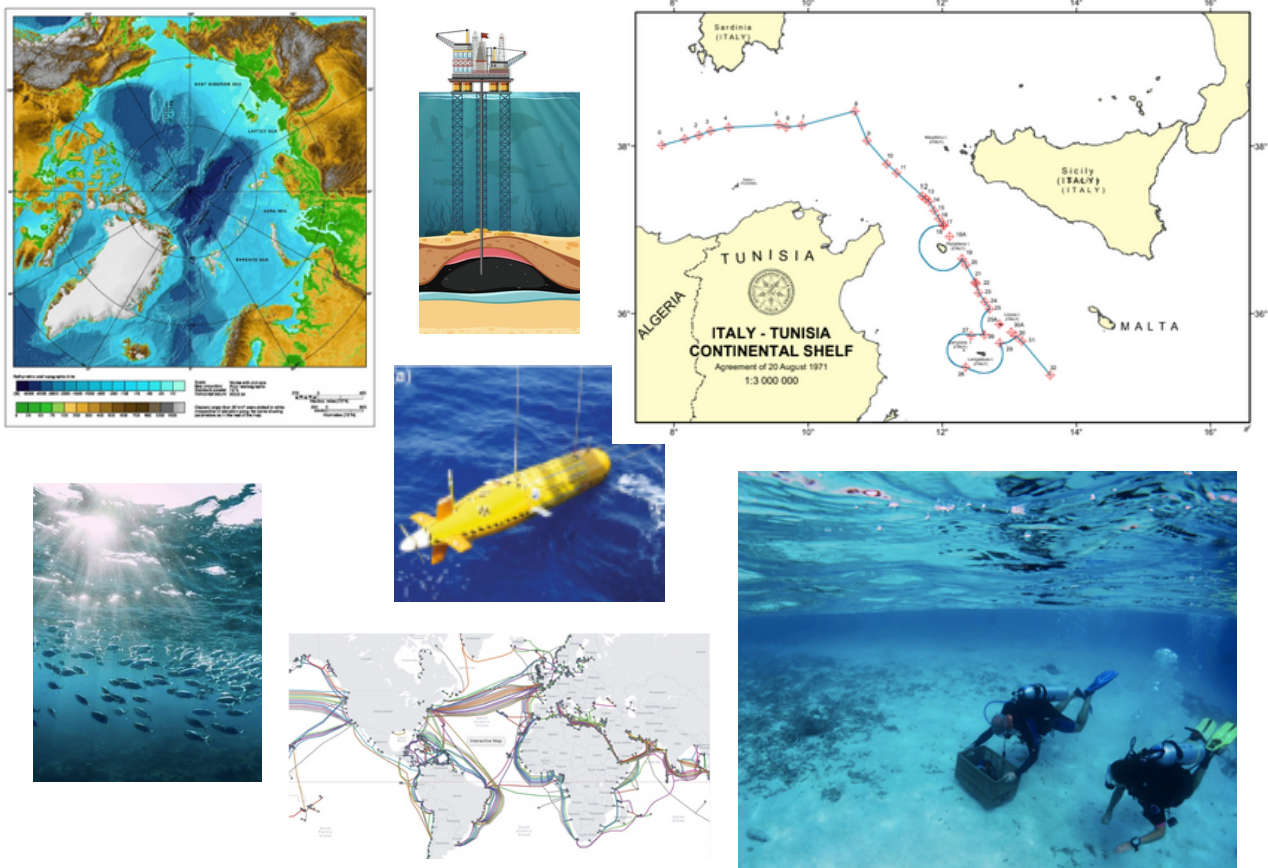


Multidisciplinary Marine Lab

The course (6 credits) is conducted through the analysis of **case studies**, selected by groups of teachers of the international master course in 'Marine Sciences' and examined in class from various perspectives. The goal is to help students understand the interactions between different disciplines in a fluid environment characterized by complex elements. This includes perspectives from the **natural sciences**, as well as consideration of the **legal, geopolitical, and geographical** aspects.

For example, a case involving a bilateral agreement or a judicial or arbitral decision on the delimitation of the continental shelf is examined from its legal, geographical, geological, and geomorphological implications. The management of a fishery stock is considered in terms of its bio-ecological, legal, and social implications. The selection of marine protected areas is made in light of conservation objectives as defined in international legal instruments, supported by scientific evidence, and it is effective when it takes into account the complex realities studied in human geography.

Through these case studies, students can understand challenges inherent in **decision-making processes** and some of the contradictions inherent in choices for managing or "partitioning" the marine environment. This approach helps students become more **aware managers and interlocutors** in their future professions, better equipped to address the complexities of marine-related issues.



DOCTORAL PROGRAMMES

The Doctor of Philosophy (Ph.D.) programmes are designed to prepare students for research careers in **academia** and the **industry**, and include the following steps:

- assigning a dissertation advisor
- successfully completing the program coursework
- passing the dissertation proposal defense to obtain candidacy status
- preparing, submitting, and successfully defending a doctoral dissertation

Two Ph.D. programmes within the **Department of Earth and Environmental Sciences** of University of 'Milano-Bicocca' offer specialized training on aspects related to the **underwater dimension**.

PH.D. IN CHEMICAL, GEOLOGICAL, AND ENVIRONMENTAL SCIENCES

CURRICULUM IN TERRESTRIAL AND MARINE ENVIRONMENTAL SCIENCES

Courses relevant to the underwater dimension offered in this Ph.D. programme include:

- **UAV/ROV and Immersive Virtual Reality for research in volcanically, tectonically and climatically sensitive areas**
(geological curriculum)
- **Introduction to geo-dynamic and landscape evolution numerical modelling**
(geological curriculum)
- **Data analysis applied to the environment: soundscape as index**
(environmental curriculum)
- **Spatial variability of environmental characteristics and mapping methodologies**
(environmental curriculum)
- **Seafloor mapping, biogenic habitats and marine management**
(environmental curriculum)
- **Open source software for spatial data analysis**
(intercurricular course)

A diverse range of research lines characterize the Ph.D. programme.

