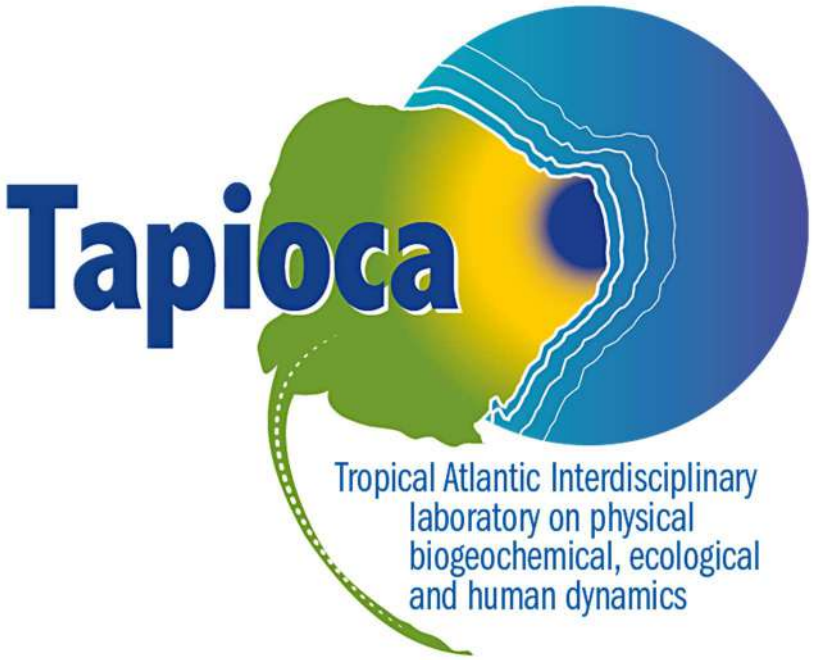
Project

International Joint Laboratory



Second phase 2023 - 2027

A Regional Centre of Excellence in Marine Sciences for the Tropical Atlantic

Contents

International Joint Laboratory

Tropical Atlantic Interdisciplinary laboratory on physical, biogeochemical, ecological and human dynamics

(IJL TAPIOCA)

0. Project ID

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Main partners and research teams
Brazil: Universidade Federal de Pernambuco (UFPE) and Universidade Federal Rural de Pernambuco (UFRPE) **France:** Institut de Recherche pour le Développement (associated units): UMRs MARBEC, LEGOS, LEMAR, LOG, MIO
Associated partners and research teams
Brazil: Universidade Federal da Bahia (UFBA), Universidade Federal do Pará (UFPA), Universidade Federal de Rio Grande (FURG), Universidade Federal de Rio Grande do Sul (UFRGS), Universidade Federal Rural da Amazônia (UFRA), Universidade Federal do Rio de Janeiro (UFRJ), Universidade Federal do Rio Grande do Norte (UFRN), Universidade Federal de Sergipe (UFS), Universidade Federal de Ceara (UFC), Universidade Federal de Alagoas (UFAL) **France:** UMRs GET, LOPS, IMAGO, LOCEAN, CEBC
Thematic priorities, scientific fields
Thematic priorities: Building knowledge, perceptions, representations and adaptation to climate change; Access to resources; South/South dynamics; Indicators of climate and environmental change in the tropical zone; Ecosystems at the continent-ocean interface in the tropical zone, extreme events **Scientific fields:** Physical and Chemical Sciences of the Global Environment; Ecological Systems Sciences; Humanities and Social Sciences; Engineering and Expertise

1. Executive summary

During its 2nd phase, the TAPIOCA IJL ambitions to build on the achievements of its 1st phase covering a variety of thematic activities, and consolidate them to be recognized as a Centre of Excellence in Marine Sciences for the Tropical Atlantic. Science and capacity building will continue to be pivotal in TAPIOCA. The consolidation of new techniques and disciplines will require the development and/or strengthening of new infrastructures and laboratories. The IJL will carry on serving as an umbrella for a variety of national and international projects, improving their complementarity, by creating a network and promoting interdisciplinarity. Finally, the results of the researches will be transferred to and interact with the society, including all stakeholders, the public, scholars and local communities. Following and fostering the dynamic of the 1st phase, TAPIOCA should move from a regional description to general processes of world interest (e.g., ocean circulation, climate, pollution, carbon cycle and storage, socio-ecosystem conservation). During its 1st phase, TAPIOCA mostly focused on comprehensive snapshots in Northeast Brazil and the time scale was explored through 'scenarios' (e.g. ABRAÇOS campaign 1 vs. 2). During this 2nd phase, a spatial extension is proposed toward the North, particularly thanks to the AMAZOMIX program. In addition, the time scale should be more explicitly accounted thanks to: (i) paleo-studies (multi-proxy sediment cores) in estuaries and in oceanic basins, and (ii) available time series and new monitoring approaches (higher spatial and temporal resolution). Additionally, numerical models (NEMO, PISCES, Ecospace, bioeconomics, conservation planning, etc.) will improve the capacity to explore processes in time and space including climate change projections. The TAPIOCA IJL will have a structure grounded over three fully interconnected Axes. The Axis 1 'Tropical Atlantic climate and dynamics' will focus on the dynamics of the ocean using a variety of data and tools. Such information feeds into the Axis 2 'Biodiversity dynamics', which will study the main ecological structure and processes, starting with the description of diversity, from bacteria to top predators, to the variety of structural and functional processes. Ecosystems are driven by climate but also by direct anthropic influence including exploitation, urbanisation or pollution. The Axis 3 'Uses and impacts' will therefore focus on assessing the impact of human activities and provide data, methods and knowledge to support conservation and sustainable uses of ecosystems, directly linked to Axes 1 and 2. The flux of information among axes and the expected outputs should provide key knowledge for societal benefits and conservation.

Continuing the dynamics of TAPIOCA 1st phase, the main coordinating partners remain the Universidade Federal de Pernambuco (UFPE) and the Universidade Federal Rural de Pernambuco (UFRPE), the host partners, and IRD. Five IRD joint research units (UMR) are official members of TAPIOCA, involving people from IRD but also from other French institutes (CNES, CNRS, IFREMER) and Universities (AMU, UBO, ULCO, UM, UPS). The experience of the 1st phase and the extension of activities to the North of Brazil led to increase the number and importance of associated partners, and an amplified participation of UFPA and UFRA. In the 2nd phase, the role and visibility of these partners will be significantly strengthened. Considering the success of the TAPIOCA 1st phase, auto-organisation and emergence will be encouraged. The IJL animation and interdisciplinary interactions will be primarily organized through consortium meetings twice a year to foster exchanges among partners and disciplines. In addition, Axes' PIs are encouraged to organise specific workshops to foster interactions and to focus on specific aspects. Money use will be oriented to ensure TAPIOCA's sustainability, prioritising both long-term infrastructure (laboratories) and capacity building of young scientists (formation, exchanges, international events, etc.). Outreach activities will promote terms of knowledge transfer to scientists, scholars, community and other stakeholders using oceanic and coastal ecosystems. Giving seminars and contributing to university lectures and workshops will provide new training opportunities for TAPIOCA partners. The main goal of the outreach plan is to maximise communication of the results, as in the TAPIOCA 1st phase, but also to better inform managers and politics about the impact of anthropogenic activities on marine environments. Besides internet and social media tools, the shared database will be complemented during the 2nd phase, and released in open access source.

The consortium sustainability will be ensured by the "new TAPIOCA generation", mainly young scientists trained through the IJL bilateral cooperation. This has started during the 1st phase but should be reinforced, secured and fostered during and after the TAPIOCA 2nd phase. New projects will be generated between TAPIOCA staff members, at bilateral or international cooperation levels, and new areas of blue growth will be targeted to develop similar activities in relation to the conceptual framework built by the IJL. New opportunities will also be generated by synergies created throughout TAPIOCA with other relevant stakeholders (e.g. NGOs, environmental managers, and politics). By creating a formal research group in Brazilian official scientific organisms, the consortium visibility as a recognised Regional Centre of Excellence, will be a "marine science hub" for the western tropical Atlantic Ocean that will foster national and international cooperation, together with a high level of recognized expertise for conservation of marine environments.

2. SWOT Analysis

Strengths	Weaknesses
• A strong interdisciplinary scientific network that has shown great resilience in the face of the pandemic and the drastic reduction in science funding in Brazil in recent years. • High national and international recognition, visibility and attractiveness. • Fostering the network towards North Brazil and incorporating new approaches and disciplines.	• Increasing consortium size may difficult coordination/interactions. • Work overload of Brazilian university professors. • Interaction by videoconference is not optimal. • Lack of dedicated staff to maintain the TAPIOCA database or coordinate outreach activities.
Opportunities	**Threats**
• Moving from description to processes of regional and world interest. • Various international (e.g. EU) projects associated to TAPIOCA and creation of the Instituto Nacional de Pesquisas Oceânicas (INPO). • Play a major role in decision-making (Belem statement, EU, Fisheries secretary, Environment ministry, FAPs, etc.).	• Political uncertainties • Current lack of students postulating to grants to perform a MSc or PhD (pandemic and political situation) • The double administrative charge and duties of co-badging PhD is limiting

The 2nd phase of TAPIOCA is proposed after analysing the weaknesses of the 1st phase, and enhancing mainly the interdisciplinary and inter-sectoral basis of the project which requires special care in checking the quality of the conducted researches. TAPIOCA will increase its conducive environment for cooperative work, and it will ensure the juxtaposition of discipline-specific approaches. The exchanges using video conference will still be promoted in the context of ecology and sustainability against global change.

3. Research, training and transfer activities

As during its 1st phase, the IJL TAPIOCA will develop and promote science and hence the capacity building for innovative research in areas not yet/fully explored in Brazil, also improving the interdisciplinaritya, covering the physical, biogeochemical, ecological, and human dynamics in North -Northeast Brazil (Figure 1). Moreover, the IJL will serve as an umbrella for a variety of existing or new national and international projects, thus improving their complementarity, by creating a network and promoting this interdisciplinarity. The consolidation of new techniques and disciplines will require the development or strengthening of new infrastructures and laboratories. Finally, the results of the researches will be transferred to and interacted with the stakeholders, including IPLC (indigenous people and local communities), scholars and the public.

[a] Interdisciplinarity is the cooperation of several disciplines around common projects. These projects open up research perspectives for each of the disciplines, which are no longer confined for the most part to situations of application. Joint activities combine data, methods, tools, theories and concepts from different disciplines into a synthesis in which the role of the disciplinary components goes far beyond mere juxtaposition (*ANR definition 2022* and see HCERES and OECD links).

Following and fostering the dynamic of TAPIOCA 1st phase, but moving from regional description to general processes of world interest (ocean circulation, climate, pollution, carbon cycle and storage, marine connectivity, socio-ecosystem sustainability, etc.), the main questions of the 2nd phase are:

Figure 1. TAPIOCA's framework.

(i) How do climate variability and other anthropic pressures affect ocean circulation and ecosystem structuring, functioning and sustainable uses?
(ii) How do the diverse uses of marine spaces account for biodiversity conservation and sustainability of socio-ecosystems?
(iii) How may interdisciplinary research contribute to decisions taken by environmental managers and policy makers?
(iv) How may interdisciplinary research contribute to international initiatives such as the SDGs and the Blue justice ("small scale fisheries in a sustainable ocean economy")?