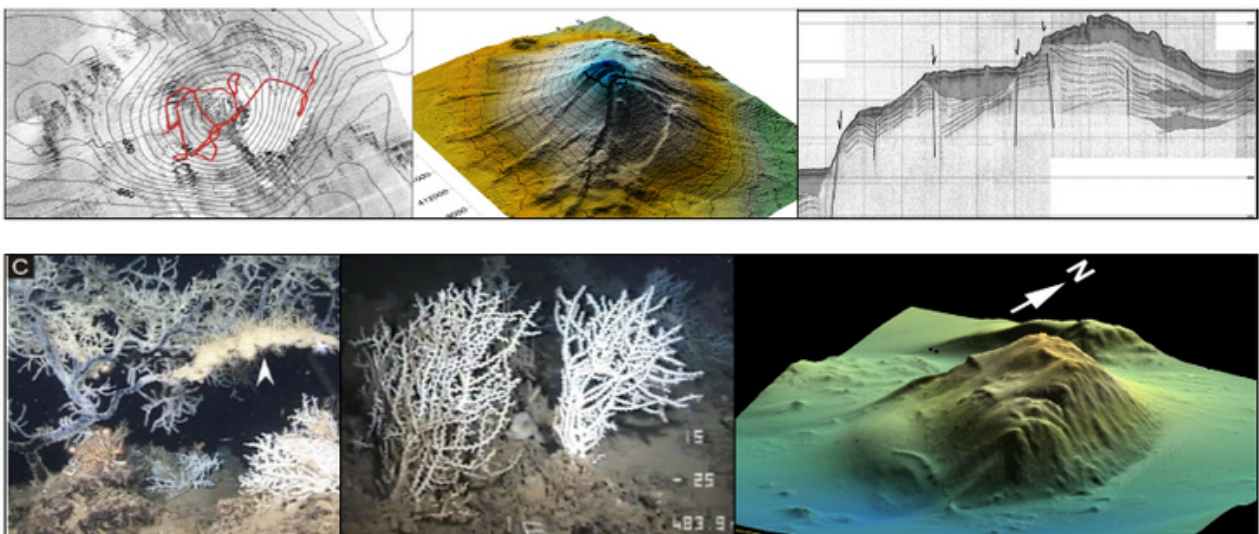
For instance, in the XXXVIII cycle, one research line of the curriculum in terrestrial and marine environmental sciences relates to ***“The use of advanced geomorphological mapping techniques for innovative research in the science of marine geohazard and environmental changes in coastal environments”***.

The research aims at proposing advanced approaches in visualization, analysis, modelling, interpretation, and communication of **geological and environmental data in 3D** for coastal and underwater environments.

More specifically, the research focuses on providing ground-breaking techniques to produce **coastal and underwater geomorphological maps** (with a seamless integration of geospatial marine and terrestrial dataset), aimed at emphasizing the role of the abiotic component in determining the spatial extent and distribution of benthic habitats of ecological importance.

Developed methodological aspects involve advanced algorithms for the generation of 3D models, with the integration of multi-source data, and of data analysis approaches based on the use of **AI (Artificial Intelligence)** and **VR (Virtual Reality)** techniques. The aim is to increase the effectiveness of interpretation processes as well as the recognition and mapping of **geological phenomena and anthropogenic impacts in underwater areas**.

The expected results aim to have important implications for the **industry**, (infrastructure, oil and gas, renewable energy, etc.), for **marine spatial planning** strategies, and in all **management practices** of the coastal and offshore environment.



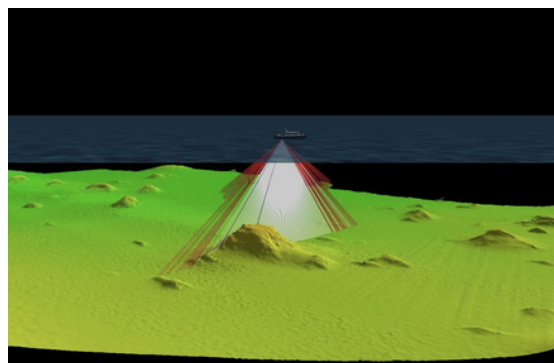
PH.D. IN MARINE SCIENCES, TECHNOLOGY, AND MANAGEMENT

This Ph.D. programme is a consortium doctorate offered by **University of 'Milano-Bicocca'** and **Istituto Italiano di Tecnologia (IIT)**. The two research entities have had formal agreements in place since 2017, including collaboration on marine research topics, resulting in numerous scientific publications and patents.

The main themes of this doctoral program encompass various **areas of interest for the underwater dimension**, offering a comprehensive perspective on marine and maritime studies. Ph.D. students have access to numerous **state-of-the-art facilities** in the fields of marine, chemical, geological, and environmental sciences, which are hosted at the Department of Earth and Environmental Sciences and other departments at University of 'Milano-Bicocca'. Facilities include equipment from the interdisciplinary microscopy platform, the University's mass spectrometry equipment, and laboratories at the MarHE Center, located in the Maldives.

Courses relevant to the underwater dimension offered in this Ph.D. programme include, among others:

- **New materials and technologies applicable in the marine environment**
- **Polar questions and the law of the sea**
- **Technical aspects of the law of the sea**
- **Maritime space and globalization: economic and environmental questions**
- **Network analysis for ecologists**
- **Habitat mapping for ecosystem-based management of the deep sea**
- **Technologies for the analysis of contamination in the marine environment**
- **Use of Unmanned Aerial Vehicles (UAVs) for monitoring coastal and nearshore environments**

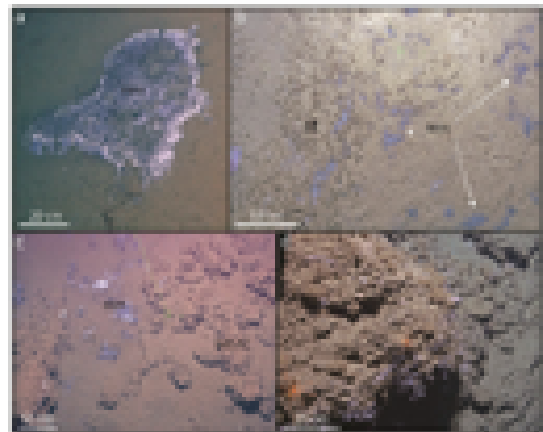


A diverse range of research lines characterize the Ph.D. programme.

For instance, in the XXXVIII cycle, one research line relates to ***“The application of 3D photogrammetry and geospatial modelling techniques for cold-seeps habitat classification in the Arctic ocean”***.

The research aims at exploring **innovative seabed mapping techniques** to further understand and categorize cold-seeps habitats of the Arctic ocean, developing 3D imaging classification workflows. Photogrammetric and advanced geospatial modeling techniques, such as OBIA (Object-based Image Analysis), are applied to a wide dataset of ROV videos (collected within the framework of the international project **‘Advanced Knowledge of Methane in the Arctic’**, AKMA), to obtain high-resolution photorealistic 3D models and orthomosaics, in order to represent cold-seeps habitats in high-resolution and classify seabed sedimentary properties and macrofauna. An additional research goal is to develop **new forms of visualization of 3D data of underwater environments** to derive meaningful information from dense optical datasets.

The project integrates the collaboration with foreign partners, namely **The Arctic University of Norway (UiT)**, and the participation in ongoing international projects, such as the international project AKMA. Candidates spend **at least 6 months at the UiT, in Tromsø, Norway**, and participate in **oceanographic expeditions in the Arctic ocean**.



Cold-seeps Research in the Arctic Ocean
(Argentino et al., 2022)

UNDERWATER DIPLOMACY

Faculty members of University of 'Milano-Bicocca' contribute to **intergovernmental processes** as State representatives or stakeholders from the relevant academic sector, as appropriate, in the **Italian delegation** attending the meetings of the following mechanisms.



United Nations Committee of Experts on Global Geospatial Information Management

The **United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM)** is the apex United Nations Member States-led policy and technical mechanism for making joint decisions and setting directions regarding the production, availability, and use of geospatial information. Faculty members of 'Milano-Bicocca' act as Italian representatives in the plenary of UN-GGIM as well as in the meetings of the following UN-GGIM Working Groups:

- ***Working Group on Policy and Legal Frameworks for Geospatial Information Management***
- ***Working Group on Marine Geospatial Information***



In August 2023, at United Nations Headquarters, UN-GGIM adopted the complete Operational Framework for Integrated Marine Geospatial Information Management (UN-IGIF-HYDRO), comprising:

Part One: *The Strategic Overview*

Part Two: *The Strategic Pathways*

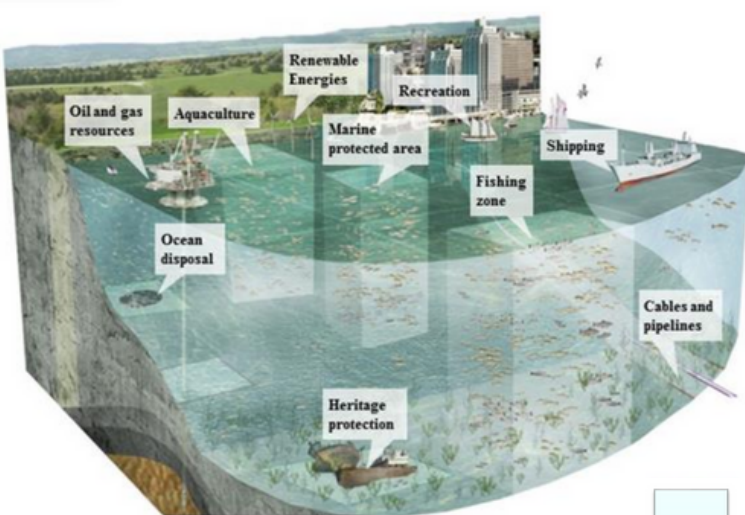


The **International Hydrographic Organization (IHO)** is an intergovernmental organization that coordinates the activities of national hydrographic offices and promotes uniformity in nautical charts and documents. It issues survey standards and best practices, provides guidelines to maximize the use of hydrographic survey data, and develops hydrographic capabilities in IHO Member States.

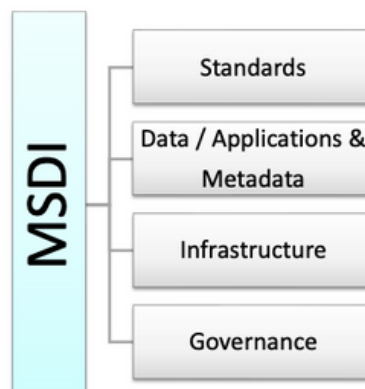
Faculty members of 'Milano-Bicocca' act as members of the following mechanism:

- ***IHO Marine Spatial Data Infrastructures Working Group (MSDIWG)***

The MSDIWG assesses the status of Spatial Data Infrastructures (SDI), Marine Spatial Data Infrastructures (MSDI) and Marine Spatial Planning (MSP) worldwide. It supports and promotes the activities of the IHO in these fields. The MSDIWG develops and maintains the IHO Publication C-17 Spatial Data Infrastructures: *"The Marine Dimension"* - Guidance for Hydrographic Offices. Members are representatives of IHO Member States, expert contributors, and accredited observers.



14th MEETING OF THE IHO MSDIWG
Genoa, Italy (30 January to 3 February 2023)
It included joint sessions with the UN-GGIM Working Group on Marine Geospatial Information and the Open Geospatial Consortium (OGC) Marine Domain Working Group





Faculty members teaching in the international master course in 'Marine Sciences' and the Ph.D. programme in 'Marine Sciences, Technology, and Management' cooperate with the **United Nations Office of Legal Affairs (OLA)** under an agreement signed by the School of Law and the Department of Earth and Environmental Sciences of University of 'Milano-Bicocca' and the **Division for Ocean Affairs and the Law of the Sea (DOALOS)**.

Under the agreement, a faculty member of 'Milano-Bicocca' acts as *Academic Focal Point* and contributes to implement the capacity-building programme named '**The United Nations - Nippon Foundation Fellowship' (UNNF Fellowship)**.

The UNNF Fellowship provides **Government officials** and other mid-level professionals from developing States with **advanced training on ocean affairs and the law of the sea**, as well as related disciplines, including marine science in support of management frameworks.

Upon completion of the UNNF Fellowship, Fellows are expected to return to their home countries and use their in-depth knowledge and extended experience to assist in formulating comprehensive ocean policy and in implementing the legal regime set out in the **United Nations Convention on the Law of the Sea (UNCLOS)** and related instruments, including through designing, implementing and/or evaluating specific improvement projects.