The IJL TAPIOCA has a structure grounded over three fully interconnected Research Axes (Figure 2). The first Axis 'Tropical Atlantic climate and dynamics', studies the properties and dynamics of the ocean using a variety of data and tools. Such information feeds into the second Axis, 'Biodiversity dynamics', which study the main ecological structure and processes, starting with the description of diversity, from bacteria to top predators, to the variety of structural and functional processes. Ecosystems are driven by climate but also by direct anthropic influence including exploitation urbanisation or pollution. The third Axis 'Uses and impacts' will therefore focus on assessing the impact of human activities and provide data, methods and knowledge to support conservation and sustainable uses, directed linked to the first and second Axes. The flux of information among axes and the expected outputs should provide key knowledge for societal benefits and conservation. As an example, ocean model validated by *in situ* data in Axis 1 will provide the framework to set up Lagrangian model to study the connectivity between sub-systems, the consequent influence in productivity and recruitment of marine organisms and the determination of biodiversity hotspots (model also constructed using data from *in situ* data) in Axis 2. Such results are necessary to feed decision support tools and provide relevant information to stake holders in Axis 3.

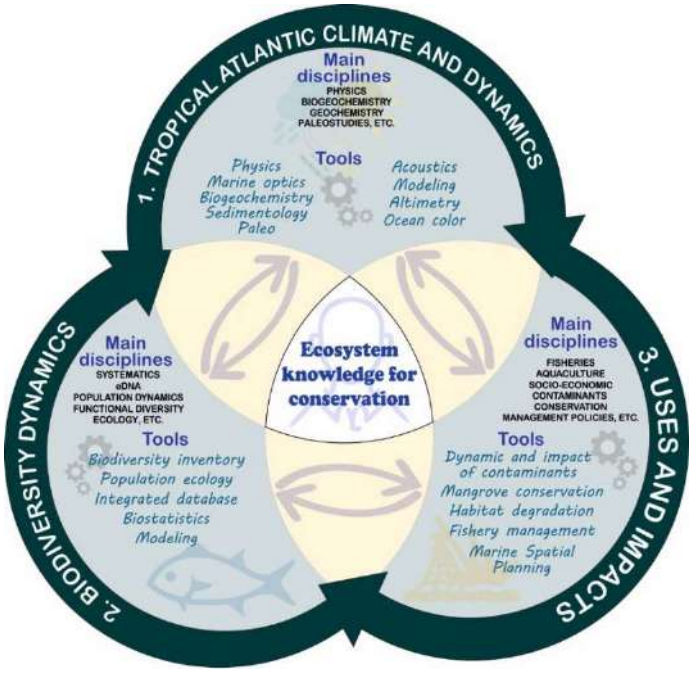

Figure 2. TAPIOCA Research Axes.

3.1. Description of research axes

Axis 1 - Tropical Atlantic climate and dynamics	PIs: Alex Costa da Silva (UFPE) Ariane Koch-Larrouy (IRD-LEGOS) Vincent Vantrepotte (CNRS-LOG)

Problematic and gaps

Considering the crucial role of the tropical ocean in regulating the earth climate, describing the impact of the recent changes in the physical (e.g. rising ocean temperature, alteration of current dynamics, modification of the precipitation regime) and biogeochemical properties (e.g. carbon stocks and fluxes) of these oceanic domains is a fundamental scientific topic. In this context, the study of the interactions between these physical processes and the biogeochemical fluxes at the interfaces ocean-atmosphere continent-ocean, seafloor-water column, coast-offshore waters and associated frontal structures still represents a key challenge. The characterization of the response of Brazilian coastal and oceanic waters to environmental changes implies the consideration of multiple processes occurring over a variety of spatial and temporal scales and the development of interdisciplinary approaches. Gathering knowledge on the current changes in oceanic physical and biogeochemical properties over tropical central and south eastern Atlantic waters is however crucial to better understand how climate and anthropogenic pressures will impact the structure and functioning of these tropical marine ecosystems.

In this context, the description of the impact of climate modulation (e.g. Tropical Atlantic Zonal and Meridional Modes interacting with ENSO, NAO and the Southern Annular Mode) on key oceanic and atmospheric physical processes (e.g. tropical West Atlantic oceanic circulation, South American Monsoon, tropical currents, western edge current, subtropical gyre, migration of the Inter Tropical Convergence Zone and its associated rainfall belt, dilution of main river plumes: Amazon, San Franciso rivers, finescale and microscale processes, and interface with offshore processes at the edge of the continental margin) driving eastern tropical eastern Atlantic marine waters dynamics at both horizontal and vertical scales represents a first prerequisite. Global climatic trends as observed observed in evolving pattern of the large scale wind stress distribution, accumulation of heat in the top and intermediate layers (Drouin et al., 2021) modify the seasonal patterns of air sea interactions. As one example, recent variation of the Brazilian boundary currents, which are part of the 'Atlantic Meridional Overturning Circulation' (AMOC), which plays a key role in regulating the global climate[1,2] and its potential dramatic consequences for the temperatures and precipitation patterns of the Atlantic Rim countries will be specifically considered. Internal tides (internal waves at tidal frequency) off the Amazon Shelf, and their impact on ocean-atmosphere heat transfer and biogeochemical vertical fluxes along the ocean water column[3] will further represent a key fine scale process that will be specifically addressed. Evaluating the impact of such key physical processes (from sub-mesoscale to basin scale) will require the consideration of a comprehensive set of biogeochemical and biological descriptors (e.g. dissolved organic and inorganic compounds, particulate matter, pH, bacteria and phytoplankton biomass distribution, primary production, carbon fluxes). This will be performed using a comprehensive set of tools including, physical and biogeochemical *in situ* measurements (from sediments to surface waters), satellite observations, in particular using the SWOT satellite altimetry and ocean colour data, and modelling strategies based on nested configuration at high resolution (e.g., ~1 km) with tides, waves dynamics, and coupled with atmospheric, or biogeochemical models.

Main Objectives

The general objective of Axis 1 during the 2nd phase of TAPIOCA will be to study the impact of climate and human pressures on the physical processes driving coastal and oceanic water masses dynamics in the NE Brazil marine systems as well as on the associated biogeochemical fluxes at the interfaces ocean-atmosphere, continent-ocean and along the ocean water column in both shelf and oceanic systems, with also new focuses on coastal processes. For this purpose, we will need to rely on interdisciplinary, including new disciplines (such as sedimentology and paleoclimate) approaches considering a variety of spatial (from local to synoptic, coastal to regional) and temporal scales (exceptional events, seasonal and long-term evolution).

During the TAPIOCA 1st phase such process-based studies have been initiated from punctual *in situ* observation (e.g. ABRACOS, AMAZOMIX cruises) with the first microstructure measurements collected off the Amazon Shelf and first works based on physical modelling. These first works will be further developed in the frame of TAPIOCA 2nd phase. For instance the microstructure measurement will be more systematic. Also more numerous and with higher resolution regional dedicated configurations will be performed (NEMO, ROMS models and non-hydrostatic simulation) all along the

Brazilian coast. In TAPIOCA 2nd phase, regional configurations will be coupled with biogeochemistry model to better understand the impact of the physic on the biology, which is central to the whole group of TAPIOCA and new innovative satellite observation (SWOT, ocean colour) analysed. In addition, new developments in the context of this second phase of TAPIOCA will consist in developing studies for better understanding climate (e.g. change in rainfall regime, increasing exceptional events) and human (land occupation and land use: anthropization, industrialization, dam installation, deforestation, intensive agriculture) impacts on the transfer of particulate and dissolved matters and associated biogeochemical fluxes (nutrient, carbon, pollutants) along the land-sea continuum. In this frame, the description of key processes driving the carbon export from coastal to offshore waters (including estuaries and mangrove influenced areas still poorly constrained will be further investigated).

Main topics

- Describe and study the dynamics of key physical processes including:
  - tropical West Atlantic oceanic circulation, tropical currents, western edge current, the temporal variability in relation to interannual fluctuations and large-scale forcings of the South Atlantic and tropical basin; (ITCZ, subtropical gyre, South American Monsoon) and their regional consequences on sea level (steric/non-steric);
  - internal tides and internal waves dynamics, and their associated mixing allowing nutrients flux in the surface layers that might impact the whole ecosystem;
  - the impact of ocean currents and physical processes (such as internal waves, upwelling, river discharge), on the atmosphere as well as on the biogeochemical component of the ocean;
  - the impact of terrigenous organic and inorganic transfers (river discharge, aeolian supply from Sahara, coastal to deep-sea transfer) on carbon storage and cycling.

- Describe the dynamics of biogeochemical fluxes and exchanges at the interfaces land/ocean, ocean/atmosphere including the characterization of:
  - the spatiotemporal variations of key biogeochemical parameters (e.g. nutrients, particles, bacteria and phytoplankton abundance, primary production, POC, DOC, CO2 fluxes) at different time scales (from exceptional/local events to multi-decadal changes) to diagnose the response of oceanic and coastal waters to climate/anthropic forcing;
  - the sedimentological environment (coastal mangrove, shelf, oceanic) to assess the impact of climatic and anthropogenic forcing on this compartment (including organic and metallic contaminants via fluvial and aeolian sedimentary inputs-redox conditions, organic matter preservation, early diagenesis) and the observed variability at decennial to centennial timescale, with specific emphasis on extreme past climatic events, and on the linked between South American hydrological regime and the tropical Atlantic climate and the AMOC.

Main tools

To address the different specific objectives of this Axis and cover the different spatial and temporal scales aimed here, a variety of observation and modelling tools will be considered. Some of these tools will represent new disciplines favouring the development of new expertise with the group.

In situ observations

- *Physics: Vertical Microstructure Profiler* (VMP, Rockland, Canada) is a profiler equipped with very high frequency (100Hz) temperature and current shear sensors that resolve turbulent scales (microstructure) designed for profiles down to a depth of 1000 m. This measurements is being more systematic in international cruises and needs to be also used on regular Brazilian cruises, as the vertical mixing it quantifies is a key process to explain ecosystem structure. Also, *acoustic data* allow simultaneous acquisition of high-resolution quantitative and qualitative data over many biotic and abiotic compartments of an ecosystem. With such data it is possible to describe physical structures (thermocline, internal waves, whirlpools[4,5,6]), which covers processes with scales ranging from a few meters to a few hundred kilometers (~1 ping per second along the trajectory and ~20 cm of vertical resolution). Finally, dedicated campaigns in the frame of the SWOT-Brazil project, in particular the use of the GNSS and wave buoys, gliders and mooring in the Abrolhos Vitoria-Trindade Ridge area, will be organized.
- *Marine optics/biogeochemistry: In situ* optical measurements can provide a variety of quantitative and qualitative information about the biological (e.g. bacteria and phytoplankton biomass distribution and community composition, fluorescence : Fluoroprobe, flow cytometry: Cytosense, Cytobuoy) and biogeochemical (particulate matter concentration and size distribution: e.g. LISST, SC6 scattering) and dissolved matter distribution: CDOM fluorescence and absorption) properties of water masses at high spatial and temporal resolution at the sea surface and along the water

column. Reflectance spectra measurements are also required for supporting bio-optical models developments used for deriving biogeochemical information from ocean colour satellite.