Candidates wishing to be considered for the UNNF Fellowship award must ensure that they meet defined criteria, which include (among others):

- Be a mid-level professional **from a national government organ** of a developing State, or another governmental or non-governmental agency in such a State, which deals directly with ocean affairs issues
- Have a professional position that allows **to directly assist the nation of origin** in the formulation and/or implementation of policy in this area, including marine sciences and the science-policy linkage
- Have a "Nomination and Recommendation Form" signed by a Government official or other official who can attest the nature of the candidate's work with respect to the **Government's ocean affairs and law of the sea** related activities

The 9-month UNNF Fellowship is composed of two consecutive phases that provide Fellows with advanced and customized research and training opportunities:

- Phase One: 3-month research and training, undertaken at **DOALOS** at United Nations Headquarters in New York
- Phase Two: 6-month advanced academic research and study, undertaken at one of the Host Institutions worldwide, which include **University of 'Milano-Bicocca'**, under the guidance of an *Academic Focal Point* who has recognized in-depth expertise in the Fellow's chosen field of study

The deliverables of the Fellowship Programme are:

- A 100-page written thesis
- A presentation of the research
- An ocean governance matrix

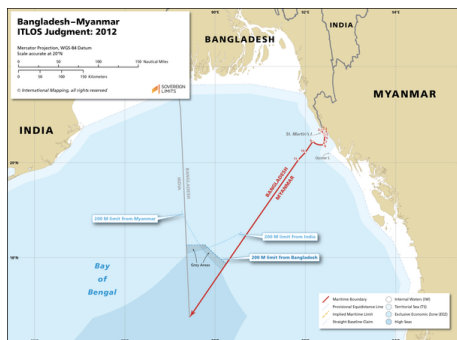
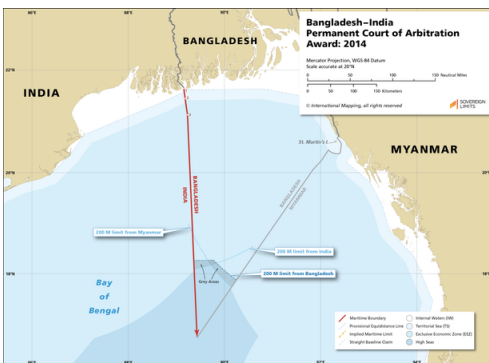
Research activities in the context of the UNNF Fellowship undertaken at 'Milano-Bicocca' have included **underwater-related questions** addressed in the Fellows' final dissertations, such as:

"International Experiences in the Legal Protection and Management of Underwater Cultural Heritage and their Possible Implementation in Uruguay" (Prado, Gonzalo Rodriguez)



The Admiral Graf Spee's rangefinder raised from seabed on 25 February 2004, some 4 nautical miles from the port of Montevideo, Uruguay.

"Resolution of the Maritime Boundaries Dispute Between Bangladesh and its Neighbouring Countries in the Context of UNCLOS: A Case Study" (Mohiuddin, Mohammad)



Bangladesh / India maritime boundary: Permanent Court of Arbitration Award of 7 July 2014.

Bangladesh / Myanmar maritime boundary: International Tribunal for the Law of the Sea (ITLOS) Judgment of 14 March 2012.

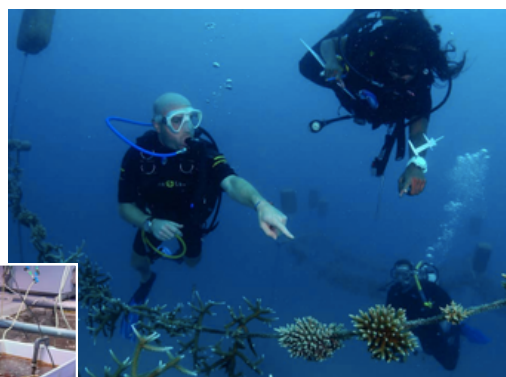
MARHE CENTER

FAAFU ATOLL (MALDIVES)

The Marine Research and High Education Center (MaRHE) Center of University of 'Milano-Bicocca', established in the Faafu Atoll in the Maldives, is acknowledged as **one of the most advanced marine research centers in the Indian Ocean.**

The Center encompasses:

- 3000 square meters of campus space
- marine biology and geology laboratories
- accommodation for up to 40 people
- a diving center
- a 50-seat research vessel



DIVING CENTER

The facility service for scientific research diving at MaRHE Center offers SCUBA equipment (air tanks, BDC Mares rover, regulators Mares rover, wet suits 3mm, masks and snorkels Mares, fins Avanti 3 Mares) as well as training, scientific, and technical support that underpins a wide range of high-class **interdisciplinary research in the underwater environment**. The Scientific Diving team delivers practical support for underwater scientific research projects through providing additional assistance for groups with limited diving experience, project management for scientists with no diving experience, and special equipment loans for researchers with diving experience but limited financial resources.



RESEARCH VESSEL

'Dhoni' boats are traditional multi-purpose vessels with a motor or latin-rigs that are used in the Maldives, South India, and Sri Lanka. A 'Dhoni' boat with a **capability of 50 people** is included in the facilities of the MaRHE Center for activities at sea.



TECHNOLOGY PLATFORMS

SERVICE	DESCRIPTION	EQUIPMENTS
Microscope	1 Olympus BX51 Fluorescence Microscope, 1 Olympus SZ61 Stereomicroscope, 3 Zeiss Microscope, 1 Leica EZ4D Microscope.	
Weather station	Temperature sensor and humidity control, wind direction and speed sensors, pyranometer, rain gauge, barometer.	
Aquarium tanks	Set of 10 glass aquarium tanks to conduct in vitro experiments; 3 aquariums dedicated to Jellyfish.	Pumps, oxygenators, heaters.
Laboratory equipments and chemicals	Bench space, cabinets, sinks, Laminar flow hood, Chemical fume hood, Tissue and sample preparation appliances, Micro-oven forced air.	Plastic tubes of various capacity and size, Refrigerator and Freezer, Petri plates, Ethanol 99%, Formaline, different chemicals upon request, Micropipettes . Basic equipments to preserve and analyze biological samples.
Molecular analysis	Laboratory instruments for extraction of proteins and nucleic acids from samples.	Immersion cooler Julabo FT902, Centrifuge HETTICH - MOD. MIKRO 120, Heating plate M520-PR, Vortex, Phmeter Mettler Toledo FiveEasy, Thermostatic bath M418-BASIC, Mortar and pestle, Micropipettes.
Environmental DNA Analysis	Laboratory instruments to collect and filtering water for eDNA Analysis	
Drones	3 DJI Phantom 4 drone, a quadcopter with high sensing qualities, equipped with a 1/2.3"CMOS camera sensor (12.4 MP) that can collect images with a resolution (R) of 4000 × 3000 pixels and an integrated GPS/GLONASS system	

EXPERT ADVICE

SUPPORTING FACILITIES

SERVICE	DESCRIPTION	EQUIPMENTS
Instrumentation testing activities	Support for testing and experimentation of advanced technologies for experimental field and laboratory activities.	Consulting activities.
MaRHE Center provides diving support for guest scientists who need specific biota from the Maldivian	2 Dive Instructors PADI, 1 Dive Instructor FIPSAS, 4 Dive Master, 3 advance scientific divers.	
VISA and scientific research permits	Support for business VISA applications and sampling authorizations.	



BluGLab

MARINE DIGITAL CARTOGRAPHY LABORATORY

BluGLab of University of 'Milano-Bicocca' has more than 20 years of experience dedicated to **the acquisition, processing, analysis, and management of marine geospatial data**, obtained using a range of acoustic and optical remote sensing techniques applied to underwater exploration and monitoring.

Research and service activities are focused on providing **geospatial solutions to model the seabed**, in 2D and 3D, through the application of innovative methodologies (including Geographic Information Systems, Machine Learning and virtual/immersive reality techniques). Main outcomes consist in tools and products designed to efficiently explore and analyse environmental patterns, **processes and interactions that characterize underwater systems at different spatial and temporal scales**, to address conservation, management, and restoration practices for the submerged environments.

The Faculty of BluGLab is involved in **national, European, and international projects and working groups** focused on quantifying ecosystem services, marine geohazards, as well as on monitoring anthropogenic impacts, the ocean-climate nexus, and especially on the assessment of benthic habitats distribution in shallow-water tropical ecosystems, and vulnerable and/or extreme deep-water environments.

The BluGLab experience organizes **training courses** for M.Sc. and Ph.D. students and professionals through national and international schools and workshops on seafloor and habitat mapping and marine geohazard.

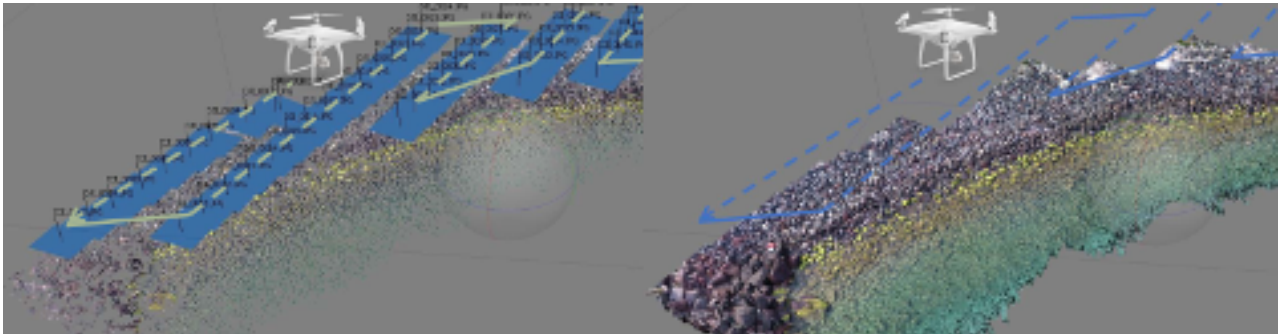
Data acquisition

Data are acquired on board Italian and foreign **research vessel** and **icebreakers** with the use of cutting edges technologies, such as UAVs, ROVs and drones (for acquiring high resolution marine geospatial dataset), as well as on board smaller motor boats and during coastal surveys.



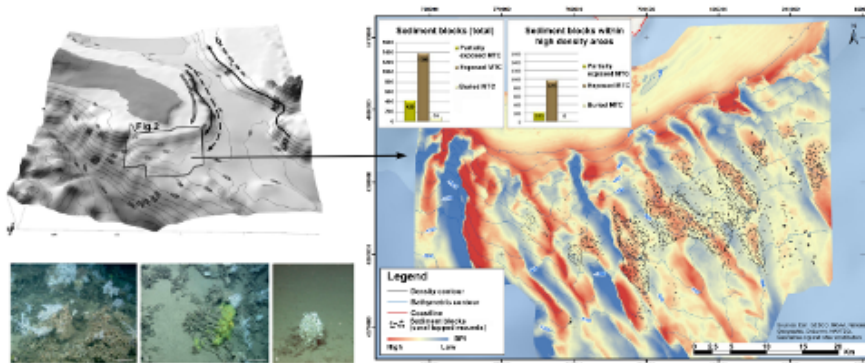
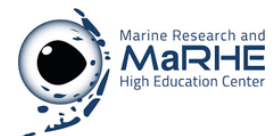
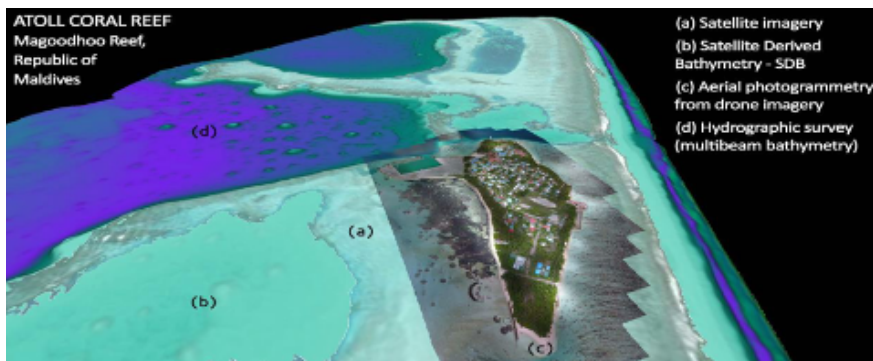
Data elaboration

BluGLab is equipped with advanced softwares designed to process raw dataset collected by a range of acoustic geophysical equipment (multibeam echosounders, side-scan sonar, seismic reflection methods) and underwater still images and videos acquired using professional underwater vehicles (ROVs)