- *Sedimentology*: Fluvial discharge and aeolian supply: will be investigated using grain-size analysis, clay mineralogy (XRD), elemental, isotopic and organic geochemistry (XRF, C-MS). Ideally, this approach is to be deployed on sediment traps, surface sediment and sediment cores in order to identify and quantify the respective contributions of river versus aeolian inputs, to reconstruct their natural variability and to highlight any anthropic forcing. Geochemical and biogeochemical processes (oxidation-reduction, bacterial sulfate-oxidation, sulfurization, vulcanization) will be investigated on surface sediments and sediment cores using organic geochemistry (CHNS, GC-MS, etc.) in order to specify their role on carbon storage or recycling at sediment interface and their evolution during burial (diagenesis).
- *Paleoclimate*: In 2023, on board of the R/V Marion-Dufresne, samples will be collected to analyse the elemental chemistry, heavy metals, salinity temperatures, nitrates, sulphates, mercury, mercury isotopes, nitrogen carbon and water levels, off the Amazon shelf. This will allow to observe the fauna, flora, bacteria, and pollen. The chronology of the sediment cores will be obtained by dating to 14C and 210Pb. The idea is to understand the chain of industrial and climatic circumstances that have led to such a degree of degradation and to seek solutions to clean up the environment; limit the future impact and protect the local population.

Modelling

- Dedicated regional configuration have been created during the 1st phase of TAPIOCA using NEMO physical model at 1/36° resolution (i.e. 3km) with and without explicit tidal forcing: AMAZON36 and TAPIOCAsouth36, TAPIOCA1 offered a dedicated highlight on submesoscale and IW dynamics along the north and northeast Brazilian coast[3,7,8]. Such nested strategy has also been carried out with ROMS with two-way nesting allowing to describe the role of the Parnaiba and Sao Francisco estuaries into coastal dynamics[9], or the impact of the Amazon plum[10]. For TAPIOCA2, coupling with the biogeochemistry model PISCES will be performed for AMAZON36 and TAPIOCASouth36. In addition, a new configuration of the connectivity from the Brazilian water throughout the Caribbean water will be performed using ROMS.
- These modelling tools are used for derived studies in TAPIOCA1, in particular Lagrangian studies (Ichthyop used for larvae dispersal, plastic pollution) or early warning (MedSlick for oil spill prediction): topics of high interest for decision making in the Northeast Brazil. For TAPIOCA 2 the physical/biogeochemical coupled system might also be a forcing for fish stock prediction models.

Satellite observation

- *Altimetry, SAR, scatterometers:* The Sentinel 3 and 6 series, complemented with other missions offer now a permanent constellation of 5-6 nadir like satellite allowing to map on weakly basis the global ocean mesoscale circulation. The launch of SWOT in December 2022 will offer for the next 4 years a revolutionary insight on small scales. Sentinel-1 data as well as scatterometer (C and Ku band like CFOSat, ASCAT on METOP) offer complementary information on surface gravity waves and wind stress. In TAPIOCA2 the AMAZOMIX, Abraços, Fernando de Noronha and Abrolhos Vitoria-Trindade Ridge area will be the main focus for SWOT and other active radar satellite data analysis.
- *Ocean colour:* Ocean Colour Radiometry (OCR) observations, which allows the description of a variety of key descriptors (e.g. phytoplankton biomass and community composition, primary production, particulate and dissolved matter pools and associated organic carbon stocks), represent a powerful and cost-effective tool for monitoring the biogeochemical dynamics of oceanic and coastal ecosystems dynamics over a large range of spatiotemporal scales (continuous 1km data from 1997, recent 10 m spatial resolution sensor). Yet, OCR information was underexploited within TAPIOCA and will represent new discipline favoured by the presence of had hoc expertise in the group. Historical (e.g. mono sensor: MODIS, MERIS or merged products: OC-CCI, Globcolor) and more recent (e.g. Sentinel2-MSI, Sentinel3-OLCI) satellite archives will be exploited 1) to deliver time series of the most adapted standard (Chla, SPM) and innovating products (e.g. POC, DOC, pCO2) at regional scales exploiting the existing and future in situ data (ANR COCOBRAZ, ANR CO2COAST) 2) analyse the generated time series for studying locally (e.g. mangroves ecosystems) or synoptically the temporal dynamics (episodic events ,seasonality, interannual variability) of the latter biogeochemical descriptors.

Axis 2 - Biodiversity dynamics	PIs: Thierry Frédou (UFRPE) Audrey Darnaude (CNRS-MARBEC) Claire Carré (IRD-MARBEC)

Problematic and gaps

Biodiversity sustains the capacity of living systems to respond to environmental changes, underpins ecosystem functions, and enhances the sustainability of marine resources exploited by fisheries[11,12]. With over 40% of the ocean surface already significantly affected by human activities[13], marine populations, communities, and ecosystems are constantly changing, across a wide range of geographic scales, as well as on both short-term ecological and evolutionary-relevant time scales. There is, however, a major lack of knowledge on the diversity and ecology of several species constituting marine systems. The deep-sea, in particular, is under-sampled and sparse in data, as highlighted by its designation as one of the major frontiers of science and discovery in the United Nations Decade of Ocean Science. Additionally, traditional monitoring techniques such as fishing and underwater surveys can underestimate biodiversity in general, often needing to be complemented by emerging techniques such as Environmental DNA (eDNA) that can detect a wide diversity of marine life, from bacteria to vertebrates, and expand our understanding of biological interactions. Moreover, our knowledge of the spatiotemporal connections among marine communities and their main drivers and consequences is still limited. As a result, connectivity at the community level is largely overlooked in ecosystem modelling and in decision-making for marine management and policy[14,15]. Gathering knowledge of the ecology, spatiotemporal dynamics of biodiversity distribution and interactions is a crucial first step toward sustainable development. It is needed to construct effective networks of protected areas, conserve vulnerable taxa, control the spread of invasive species, pathogens, and aquaculture escapees, and promote sustainable fisheries management[16,17,18], but also to provide sound estimates of the ocean capacity to mitigate atmospheric CO_2 level rises. For example, recent attempts to estimate the amount of carbon exported to the depths via the biological carbon pump suggested that the respiratory demand for carbon exceeds the amount of carbon supplied by sinking particulate organic matter fluxes by three orders of magnitude[19]. Thus, it is likely that deep-sea carbon trapping has been underestimated so far. To solve this and provide effective knowledge on the functioning of the ocean, the connectivity of coastal and pelagic systems and the functional roles of migratory biodiversity have to be elucidated without delay.

In Brazil, the exceptional variety of biological and ecological features in the marine environment[20], coupled with intensifying threats to local marine biodiversity call for urgently expanding our knowledge on local marine ecosystems and their biomes, including ecological aspects such as landscape connectivity, matter and energy fluxes, and species behaviour and distribution. The health of local marine ecosystems is threatened by diverse pressures, including fishing, pollution (see Axis 3), and climate change (see Axis 1), which all intensified over the last decades. Anticipating these effects and mitigating them is vital for effectively conserving local bioresources and ecosystem structure and function. Sustainable planning of marine activities in the local coastal and offshore areas also requires a thorough knowledge of the distribution of marine species, their interactions and their roles in the healthy functioning of ecosystems, at sea and at the land-sea interface.

With this regard, the 1st phase of TAPIOCA has already gathered a large amount of information on the diversity and distribution of marine biota in North-eastern Brazil and shed light on ecosystem structure in local coastal and offshore areas (ABRACOS I & II surveys) as well as in the estuarine complex of the Amazon River and its adjacent waters (AMAZOMIX survey). However, significant gaps of knowledge remain on the functioning and key components of these ecosystems and on how they are interconnected. They will need to be filled for producing efficient management strategies (Axis 3), considering the spatially explicit interactions between local sub-systems and their components. Lastly, further research is needed to strengthen conclusions on the vulnerability and resilience of local coastal social-ecological systems in the face of the pressures caused by resource use and environmental change in the area.

Main Objectives

For 2st phase of TAPIOCA, Axis 2 will deepen the research undertaken during the 1st phase by gathering additional key information on the diverse marine taxa present in North-eastern Brazil, their spatiotemporal dynamics and their respective roles in ecosystem functioning and connecting. Research activities will mainly aim to gather missing knowledge in crucial areas for better understanding the functioning of the local ocean system and anticipating its evolution in the face of local environmental and anthropic pressures. These also include studying: (i) the processes that transform and consume organic matter; (ii) population dynamics and ecology; (iii) the interaction between oceanographic scenarios, biomass and biodiversity (to allow future projections, including

those associated with climate change impacts); and (iv) the role of marine biodiversity in greenhouse gas sequestration.

Main topics

Our first main goal will be to fill in the geographic and taxonomic gaps remaining in the current map of local biodiversity to obtain a more exhaustive image of marine communities' composition, from bacteria to top-predators. For this, Axis 2 will combine the identification and quantification of marine life using traditional taxonomic approaches but also state-of-the-art genetic techniques (eDNA) and automated monitoring approaches (e.g., deep-learning based automated detection systems). Axis 2 will also seek to deepen the knowledge on key species ecology in the area, notably by characterizing their movements and the associated fluxes of individuals and biomass across ecosystems. The second goal is to better understand how (and for how long) different guilds of organisms with a key ecological role occupy different habitats in order to better assess the resulting horizontal (coast - ocean) and vertical (diel vertical migrations) carbon fluxes, and thus unveil the role of biodiversity in local carbon cycling and storage (under changing climate change conditions). The third objective will be to clarify species' role in the functioning of various local ecosystems and its relation to the vulnerability or stability of associated socio-ecological systems. For this, a trait-based approach will be used to evaluate functional biodiversity in meta-ecosystems in relationship with spatial and temporal changes in abiotic drivers. Notably state-of-the-art descriptors of organisms' dispersal potential will be linked with variations in the horizontal and vertical distribution of biota with changes in ecosystems' structure and functions (e.g. productivity). Finally, previous results will be combined to propose a comprehensive view of the ecosystem, linking physical phenomena, biodiversity, ecological aspects, and the functional roles of marine species; allowing to understand their functioning and possible adverse effects of climate change, as well as providing information that will serve as subsidies for mitigation and management actions.

Main tools

- *Biodiversity inventory, monitoring and quantification.* The oceanographic campaigns (ABRAÇOS - AMAZOMIX) and smaller scale sampling programs (monitoring such as the Long-Term Ecological Research PELD TAMS - Tamandaré Sustentável / experiments allowing specific studies) carried out during the 1st phase of TAPIOCA already allowed to build a large inventory of local marine species and their distribution via taxonomic studies combining species morphological characteristics and genetic description. Acoustics data completed these observations and allowed for a 3D characterization of the ecosystems. During the 2nd phase of TAPIOCA, this information will be completed and extended through the assessment of all the different components (Alpha and Beta), or facets of biodiversity (such as richness, evenness as well as taxonomic or functional diversity), which all shed different light on the degree of difference between species or communities. A particular effort will be made to improve our assessment of the Beta biodiversity, which aims to characterize species diversity in terms of functional roles, on the basis of varied their physical, behavioural of physiological traits.
- *Population ecology and dynamics*. During the 1st phase of TAPIOCA, the movement patterns of several key taxa (e.g. fish, birds) have been inferred using natural tags (isotopic or chemical markers in soft and hard tissues) and artificial marks (acoustic or archival tags). A large amount of stomach content data and stable isotopic signatures in carbon and nitrogen have also been obtained and compiled. This has allowed clarifying trophic relationships in diverse types of habitats and the degree of ecological connection among them. In this second phase, new analyses (e.g. of amino acid profiles) will be incorporated, to help filling the knowledge gaps identified during the 1st phase. Moreover, other aspects of species' ecology (such as populations' age structure, growth parameters and reproductive traits) will be investigated, especially for deep-sea species in which they are largely unknown. This information is important as an input for different models to be developed in Axes 2 and 3, and for the overall understanding of species roles in local ecosystem functioning.
- *Integrated database.* During TAPIOCA 1st phase, a database, compiling all the information already gathered, has been developed and will be completed and consolidated during this next phase. Indeed, the group rely on this exceptional combined data set that will allow addressing questions of world interest, integrated processes studies and temporal variability exploration. An objective for TAPIOCA 2st phase will be to improve the visibility and accessibility of this database in an easy and open-source framework.
- *Biostatistics and modelling*. (i) Ecosystem functioning - To characterize the relationship between biota and abiotic variability, functional groups, as well as other biotic data, will be summarized and confronted with abiotic data associated with climate and environmental factors. Net effects and their partitioning into direct and indirect factors will be estimated using structural equation modelling (SEM) and Ecosystem Network Analysis (ENA), or time series modelling. These

methodologies have been increasingly used to disentangle the complex effects of environmental and climate change at the community or ecosystem level, from their current state to their long-term evolution with the description of future scenarios related to global change effects. (ii) Species distribution and connectivity - The prediction of suitable habitats and potential future distributions of species is a central issue in ecology. To assess it, new methodological developments in the emerging field of *Marine Functional Connectivity* will be built, aiming at better characterizing the flows of genes, species and matter produced across the seascape. Ultimately, Species Distribution Models (SDMs) which allow to map and predict shifts in species ranges in response to global change will be applied. These include Ecological Niche Models (ENMs), Habitat Suitability Models (HSMs), Habitat Distribution Models (HDMs), Climate Envelope Models (CEM).

Axis 3 - Uses and impacts	PIs: Alex Lira (UFS) Jacques Panfili (IRD-MARBEC)

Problematic and gaps

The oceanic and coastal environments of the southeastern Atlantic are object to numerous and diverse uses (e.g., industrial and small-scale fisheries, aquaculture, mine exploitation, industries, coastal building, and tourism). All these marine systems are at risk, submitted to many pressures, including climate variability[21], increasing salinity in coastal zones[22], and many human impacts from fisheries, habitat loss and pollution from oil spill[23], sugar cane fields effluents, gold panning using mercury, and contamination from urbanization[24]. As an example, microplastics (<5 mm; MPs) and mercury (Hg) are among the most prominent pollutants present in aquatic ecosystems. Microplastics have gained attention due to their toxicity and widespread occurrence as a contaminant in the aquatic environment[25], while mercury also causes severe impacts on the ecosystem, and grows with anthropogenic activities. Once in the ocean, these pollutants may be ingested by organisms, intentionally or otherwise, and cause deleterious effects on the sensory, behavioural, and immune systems [26]. Additionally, MPs can serve as a substrate for Hg, and the two pollutes act synergistically [26]. The context is made worse by the presence of the Amazon, the largest river on earth by water discharge with a plume that extends more than 1500 km into the Atlantic Ocean.

Despite the many studies focusing on the MPs and Hg contamination on marine organisms, only a few have addressed these contaminants connecting different oceanic layers[27,28]. Overall, these works report the prominent and progressive impact of MPs and Hg. However, several questions about the transport of these pollutants in the food webs and their fate in ecosystems remain open. For instance, in the same way mesopelagic transport carbon to the deep-ocean and serve as food for epipelagic species, they can also transport contaminants up and down[29,30]. However, despite being part of the largest migration on earth, this phenomenon is still poorly studied, and its potential impacts are unclear.

In addition to the ecological aspects addressed in Axis 2, the main gap in conserving marine environments and associated biodiversity is the lack of knowledge of the current effects of external and human pressures[31]. For example, in Brazil, the state of the fisheries remains questioned because of the absence of systematic monitoring surveys or statistical data analysis for decades. Providing relevant information to stakeholders is a key issue that involves interdisciplinary science. Better knowledge of the uses and impacts is a prerequisite to improving the balance between the need to protect the marine environments and the needs of indigenous people and local communities (IPLC) from exploiting the resources[32]. During its first phase, TAPIOCA highlighted the effects of different coastal and marine anthropogenic impacts, such as the vulnerability and contamination of marine resources, showing a critical state of aquatic organisms due to fishing[33] or given the ingestion of high quantities of plastics[34,35,36] and the exposure to metals, from coastal zones to the deep sea.

In this context, the main questions addressed in the TAPIOCA 2nd phase are: (i) How is the vertical transport of contaminants done through the food-web?; (ii) what are the interactions between functional traits and contamination levels?; (iii) what are the potential sources of contaminants?; (iv) what are the potential effects of contamination on the many ecosystems process of estuarine, coastal, pelagic and mesopelagic species?; (v) How can the diverse uses of the marine space integrate fair and sustainable biodiversity conservation?; (vi) will critical assessment allow managers and decision makers to make fair choices for conservation and sustainable use?; and (vii) Can the results contribute to a global initiative for SDG?

The main challenges in answering these questions are the diverse uses of marine systems, the multiple threats affecting them, and the difficulty of drawing a clear image of the management options. Scientific surveys and conservation policies often favour certain sustainable development goals to the detriment of others. Putting in evidence transformative solutions through new

understanding of the dynamics and uses of coastal and marine socio-ecosystems is crucial to achieving SDG, looking for positive synergies ("co-benefits") between stakeholders to ensure healthy ecosystems while maintaining their diverse uses.

Main Objectives

Axis 3 encompasses the uses and impacts of global environmental pressures to provide information on fair and sustainable conservation of the environment and associated resources. Its main goal is to evaluate the different uses and anthropogenic impacts (e.g. pollution) in the various compartments of the biota, from the estuarine environments to the deep sea. It will provide a synthetic assessment in the context of interdisciplinary sciences, facilitate the intersectoral implementation of information for conservation, and provide an accurate assessment to managers and decision makers.

Axis 3 will also reinforce the links between Axes 1 and 2, by combining the data of the main environmental pressures and the most impacted species among the biodiversity to reach specific objectives:

- Quantifying the main uses of coastal and marine environments (fisheries, aquaculture, mangrove exploitation, urbanization);
- Quantifying the main pressures (climate variability, salinity increase, over-fishing, habitat degradation, contaminant) on coastal and marine environments;
- Quantifying how physical hydrodynamics (from estuaries to continental margins and in frontal systems) affect the dispersion and transport of contaminants associated to the dissolved and particulate phase (link with Axis 1);
- Quantifying and characterizing how the trophic relationships among vertically migrating organisms can enhance contaminants transport within oceanic layers, and influence the fate of the contaminants and thus ecosystems processes (link with Axis 2);
- Elaborating knowledge databases on case studies relying on existing or newly collected data, at relevant temporal and spatial scales, for giving an interdisciplinary assessment of environmental pressures;
- Interacting with stakeholders, environment managers and decision makers, with direct exchanges and a delivery of accurate information;
- Conceptualizing the current environmental governance and conservation schemes, and analysing the strengths and weaknesses of conservation models and alliances.

Main topics

The scientific barriers to be opened depend on the capacity to collectively build the definition of a healthy or non-impacted social-ecological system based on norms and values. Axis 3 will then target some of the main uses or impacts among the multitude in the work area, initially highlighted in TAPIOCA:

- the dynamic and impact of contaminants such as heavy metals and organic contaminants, macro- and micro-plastics on oceanic and coastal systems;
- the uses of coastal ecosystems including mangroves, which are good examples for external pressures associated with degradation, and the implementation of co-benefits from conservation;
- the habitat degradation along the coastline of North-Northeast Brazil including main threats on biodiversity conservation;
- the indicators for fisheries and resources status and the needs for effective conservation;
- the actions towards Marine Spatial Planning (MSP).

Main tools

To facilitate the implementation of its objectives, Axis 3 will develop an interdisciplinary critical analysis with an assessment of the different impacted habitats and their uses. For each of the five main topics, a database will be constructed and released in open access. The methods supporting the analysis will be diverse depending on the studied impacts, but will include societal surveys, GIS, modelling (MPS for particles, fisheries, conservation, etc.).

- *Dynamic and impact of contaminants*. TAPIOCA, during the 1st phase, started to study heavy metal, macro- and micro- plastic pollutions using specific analysis: concentration, occurrence, shapes and polymer nature of the ingested particles. Results are significant and reveal that contamination is pervasive. During the 2nd phase, TAPIOCA will continue developing this research field, include organic contamination and use new techniques such as specific indicators for pollution in the sediment (e.g. geo-accumulation index, contamination factor, Nemerow multi-factor, enrichment factor, and ecological risk assessment) and biota; moving particle semi-implicit (MPS) methods for simulating free surface flows (Lagrangian modelling). Deep learning approaches (e.g. neural network modelling) could be developed for predicting the heavy metal

concentrations associated to several environmental and social parameters[37]. In addition, sediment cores in estuaries will allows for long-term temporal reconstruction.

- *Mangrove conservation*. Mangroves in Northern Brazil are heavily affected by industrial effluents, aquaculture (shrimp farming), fishing activities and climate change as highlighted in TAPIOCA 1[38]. The biological characterisation of mangroves should be completed with satellite imagery processing combined with spatial analysis over years[38]. Interviews (e.g. participatory approaches with non-supervised interviews) will enable to quantify and spatialize resource management. Data generated will be of various nature (biodiversity, environmental, socio-economical), and alternative statistical methods incorporating multiple sets of data of different types (e.g. points and maps, taxonomic, genetics) will be used.
- *Habitat degradation*. Actions will focus on habitat loss due to anthropogenic and environmental factors, and their effect on biodiversity. For this, we will use tools such as GIS, Boolean modelling framework or Boosted Regression Trees coupled with information on environment and driver changes.
- *Fishery management*. The involvement of different TAPIOCA members in the ICCAT comities will give the opportunity for data analysis and message transmission of scientific information on connectivity of populations for some migratory fish species (e.g., tunas, sharks, barracudas). In addition, important target resources from a socio-economic point of view associated to small-scale fisheries (shrimps, jacks, snooks, snappers, croakers and mackerels) will also be evaluated. Pre-existing temporal and spatial databases will be used to build ecosystem quantitative models (e.g. EwE, Atlantis and/or end-to-end models), semi-quantitative analyses (e.g. Productivity and Susceptibility Analysis) and stock assessment model (e.g. data-poor approach) to evaluate the current impact of fishing and its behaviour in the face of future changes in the climate, including socio-economic factors and environmental drivers.
- *Marine spatial planning*. MSP is positioned as a collective and rational decision-making process that regulates the uses of marine spaces and resources in order to allow a better use of marine space by diverse sectors and reduce tensions between uses and conservation. MSP will involve collective mobilisation because its process is based on spatially explicit cross-cutting information (ecological, legal, social, economic, etc.) using decision support tools (DSTs). DSTs will take the form of spatially explicit tools, involving interactive software with maps, models, communication modules and additional elements that can help solving multifaceted problems too complex to be undertaken by conventional approaches alone.