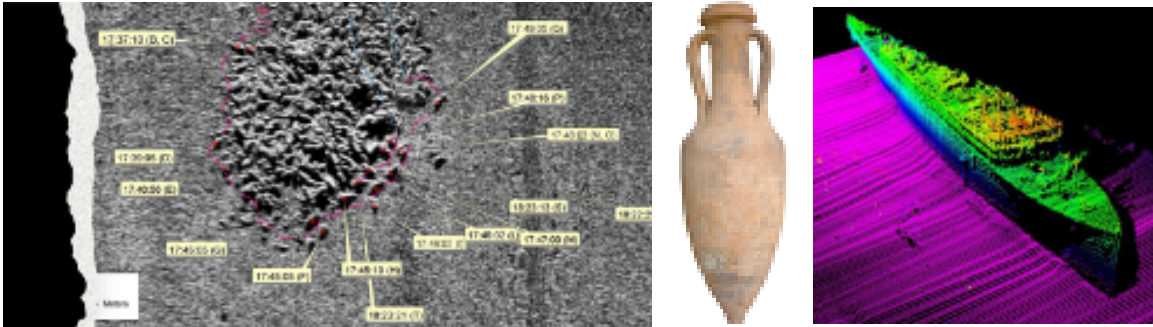
Data analysis and interpretation

- Data validation and quality assessment
- Integration of multiscale and multisource marine geospatial dataset
- Quantitative analysis based on algorithms from geomorphometry
- Machine Learning / Deep Learning
- Object-based image analysis
- Semi-automatic characterization of physical processes

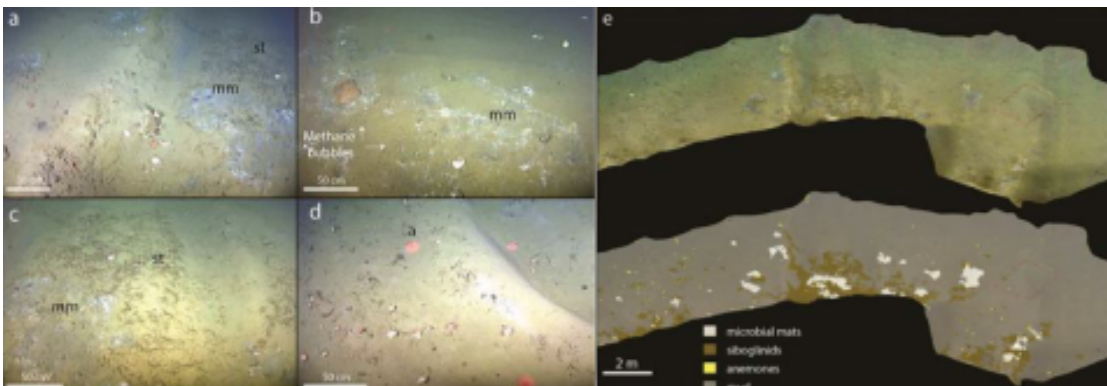


Applications

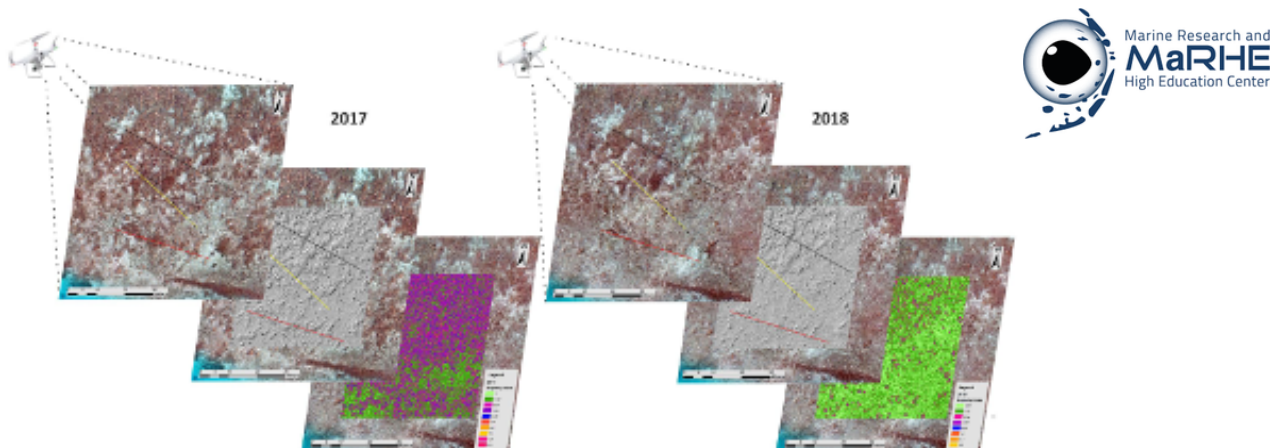
Underwater archaeology (in photo: a roman wreck offshore Albenga and the wreck of the Italian hospital ship *Po* in the Bay of Vlora, Albania)



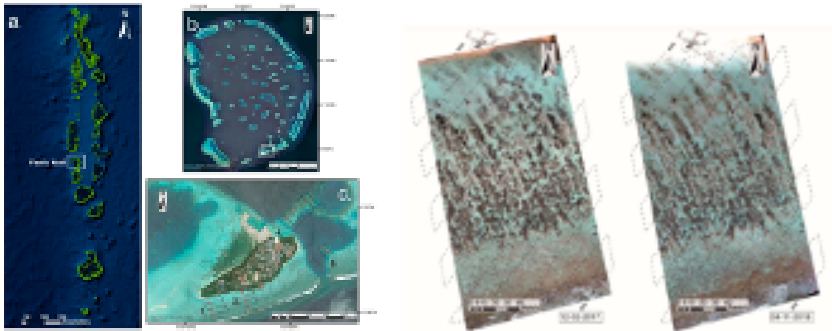
Habitat mapping (shallow water tropical reefs, cold-water carbonate bioconstructions and cold-seeps associated habitats in extreme environments - Argentino et al., 2022)