3.2. Spatiotemporal scales

During TAPIOCA 1st phase, the IJL mostly focused on comprehensive snapshots in Northeast Brazil, and the time scale was mostly explored through 'scenarios' (e.g. ABRAÇOS program 1 vs. 2). During the 2nd phase, a spatial extension is proposed toward the North, particularly thanks to the AMAZOMIX program, and an amplified participation of UFPA and UFRA (Figure 3). In addition, time should more explicitly accounted thanks to: (i) paleo-studies (multi-proxy sediment cores) in estuaries and in oceanic basins, and (ii) available time series and new monitoring (Figure 4). Additionally, numerical models (NEMO, PISCES, Ecospace, bioeconomics, conservation planning, etc.) will improve our capacity to explore processes in time and space including climate change projections.

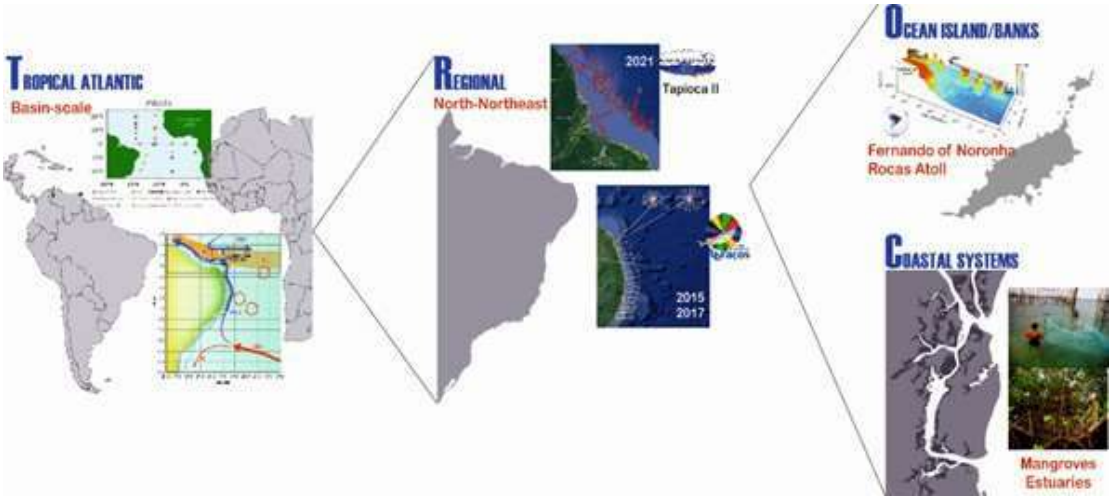

Figure 3. The main spatial scales of field activities.

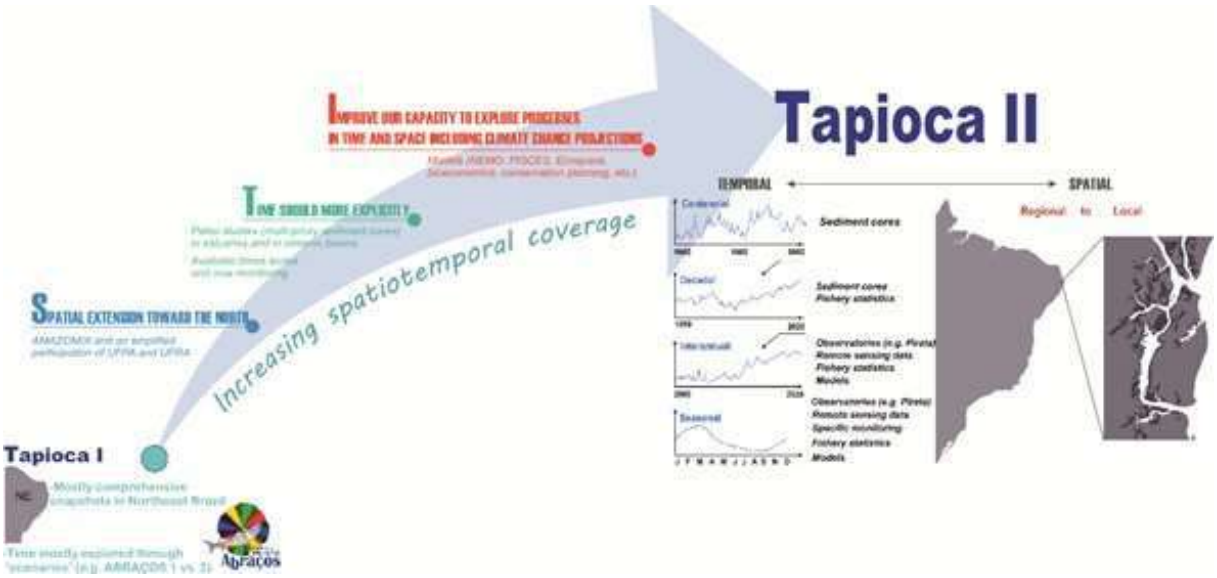

Figure 4. Spatiotemporal scales during the 2nd phase of TAPIOCA.

3.3. Schedule

- January 2023: launch of TAPIOCA 2nd phase
- March 2023: kick-off meeting (video-conference)
- November 2023: 2nd TAPIOCA meeting
- December 2023: Scientific Committee meeting (video-conference)
- May 2024: 3rd TAPIOCA meeting
- November 2024: 4th TAPIOCA meeting
- December 2024: Scientific Committee meeting (video-conference)
- May 2025: 5th TAPIOCA meeting
- September: TAPIOCA summer school
- December 2025: Scientific Committee meeting (video-conference)
- May 2026: 6rd TAPIOCA meeting
- November 2026: 7th TAPIOCA meeting
- December 2026: Scientific Committee meeting (video-conference)
- October 2027: launch of the "Regional Centre of Excellence in Marine Sciences for the Tropical Atlantic" during the TAPIOCA closing symposium

3.4. Innovative scope of the project

The 2nd phase of TAPIOCA will give opportunities to test new research fields and to use up-to-date innovative tools, not yet fully developed in Brazil, such as e-DNA, marine optics, marine spatial planning, among others (see research Axes). Modelling should be a main part of activities during the 2nd phase, allowing sharing information between disciplines, linking the different research Axes, and integrating data for reaching environmental managers with clear messages. The aim should be to increase the spatiotemporal scales of observation, thanks to the past oceanographic surveys, Abraços and Amazomix, the new time series and the models, providing large information that will be complemented by new research methods (e.g. geochemistry, ocean colour and altimetry remote sensing, biogeochemistry) which will enlarge the TAPIOCA spectrum of analyses.

Interdisciplinary research is viewed as an innovative aspect of interactions of specialities in the consortium during the 2nd phase of TAPIOCA. It will allow to collectively build definitions of healthy or non-impacted social-ecological systems, based on indicators, norms and values. The generated information will provide advice on important national and international questions dealing for example with climate, fisheries, or marine conservation. The activities developed during this phase should correspond to a network of projects merging to common results and ideas. TAPIOCA will be seen as a consortium of experts for enquiries related to marine environments in North-North-eastern Brazil.

3.5. Expected results

- A development and **establishment** of a "Regional Centre of Excellence in Marine Sciences for the Tropical Atlantic".
- **An implementation and perpetuation of innovative** research areas not yet well developed in Brazil by promoting courses (two by year), adapting the TAPIOCA laboratories and training young researches and students of different levels (undergraduates, masters, PhD) in new disciplines.
- **A final available** integrated open source **data base on marine science in North-North-eastern Brazil.**
- **An expertise in national and international marine policies** aiming at the sustainable use and conservation of coastal to deep sea areas.
- **An outreach on research on marine environments** along the north-eastern Brazilian coasts.

4. Scientific project versus development stakes - balance between advancement of knowledge and impact on development issues

The threats to oceanic and coastal marine waters are generally similar to those in other countries or areas in the world, with resource exploitation, pollution or conversion to land uses being the most important issues. Environmental conservation is then a major challenge for North/North-eastern Brazil and its partners, and managers or politics are waiting for expertise and advice. TAPIOCA will support the knowledge transfer to stakeholders, and help innovations and technologies' transfer for habitat conservation in the different areas of its actions, since many of the TAPIOCA participants are members of national and International Commissions. The IJL will build links with private or public companies using coastal ecosystems, and promote the exchange of experiences and technologies, with clear and unambiguous messages against uses giving degradation. TAPIOCA will also be used for strengthening the sectorial linkages around uses and its conservation, as a clear innovation given past information from the 1st phase and complements of new results obtained during the 2nd phase.

For example, the IJL network will provide data related to threatened species, information that may support the delineation of priority areas for conservation and results that may help the sustainable use and trade of the main fisheries resources. Much of this information can be incorporated into the Brazilian IUCN assessment of the extinction risk of marine species and assessment of commercial fisheries, using the new tools that will be developed here. Moreover, in an international viewpoint, TAPIOCA, through its partnership, will be seen as an actor of the SDG on oceanic and coastal marine environments, and as a main actor in international cooperation actions. TAPIOCA products will contribute for the different ODSs. For example, the United Nations Decade of Ocean Science for Sustainable Development (2021–2030) recognizes the deep sea as a frontier of science and discovery and calls for research to advance understanding of this environment, its diversity, vulnerabilities, and roles in the global ecosystems.

Finally, the IJL methodological framework and results on indicators on ecosystem health are main objectives, and could be released as innovation for conservation tools in other regions.

5. Description of partnership and governance

Following the dynamics of the first phase of the IJL TAPIOCA, the main partners coordinating are the Universidade Federal de Pernambuco (UFPE) and the Universidade Federal Rural de Pernambuco (UFRPE), the host partners, and IRD. However, the experience of the first phase of TAPIOCA and the extension of our activities to the North of Brazil lead us to increase the number and importance of the associated partners. In the second phase of TAPIOCA, we therefore wish to significantly strengthen the importance, role and visibility of the associated partners.

5.1. Main partners

Universidade Federal de Pernambuco (UFPE)
At UFPE (www.ufpe.br), the Department of Oceanography (DOCEAN) is the oldest, largest and most reputable center of Oceanography in North and Northeast of Brazil. Created in 1952, the DOCEAN is the second oldest Oceanography centre in Brazil, now completing 63 years. The Department of Oceanography of UFPE has over 3.000 m2 located in the Technology and Geoscience Centre (CTG/UFPE). The DOCEAN is constituted by nine research laboratories: Phytoplankton, Zooplankton, necton, phytobenthos, zoobenthos, Sea Water Chemistry, Physics, Geology, Mariculture, and also an Oceanographic Museum. The Master/PhD Program in Oceanography (PPGO) is also the oldest in the North and Northeast of Brazil, completing 33 years of existence. This program has contributed to the formation of 300 masters and 110 PhDs. The team of the Project is developing research directly with the Department of Oceanography - DOCEAN and also with the Centre for Studies and Essays in Environmental Modelling and Risk - CEERMA located at UFPE.