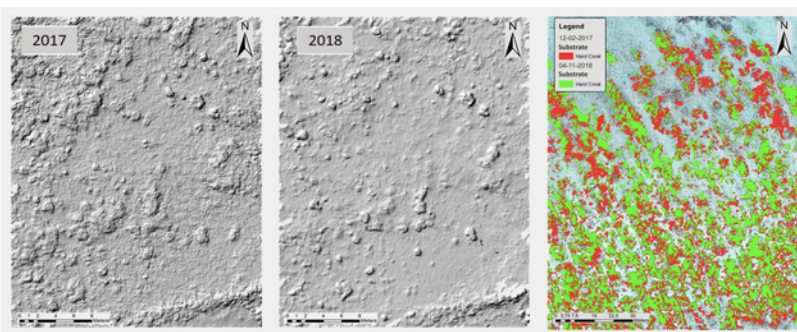
Quantification and extension of vulnerable habitats (in photo: Multi-Temporal UAV Data and Object-Based Image Analysis (OBIA) for Estimation of Substrate Changes in a Post-Bleaching Scenario on a Maldivian Reef - Fallati et al., 2020)



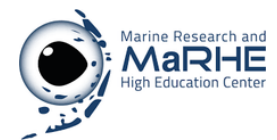
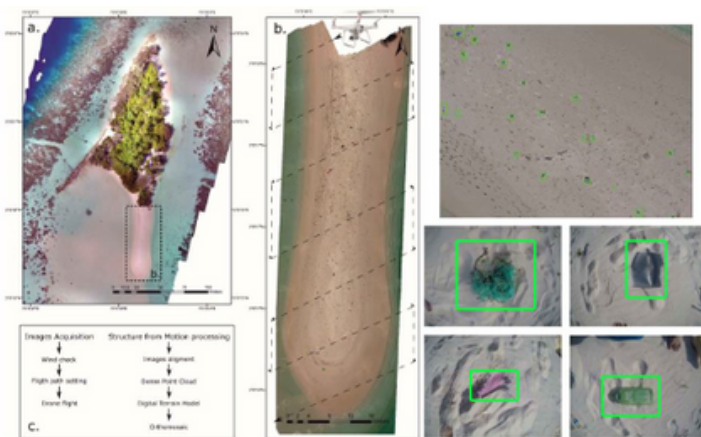
Quantification and extension of vulnerable habitats (in photo: Benthic Habitat Mapping in shallow water – coral reef environments)



Quantification and extension of vulnerable habitats (in photo: Multi-Temporal UAV Data and Object-Based Image Analysis (OBIA) for Estimation of Substrate Changes in a Post-Bleaching Scenario on a Maldivian Reef – Fallati et al., 2020-Remote sensing; (right) UAV flight paths in 2017 and 2018)



Evaluation of underwater anthropogenic impacts (in photo: development of automated systems for the quantification of plastic debris along the beaches of tropical islands. Very high-resolution monitoring systems (UAV) and use of artificial intelligence and deep learning) – Fallati et al., 2020)



EUROCOLD

THE LABORATORY ON THE POLAR REGIONS

Studying the Arctic and Antarctic is critical for addressing global challenges related to climate change, sea-level rise, biodiversity conservation, ocean circulation, and resource management.

Polar regions serve as **sensitive barometers of environmental changes** and have a profound impact on the health and ecosystems stability of the Earth, including within its underwater dimension.

The Department of Earth and Environmental Sciences of University of 'Milano-Bicocca' has an **integrated laboratory with controlled atmosphere** (rooms at -50°C) to simulate mean Arctic and Antarctic environmental conditions.

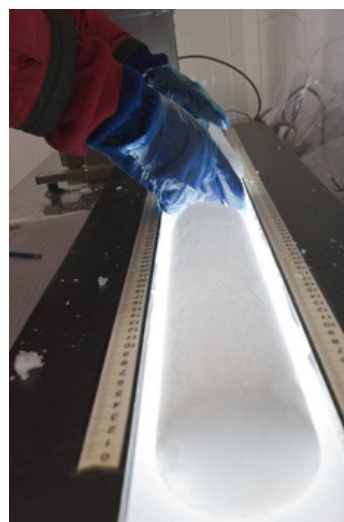
Research areas at the EUROCOLD LABORATORY that can be relevant also to the underwater dimension include:

1 Polar ice core and paleoclimate research

Quaternary paleoclimate reconstructions through the production of precise stratigraphic records of dust concentration, flux, and grain size that are used as benchmark for many other paleoclimate proxies.

2 Climate and paleoclimate modelling including mineral dust cycle

Mineral dust is the most abundant aerosol by mass in the atmosphere, alone contributing about a quarter of the total sunlight extinction by atmospheric aerosols, natural and anthropogenic. Dust acts both as a tracer and a forcing agent of climate change.



EXTERNAL COLLABORATIONS

Academia. Industry. International organizations.

AUSTRALIA

Curtin University

BRAZIL

Federal Fluminense University

Federal University of Paraná

COLOMBIA

Corales de Paz

Universidad Pontificia Bolivariana

CZECH REPUBLIC

Masaryk University

FRANCE

Centre national de la recherche scientifique (CNRS) Orléans

École normale supérieure

Muséum Nationale d'Histoire Naturelle

Université de Brest

GERMANY

Max Planck Institute for Animal Behaviour

GEOMAR Helmholtz Centre for Ocean Research Kiel

University of Kiel

University of Monaco

GREECE

Hellenic Centre for Marine Research

Kapodistrian University of Athens

INDIA

Pondicherry University

EXTERNAL COLLABORATIONS

IRELAND

University College Cork
University College Dublin

ISRAEL

Bar-Ilan University
University of Haifa
The Inter-University Institute for Marine Sciences in Eilat

ITALY

Arena Sub
Associazione Italiana Operatori Scientifici Subacquei (AIOSS) (affiliation)
Carmacoring
CODEVINTEC
Ecomarin
ENI
Euro-Mediterranean Center on Climate Change (CMCC)
ExplorerX
FUGRO Italy
Istituto Italiano di Tecnologia (IIT)
Istituto superiore per la protezione e la ricerca ambientale (ISPRA)
GEOEVO Seabed Solutions
GeoNautics
Institute of Marine Sciences of the National Research Council (CNR-ISMAR)
Marche Polytechnic University
MARINA MILITARE
Marine Coastal Environment Institute of the National Research Council (IAMC-CNR)
Marine Protected Area of Capo Rizzuto
Marine Protected Area of Capo Carbonara
MEPECO
National Inter-University Consortium for Marine Sciences (CoNISMa)
Poliservizi
Polytechnic University of Turin
Stazione Zoologica Anthon Dohrn
The MacArtney Italy
The Sea Opportunities
University of Bari
University of Calabria
University of Cagliari
University of Catania
University of Ferrara
University of Genoa

EXTERNAL COLLABORATIONS

University of Messina
University of Parma
University of Pisa
University of Rome La Sapienza
University of Salento
University of Sassari
University of Tor Vergata
University of Venice (IUAV)

JAPAN

University of the Ryukyus
Miyazaki University

MALDIVES

The Maldives National University

MALTA

University of Malta

MAURITIUS

University of Mauritius

THE NETHERLANDS

Naturalis Biodiversity Center

NORWAY

The Arctic University of Norway (UiT)

PORTUGAL

University of Algarve
Universidade de Aveiro

RUSSIAN FEDERATION

Russian Academy of Sciences

SAUDI ARABIA

King Abdullah University of Science and Technology (KAUST)

SINGAPORE

National University of Singapore (NUS)

SPAIN

Institut de Ciències del Mar (CSIS)
University of A Coruña
University of Seville
University of the Balearic Islands
University of Vigo

EXTERNAL COLLABORATIONS

SWITZERLAND

University of Fribourg
 University of Geneva
 University of Lausanne
 University of Neuchâtel

UNITED ARAB EMIRATES

University of Dubai

UNITED KINGDOM

Heriot-Watt University
 University of Edinburgh
 University of Exeter
 Loughborough University
 Scientific Committee on Antarctic Research (SCAR)
 St Andrews University
 University of York

UNITED STATES

Georgia Institute of Technology (Georgia Tech)
 Harvard University
 Monterey Bay Aquarium Research Institute (MBARI)
 University of Hawai'i
 University of Miami

INTERNATIONAL

European Space Agency
 International Hydrographic Organization (IHO)

- IHO Marine Spatial Data Infrastructures Working Group (IHO-MSDIWG)

 International Union for Conservation of Nature (IUCN)
 Open Geospatial Consortium (OGC)

- Marine Domain Working Group (OGC-MDWG)

 United Nations Office of Legal Affairs (OLA)

- Division for Ocean Affairs and the Law of the Sea (DOALOS)

 United Nations Department of Economic and Social Affairs (DESA)

- Committee of Experts on Global Geospatial Information Management (UN-GGIM)
 (Working Group on Policy and Legal Frameworks for Geospatial Information Management)
 (Working Group on Marine Geospatial Information)

FUTURE PROFESSIONS

INTERNATIONAL MASTER COURSE IN 'MARINE SCIENCES'

Career opportunities for graduates in the master course in 'Marine Sciences' include positions in the public or private sectors as marine environment analysis and management experts, marine biologists and ecologists, marine and coastal resources experts, marine and coastal environmental policy experts, and experts in maritime activities.

PH.D. IN 'CHEMICAL, GEOLOGICAL, AND ENVIRONMENTAL SCIENCES'

The Ph.D. in 'Chemical, Geological and Environmental Sciences' offers professional opportunities in the field of university research and at research institutes, both in Italy and abroad, and employment opportunities in companies and private research centers operating in the sectors specific to each curriculum. The highly multidisciplinary nature of the programme allows Doctors to enter working fields with managerial roles, as well as access roles in public administration, where the Ph.D. constitutes a rewarding qualification. Doctors could work for environmental organizations, natural science museums, national agencies for environmental protection, regional and local planning agencies, and other such agencies that need geological expertise.

PH.D. IN 'MARINE SCIENCES, TECHNOLOGY, AND MANAGEMENT'

Ph.D. graduates in 'Marine Sciences, Technology, and Management' may pursue academic research, both in Italy and abroad, within public or private institutions, or become senior managers in both public and private sectors engaged in marine and maritime activities.

Particularly relevant are the employment prospects in the so-called **Blue Economy**, which includes all sectors related to oceans, seas, and coasts. This is a large and rapidly evolving segment of the economy, which has taken significant steps to modernize and diversify over the past decade. Alongside the traditional ones, **innovative sectors** such as those related to the restoration of areas damaged by anthropogenic activities, biotechnology, sustainable ecotourism, environmental certification, area-based management tools, offshore renewable energy, deep seabed mining, and STEM education are developing. Emerging and new activities will bring new opportunities, growth, and greater diversity to the ocean economy. **Blue finance**, as an offshoot of green finance, will offer opportunities in developments related to the Blue Economy.

FUTURE PROFESSIONS

INTERNATIONAL MASTER COURSE IN 'MARINE SCIENCES'

- Aquaculturist
- Aquarium curator
- Coastal zone manager
- Energy and mineral explorer
- Environmental consultant
- Environmental health specialist
- Environmental planner
- Fisheries scientist
- GIS analyst
- Marine biologist
- Marine conservationist
- Marine ecologist
- Marine geologist
- Marine educator
- Marine science communicator
- Marine technician
- Marine tourism specialist
- Museum and aquarium administrator
- Oceanography technician
- Technical writer
- Water pollution technician

PH.D. IN 'CHEMICAL, GEOLOGICAL, AND ENVIRONMENTAL SCIENCES'

PH.D. IN 'MARINE SCIENCES, TECHNOLOGY, AND MANAGEMENT'

- *Previously mentioned career options*
- Blue economy specialist
- Blue finance analyst
- Chemical oceanographer
- Consultant for private and public companies, and NGOs
- Marine data scientist
- Marine geologist in corporations involved in offshore oil and gas operations
- Marine geochemistry scientist
- Marine policy analyst
- Marine protected area manager
- Oceanographer
- Postdoctoral research scientist
- Scientific expert for international organizations
- Scientific programme manager
- Scientist in biotechnology companies
- Technical advisor for international, regional, and national organizations

CONTACTS

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Website marine.sciences.unimib

Chairman Paolo Galli (paolo.galli@unimib.it)

PH.D. IN 'CHEMICAL, GEOLOGICAL, AND ENVIRONMENTAL SCIENCES' CURRICULUM IN 'TERRESTRIAL AND MARINE ENVIRONMENTAL SCIENCES'

Website unimib.dottorato.scienze.chimiche.geologiche.ambientali.

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Website eurocold.disat.unimib

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Alessandra Savini (alessandra.savini@unimib.it) (also BluGLab coordinator)

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