Universidade Federal Rural de Pernambuco (UFRPE)
Two Departments (Fisheries and Aquaculture, and Statistics and Informatics) of the UFRPE (www.ufrpe.br) will participate to the IJL TAPIOCA. The Department of Statistics and Informatics has three main areas: Statistics, Informatics and Computing Systems. It is responsible for the Post-Graduate Program in Biometry and offers statistics course to undergraduate and postgraduate students of others Departments of UFRPE. The Department of Fisheries and Aquaculture occupies an area of 4500 m^2 and has two auditoriums with capacity of 40 and 100 places. It has been contributing to the formation of professionals in fisheries, aquaculture, fishery technology, oceanography and applied ecology since 1970. It was pioneer in Brazil for the formation of undergraduate Fisheries Engineers. This Department is also responsible for the Post-Graduate Program in Fisheries Resources and Aquaculture (Master and PhD), created in 2000. Currently about 100 students develop their studies with a multidisciplinary approach.

IRD (main partner, France)
Five IRD joint research units (UMR) are official members of the IJL TAPIOCA, involving people from IRD but also from other French institutes (CNES, CNRS, IFREMER) and Universities: (AMU, UBO, ULCO, UM, UPS):

MARBEC: Marine Biodiversity, Exploitation and Conservation (UMR248, IRD/Ifremer/UM/CNRS)
The purpose of the UMR Marbec (www.umr-marbec.fr) is to produce and disseminate knowledge, train scientists and provide expertise in the field of marine biodiversity and its uses, mainly in the Mediterranean and in tropical marine ecosystems. Its research activity is based on six ambitions defined according to the challenges facing society in relation to marine biodiversity and its uses: (i) Taking stock of marine biodiversity; (ii) Understanding and modelling the functioning and evolution of marine organisms and ecosystems; (iii) Assessing the causes of marine biodiversity loss; (iv) Proposing tools for the conservation of marine biodiversity and anticipating emerging risks; (v) Promoting sustainable marine fisheries and aquaculture; and (vi) Developing a digital ocean to protect marine biodiversity

LEGOS: Laboratoire d'Etudes en Géophysique et Océanographie Spatiales (UMR065, CNES/CNRS/IRD/UPS)
LEGOS (www.legos.obs-mip.fr) is a multidisciplinary research laboratory working on key environmental issues related to ocean health and its response to climatic forcing. They associate physical oceanography, marine geochemistry and biogeochemistry. Theses researches themes are linked by an observational approach using remote sensing from satellites. LEGOS specificities are the development of original algorithms for oceanography and the acquisition of in situ data. LEGOS is also leader in the development of sensors and development of new generation numerical models for both open and regional oceans. LEGOS researchers contribute also to the scientific developments of operational oceanography at Mercator Océan. IRD team of LEGOS coordinates PIRATA in France and is strongly involved in West Africa through its team in Cotonou/Benin (projects PROPAO & ALOC-GG and capacity building with regional Master & PhD) in interaction with Brazilian partners (UFPE).

LEMAR: Laboratoire des sciences de l'Environnement Marin (UMR195, IRD/CNRS/UBO/ IFREMER)
The LEMAR (www-iuem.univ-brest.fr/LEMAR) is a laboratory, which main research objectives are the study and understanding of the processes regulating the interactions between the environment, climate and marine ecosystems in the context of global change. The laboratory is highly multidisciplinary including biology, physics, chemistry, ecotoxicology, law or sustainability science. The laboratory is essentially structured by the scale, with three teams: the 1st team studies are mainly from the molecular to the population level, the 2nd's from the organism to the socio-ecosystem level and the 3rd's from the element to the global ocean. The second team, particularly

involved within TAPIOCA, aims at understanding diversity, structure, dynamics and functioning of populations and communities in marine ecology. Pelagic and benthic ecosystems are studied, as well as the interfaces, by a combination of approaches including underwater acoustics, laboratory experiments, proxy calibration and modelling.

LOG: Laboratoire d'Océanologie et de Géosciences (UMR8187, ULILLE/ULCO/CNRS/IRD)
The Laboratory of Oceanology and Geosciences (www.log.cnrs.fr) is a highly interdisciplinary laboratory dealing with fundamental and applied research in oceanology and geosciences focusing on both coastal and open ocean ecosystems. The research performed at LOG is remarkably balanced between observation, experimentation, and modelling activities. The pronounced pluri-disciplinary dimension of LOG researchers (marine geology, ecology, biology, marine biogeochemistry, physical oceanography, marine optics, geomorphology, sedimentology) allows scientific questions to be addressed over a large range of spatiotemporal scales (from bacteria to satellites; from microscales to climate) in the general objective of better understanding the response of marine ecosystems to environmental changes of natural and anthropogenic origins. LOG teams are also involved in the international joint laboratories LOTUS (Vietnam) and ECLAIRS 2 (Western Africa).

M.I.O.: Institut Méditerranéen d'Océanologie (UMR Aix-Marseille Univ., Univ. Toulon, CNRS, IRD)
The objectives of M.I.O. (www.mio.osupytheas.fr) are to investigate the ocean system and its evolution in response to global change. M.I.O. is a multidisciplinary research unit with a strong expertise in biology, ecology, biodiversity, microbiology, fisheries, physics, chemistry, biogeochemistry and marine sedimentology. The working environment of M.I.O. is the world ocean, its interfaces with the continent, the atmosphere and the sediment. M.I.O. scientists conduct research in the areas (i) of ocean and atmospheric circulation, (ii) of marine ecosystems and biodiversity from bacteria to fish, (iii) of biological functioning in extreme environments and (iv) of ocean pollution and contaminants. M.I.O. requires oceanographic cruises, the use of innovative instruments equipped with sensors, radars installed on the coast and analysis of satellite images, as well as numerical analysis, mathematical modelling and laboratory resources.

5.2. Associated Institutions, Brazil

- Universidade Federal da Bahia (UFBA): www.ufba.br/
- Universidade Federal de Alagoas (UFAL): www.ufal.br
- Universidade Federal de Ceara (UFC): www.ufc.bf
- Universidade Federal de Rio Grande (FURG): www.furg.br/
- Universidade Federal de Rio Grande do Sul (UFRGS): www.ufrgs.br
- Universidade Federal de Sergipe (UFS): www.ufs.br
- Universidade Federal do Pará (UFPA): www.portal.ufpa.br
- Universidade Federal do Rio de Janeiro (UFRJ): www.ufrj.br
- Universidade Federal do Rio Grande do Norte (UFRN): www.ufrn.br
- Universidade Federal Rural da Amazônia (UFRA): www.ufra.br

5.3. Associated structures, France

- GET - Laboratoire Géosciences Environnement Toulouse (CNES/CNRS/IRD/UPS) : www.get.obs-mip.fr/
- LOCEAN: Laboratoire d'Océanographie et du Climat: Expérimentations et Approches Numériques : www.locean-ipsl.upmc.fr
- LOPS - Laboratoire d'Océanographie Physique et Spatiale (CNRS/IFREMER/IRD/UBO) : www.umr-lops.fr
- MERCATOR Ocean, a French operational agency for oceanography: www.mercator-ocean.fr
- CEBC - Centre d'Études Biologiques de Chizé : www.cebc.cnrs.fr/

5.4. Governance

From the experience of TAPIOCA 1st phase, the governance will be kept as simple as possible. TAPIOCA will be animated by three coordinators, two from Brazil (Moacyr Araujo, UFPE and Flávia Lucena Frédou, UFRPE) and one from France (Arnaud Bertrand, IRD). Each Axis will be leaded by two (Axes 1 and 3) or three (Axis 2) PIs to cover the variety of disciplines.

The coordinators will ensure the management of the different actions and links between Axes and participating organisations, with the help of the Axes' PIs, in compliance with the general objectives. They will encourage the participation of the ILJ staff to international activities of training and research valorisation, allowing communication and dissemination of results, manage the financial and material

resources of the ILJ. They will be particularly in charge of networking and capacity building organisation.

A scientific committee will help the coordinators in the development of scientific and academic activities (Figure 5). It will be composed by the 3 coordinators, the 7 Axes' PIs, and 4 referent personalities (2 for Brazil and 2 for France), for a total of 14 members. The scientific committee will meet once a year by videoconference, but will also convened for extraordinary meeting in case of necessity.

The scientific committee will be composed by:

- The coordinators: Moacyr Araujo (UFPE), Flávia Lucena-Frédou (UFRPE) and Arnaud Bertrand (IRD-MARBEC);
- The Axis 1 PIs: Alex Costa da Silva (UFPE), Ariane Koch-Larrouy (IRD-LEGOS), Vincent Vantrepotte (CNRS-LOG);
- The Axis 2 PIs: Thierry Frédou (UFRPE), Audrey Darnaude (CNRS-MARBEC) and Claire Carré (IRD-MARBEC);
- The Axis 3 PIs: Alex Lira (UFS) and Jacques Panfili (IRD-MARBEC) ;
- Four referent personalities: Victoria Isaac (UfPa), Carlos Lentini (UFBA), Frida Lasram (ULCO) and Patrice Guillotreau (IRD).

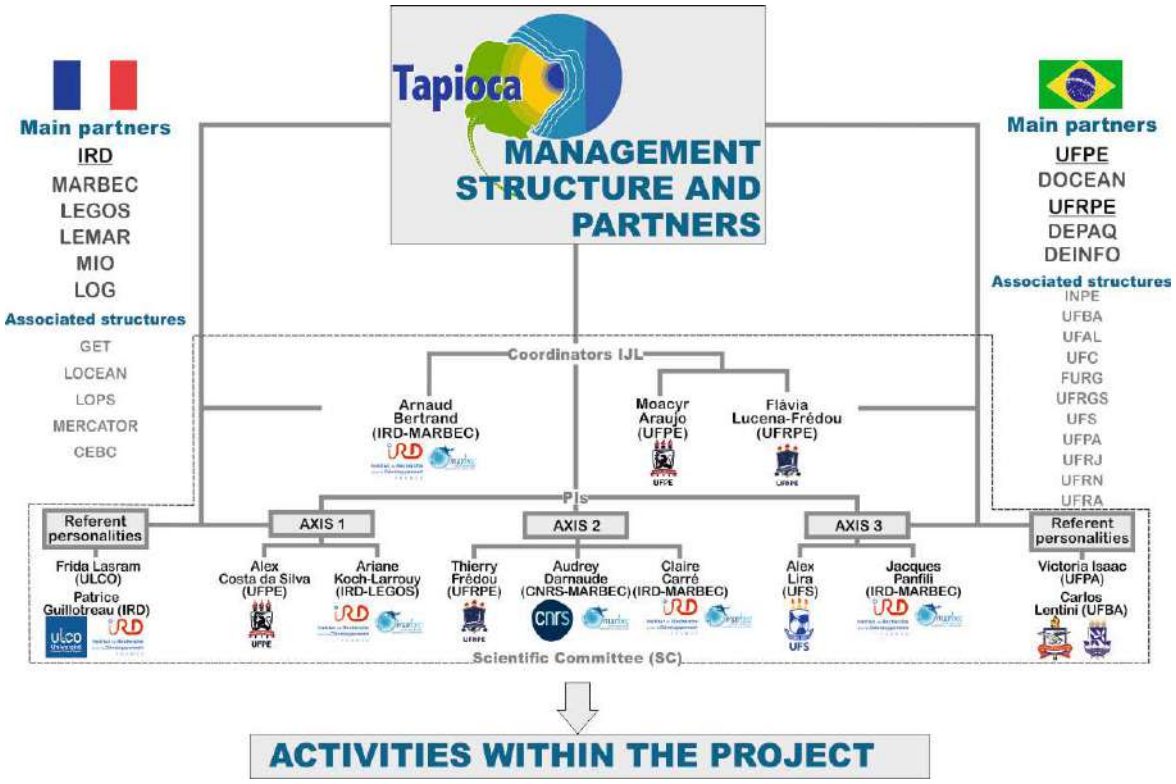

Figure 5. TAPIOCA management structure, partners, and Scientific Committee.

Considering the success of TAPIOCA 1st phase, auto-organisation and emergence will be encouraged. The IJL animation and interdisciplinary interactions will be primarily organized through consortium meetings twice a year to foster exchanges among disciplines and partners. In addition, Axes' PIs are encouraged to organise specific workshops to foster interactions and to focus on specific aspects. Money use will be oriented to ensure TAPIOCA's sustainability, prioritising both long-term infrastructure (laboratories) and capacity building of young scientists (training, exchanges, international actions other than symposiums, etc.).

Data policy: The IJL TAPIOCA (i) encourages the creation of interdisciplinary databases and data banks, released in open access after valorisation, (ii) promotes data mining and rescue to build or complete historical databases, and (iii) promotes open-access. Finally, considering the importance of outreach in TAPIOCA, activities linked with data management will be coordinated by Cristiano Lopez

(UFRPE), Anne Justino (UFRPE) and Martine Couapel (MARBEC/IRD) who played a pivotal role in TAPIOCA 1st phase.

6. Added value of a second phase and longer horizons

The success of the five main fields of TAPIOCA 1st phase (science, capacity building, outreach, national and international networking and visibility, and infrastructure) will be fostered during this 2nd phase by:

(i) including more universities and hence promoting additional co-badging and co-supervision for PhD students;

(ii) fostering the South-South-North capacity building (e.g. regional Master in Oceanography in Benin – M2-OPA IRD/UPS), mainly by taking the advantage of the already consolidated partnership of members of the IJL (e.g. Gabon, Senegal, etc.);

(iii) increasing the reach of the capacity building of new disciplines (e.g. contaminants, marine optics/ocean colour remote sensing, eDNA, microchemistry, modelling, automated *in situ* and *in vivo* optical approaches, Marine Spatial Planning…), especially for students and young scientists, by joining remote courses from different universities/countries;

(iv) generating responses to calls for funding and new projects, at consortium, bilateral or international cooperation levels;

(v) improving the infrastructure of the IJL partners' laboratories adapting to the new disciplines, making available for many groups of the country, from universities to NGOs;

(vi) enhancing the outreach and national and international visibility by the incorporation of two coordinators to lead the actions at different sectors of the society (e.g. community, stakeholders, schools, scientists).

Moreover, the consortium sustainability will be insured by the "new TAPIOCA generation", mainly the young scientists formed through the bilateral cooperation. This has been already observed during the 1st phase, and should be fostered during and after the TAPIOCA 2nd phase.

The ultimate goal of the 2nd phase of the TAPIOCA IJL is to ensure the sustainability taking the advantage of the successful integration of the consortium acquired in the 1st phase. Given this integration, indeed, TAPIOCA may be already considered as a "Regional Centre of Excellence in Marine Sciences for the Tropical Atlantic", but it will be supported by creating a formal research group between Brazilian official scientific institutions. This Regional Centre would perform as a "marine science hub" for the western tropical Atlantic Ocean that will foster national and international cooperation.

7. Ambition of the project, particularly in terms of regional and international visibility
- link with the structuring actions of the other institutions involved

UFPE-UFRPE are Brazilian prime sister universities in Ocean Sciences with a long term and strong international cooperation, especially France-Brazil. By consolidating the "Regional Centre of Excellence in Marine Sciences for the Tropical Atlantic", leaded by these two Institutions with the cooperation of the others important Universities of the region, the north-northeast Brazil, traditionally considered as less developed in Brazilian science, will be a national and international reference for the western tropical Atlantic Ocean. The common laboratory platforms, with a very strong official link between Universities, will share marine science infrastructures and knowledge with not only the regional institutions but also with groups elsewhere in Brazil, creating a "Federal Research Group" with regional and international visibility. During the 1st phase, TAPIOCA has received and trained not only Brazilian students from different states, but also international ones. This visibility and attractiveness should be even improved and enhanced during TAPIOCA 2nd phase.

The TAPIOCA IJL will be also reinforced by current and future actions with structuring ongoing projects such as PIRATA and the Synthesis Centre on Environmental and Climate Changes – Rede CLIMA. Moreover, a New Societal organization (OS) (OS-INMAR - "INSTITUTO NACIONAL DE PESQUISAS OCEÂNICAS – INPO") built from INPO's interaction with the Science and Technology Institutions (ICTs), the National Institutes of Science and Technology (INCTs) and Technical-Scientific Societies, will be structuring and will help to foster innovation, scientific and capacity building efforts. The OS will support the management of ocean research at the tactical and operational levels and will work closely with national and international programs and projects.

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APPENDICES

1. Overall presentation of the team

List of Main members (participants involved >30% FTE)

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France	IRD-LEMAR	PETEK	Sylvain	CR	Sponges, Marine natural products	0000-0001-7920-0467	2,3	10	Sylvain.petek@ird.fr
France	IRD-LEMAR	ROUDAUT	Gildas	IE	Acoustics		1,2	15	gildas.roudaut@ird.fr
France	LOG	ARTIGAS	Felipe	MCF	Phytoplankton/bacteria ecology, biogeochemical dynamics		2	10	felipe.artigas@univ-littoral.fr
France	LOG	BOUT-ROUMAZEILLES	Viviane	DR	Sedimentology, mineralogy, geochemistry		1	20	viviane.roumazeilles@univ-lille.fr
France	LOG	LASRAM	Frida	Pr	Trophic modelling		2,3	5	frida.lasram@univ-littoral.fr
France	LOG	LOISEL	Hubert	Pr	Marine Optics, Ocean color remote sensing		1	15	hubert.loisel@univ-littoral.fr
France	LOG	MERIAUX	Xavier	IR	Marine optics/biogeochemistry		1	5	xavier.meriaux@univ-littoral
France	LOG	MONCHY	Sebastien	Pr	Ecology, molecular biology, genetics		2	10	sebastien.monchy@univ-littoral.fr
France	LOG	RIBOULLEAU	Armelle	MCF	Sedimentology, mineralogy, geochemistry		1	5	armelle.riboulleau@univ-lille.fr
France	LOG	TRIBOVILLARD	Nicolas	Pr	Sedimentology, mineralogy, geochemistry		1	10	nicolas.tribovillard@univ-lille.fr
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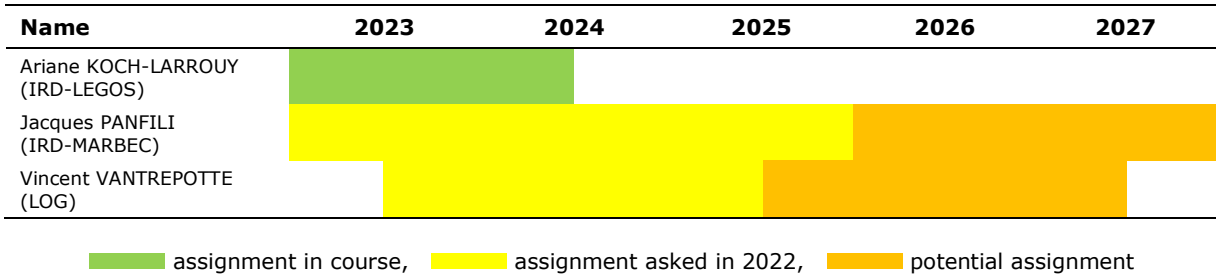
France	AMU-MIO	BERLINE	Léo	MCF	Modelling		1,2,3	20	leo.berline@mio.osupytheas.fr
France	AMU-MIO	BOULANGER	Emilie	PhD stud.	Ecology/eDNA		2,3	25	emilie.boulanger@mio.osupytheas.fr
France	IRD-MIO	CHANGEUX	Thomas	IR	Marine ecology		2,3	10	thomas.changeux@ird.fr
France	AMU-MIO	CUNY	Philippe	Prof	Contaminant		2,3	10	philippe.cuny@mio.osupytheas.fr
France	CNRS-MIO	MARTINI	Séverine	CR	Marine ecology		2	15	severine.martini@mio.osupytheas.fr
France	AMU-MIO	MICHOTEY	Valérie	Pr	Microbiology/eDNA		2,3	20	valerie.michotey@univ-amu.fr
France	AMU-MIO	MILITON	Cécile	MCF	Contaminant		2,3	10	Cecile.militon@mio.osupytheas.fr
France	U.Toulon-MIO	MOUNIER	Stéphane	MCF	Chemistry	9805203612762919	2,3	15	stephane.mounier@mio.osupytheas.fr
France	U.Toulon-MIO	PATEL	Nathalie	MCF	Contaminant		2,3	10	nathalie.patel@mio.osupytheas.fr

France	Univ Toulon-MIO	PLIHON	Hélène	PhD stud.	Geochmistry, contaminant		2,3	80	helen.plihon@mio.osupytheas.fr
France	AMU-MIO	POGGIALE	Jean-Christophe	Pr	Mathematical modelling		2	20	jean-christophe.poggiale@univ-amu.fr
France	U.Toulon-MIO	TADINI	Amanda	Post Doc MOPGA	Geochemistry	2891353065782403	2,3	100	amanda.tadini@mio.osupytheas.fr
France	CNRS-MIO	TAMBURINI	Christian	DR	Microbiology		2	15	christian.tamburini@mio.osupytheas.fr
France	AMU-MIO	THIBAULT	Delphine	MCF	Marine ecology		2,3	20	delphine.thibault@univ-amu.fr
France	AMU-MIO	THIBAUT	Thierry	Pr	Marine ecology		2,3	15	thierry.thibaut@univ-amu.fr

Provisional program of assignment in Brazil



In addition to assignment, several IJL members already asked or plan asking "**long duration missions**" (**MLD IRD**, between 2 and 4 months) during the 5-year period of the IJL: Felipe ARTIGAS (LOG), Arnaud BERTRAND (IRD-MARBEC), Claire CARRÉ (IRD-MARBEC), Fabrice DUPONCHELLE (IRD-MARBEC), Sophie LANCO-BERTRAND (IRD-MARBEC), Juan Carlos MOLINERO (IRD-MARBEC).

2. Curricula vitae of project leaders and main publications of project members (past 5 years)

Professor Flávia LUCENA FRÉDOU, born in 1973 (48 years-old)

Full professor since 2018

Nationality: Brazilian and French
Idioms: Portuguese, English and French (Fluent); Spanish (moderate)
Complete Curriculum: http://lattes.cnpq.br/4779271407117528
Research gate: https://www.researchgate.net/profile/Flavia-Lucena-Fredou
Orcid: https://orcid.org/0000-0001-5492-7205
Current Professional Address: (From 2010) Universidade Federal Rural de Pernambuco (UFRPE), Departamento de Pesca. Rua Dom Manoel de Medeiros, Dois Irmãos, 52171900 – Recife (PE)– Brazil
Phone:+55(81) 33206514
Email:flavialucena@hotmail.com or flavia.fredou@ufrpe.br
Previous Professional Address: From 2002 to 2009. Universidade Federal do Pará (UFPA)

FORMATION

1997 – 2000 – PhD in Centre of Environmental Fisheries and Aquaculture Sciences, CEFAS, England "Species interaction in fish stock assessment and management in southern Brazil: a bio-economic approach"
1995 – 1997 – MSc – Biological Oceanography, Universidade Federal do Rio Grande, FURG, Brasil."A pesca da anchova Pomatomus saltatrix (Pisces: Pomatomidae) na costa do Rio Grande do Sul: estrutura do estoque e seletividade da rede de emalhar".

1990 – 1995 – Licence in Fisheries Engineering, Universidade Federal Rural de Pernambuco.

INTERNATIONAL INSERTION

- Co-Coordinator within Global Marine Species Assessment (GMSA), IUCN (International Union of Conservation of Nature) and Conservation International (CI) – Estuarine and Shelf Fishes (Regional Assessment – Brazil).
- Co-Coordinator of LMI TAPIOCA Brazil-France.
- Member of Atlantic Tunas Research Brazilian subcommittee, representing Brazil in ICCAT (International Commission for the Conservation of Atlantic Tunas).
- Coordinator of Small tuna Working Group of ICCAT (International Commission for the Conservation of Atlantic Tunas) (2018-2021).
- Participant in the process of Description of Ecologically or Biologically Significant Marine Areas (EBSAs) organized by CDB (Convention on Biological Biodiversity).
- Member of "World Ocean Assessment Pool of Experts" (ONU).
- Member of IUCN Species Survival Commission, IUCN SSC Sciaenid Red List Authority and IUCN SSC Tuna & Billfishes Specialist Group.
- 1 year Mission in France (MARBEC – Sète) (2013-2014).

SUPERVISION

- Ph.D students –5 ongoing and 9 finalized
- MSc. Students – 2 ongoing and 25 finalized
- Pos-doc – 2 on going and 4 finalized
- Licence (Fisheries Engineering, Biology and Oceanography) – 1 ongoing and 19 finalized

PROJECTS

- 60 projects (9 ongoing) - 11 as coordinator (two ongoing) and 7 with international cooperation (ABRAÇOS, AMAZOMIX, TAPIOCA, SMAC, TRIATLAS, REBYC and PADDLE)– see complete CV for project list.

TEACHING

-Undergraduate

- UFPA (a) Population Dynamics (60 hours/semester); (b) Stock Assessment (60 hours), (c) Biological Oceanography (60 hours), (d) Biometry (60 hours)
- UFRPE (a) Aquatic Management (60 hours); (b) Ethics and fisheries legislation of fisheries (45 hours); (c)Management and Legislation of fisheries (60 hours)

-Graduate

- UFPA (a) Population Dynamics (60 hours/semester);
- UFRPE (a) Politics and fishery and environmental legislation (45 hours/semester).

- Jury of 25 Ph.D and 60 MSc. thesis
- Referee of 19 Journals and Associate editor of Aquatic Living resources
- 138 Abstracts published in international and national conferences

ISI - H_{index} = 16	**Number of citations = 875**	**Total papers = 118** Total in the last 05 years = 59

PUBLICATION IN THE LAST 5 YEARS

1. FERREIRA, G.; JUSTINO, A. K.S.; EDUARDO, L.; LENOBLE, V.; FAUVELLE, V.; SCHMIDT, N.; VASKE JUNIOR, T.; FRÉDOU, T.; LUCENA-FRÉDOU, F. Plastic in the inferno: Microplastic contamination in deep-sea cephalopods (Vampyroteuthis infernalis and Abralia veranyi) from the southwestern Atlantic. MARINE POLLUTION BULLETIN, v. 174, p. 113309, 2022.
2. LIRA, A. S.; LE LOC'H, F.; ANDRADE, H. A.; LUCENA-FRÉDOU, F. Vulnerability of marine resources affected by a small-scale tropical shrimp fishery in Northeast Brazil. ICES JOURNAL OF MARINE SCIENCE, v. 1, p. 1, 2022.
3. JUSTINO, A. K.S.; FERREIRA, G. V.B.; SCHMIDT, N.; EDUARDO, L. N.; FAUVELLE, V.; LENOBLE, V.; SEMPÉRÉ, R.; PANAGIOTOPOULOS, C.; MINCARONE, M.; FRÉDOU, T.; LUCENA-FRÉDOU, F. The role of mesopelagic fishes as microplastics vectors across the deep-sea layers from the Southwestern Tropical Atlantic. ENVIRONMENTAL POLLUTION, v. 1, p. 118988, 2022.
4. BRUZACA, D. N.A.; JUSTINO, A. K.S.; MOTA, G. C.P.; COSTA, G. A.; LUCENA-FRÉDOU, F.; GÁLVEZ, A. O. Occurrence of microplastics in bivalve molluscs Anomalocardia flexuosa captured in Pernambuco, Northeast Brazil. MARINE POLLUTION BULLETIN, v. 179, p. 113659, 2022.
5. MINCARONE, M.; MARTINS, J. R.; Di DARIO, F.; EDUARDO, L. N.; FRÉDOU, T.; LUCENA-FRÉDOU, F.; BERTRAND, A. Deep-sea smelts, pencil smelts, and barreleyes (Teleostei: Argentiniformes) from oceanic islands and seamounts off northeastern Brazil. Marine Biology Research, v. 1, p. 1-12, 2021.
6. Jimenez, E.; GUAZZELLI, J.; LUCENA-FRÉDOU, F. Sustainability indicators for the integrated assessment of coastal small-scale fisheries in the Brazilian Amazon. ECOLOGICAL ECONOMICS, v. 181, p. 106910, 2021.
7. AFONSO, G. V. F.; MINCARONE, M.; Di DARIO, F.; NOLÉ EDUARDO, L.; LUCENA-FRÉDOU, F.; BERTRAND, A. Taxonomy and Distribution of Deep-Sea Bigscales and Whalefishes (Teleostei: Stephanoberycoidei) Collected off Northeastern Brazil, Including Seamounts and Oceanic Islands. ICHTHYOLOGY & HERPETOLOGY, v. 109, p. 467, 2021.
8. PELAGE, L.; GONZALEZ, J. G.; LELOCH, F.; FERREIRA, V.; MUNARON, J.; LUCENA-FRÉDOU, F.; FRÉDOU, T. Importance of estuary morphology for ecological connectivity with their adjacent coast: A case study in Brazilian tropical estuaries. ESTUARINE COASTAL AND SHELF SCIENCE, v. 1, p. 107184, 2021.
9. LIRA, A. S.; LUCENA-FRÉDOU, F.; MÉNARD, F.; FRÉDOU, T.; GONZALEZ, J. G.; FERREIRA, V. E.; FILHO, J. S. R.; MUNARON, J.; LE LOC'H, F. Trophic structure of a nektobenthic community exploited by a multispecific bottom trawling fishery in Northeastern Brazil. PLoS One, v. 16, p. e0246491, 2021.
10. BARROS, M. J. G.; EDUARDO, L. N.; BERTRAND, A.; LUCENA-FRÉDOU, F.; FRÉDOU, T.; LIRA, A. S.; FERREIRA, B. P. Bottom trawling on a carbonate shelf: Do we get what we see?. CONTINENTAL SHELF RESEARCH, v. 213, p. 104314, 2021.
11. LIRA, A. S.; LUCENA-FRÉDOU, F.; LE LOC'H, F. How the fishing effort control and environmental changes affect the sustainability of a tropical shrimp small scale fishery. FISHERIES RESEARCH, v. 235, p. 105824, 2021.
12. MINCARONE, M.; AFONSO, G. V. F.; Di DARIO, F.; EDUARDO, L. N.; FRÉDOU, T.; LUCENA-FRÉDOU, F.; BERTRAND, A.; PIETSCH, T.L. Deep-sea anglerfishes (Lophiiformes: Ceratioidei) from off northeastern Brazil, with remarks on the ceratioids reported from the Brazilian Exclusive Economic Zone. Neotropical Ichthyology, v. 19, p. e200151, 2021.
13. GUAZZELLI GONZALEZ, J.; DARNAUDE, A. M.; DUARTE-NETO, P. J.; LE LOC'H, F.; LIMA, M. C.; MENARD, F.; FERREIRA, V.; LUCENA-FRÉDOU, F.; MUNARON, J.; FRÉDOU, T. Trophic ecology of the juveniles of two jack species (Caranx latus and C. hippos) in contrasted tropical estuaries. ESTUARINE COASTAL AND SHELF SCIENCE, v. 1, p. 107370, 2021.
14. JUSTINO, A. K.S.; LENOBLE, V.; PELAGE, L.; FERREIRA, G. V.B.; P., R.; FRÉDOU, T.; LUCENA-FRÉDOU, F. Microplastic contamination in tropical fishes: An assessment of different feeding habits. REGIONAL STUDIES IN MARINE SCIENCE, v. 1, p. 101857, 2021.
15. JIMENEZ, É.; LEITÃO BARBOZA, R. S.; DA SILVA GARCIA, J.; CRISTINA DA SILVA CORREA, E.; AMARAL, M. T.; LUCENA-FRÉDOU, F. International trade of Amazon fish byproducts: Threats and opportunities for coastal livelihoods. OCEAN & COASTAL MANAGEMENT, v. 212, p. 105812, 2021.
16. LUCENA-FRÉDOU, F.; MOURATO, B.; FRÉDOU, T.; LINO, P. G.; MUÑOZ-LECHUGA, R.; PALMA, C.; SOARES, A.; PONS, M. Review of the life history, fisheries, and stock assessment for small tunas in the Atlantic Ocean. REVIEWS IN FISH BIOLOGY

AND FISHERIES, v.31, p. 1, 2021.
17. PELAGE, L.; BERTRAND, A.; FERREIRA, B. P.; LUCENA-FRÉDOU, F.; JUSTINO, A. K S ; FRÉDOU, T. Balanced harvest as a potential management strategy for tropical small-scale fisheries. ICES JOURNAL OF MARINE SCIENCE, v. 1, p. 1, 2021.
18. MARTINS, K.; PELAGE, L.; JUSTINO, A. K. S.; LUCENA-FRÉDOU, F.; VASKE JÚNIOR, T.; LE LOC'H, F.; TRAVASSOS, P. Assessing trophic interactions between pelagic predatory fish by gut content and stable isotopes analysis around Fernando de Noronha Archipelago (Brazil), Equatorial West Atlantic. JOURNAL OF FISH BIOLOGY, v. 1, p. jfb.14863, 2021.
19. SANTOS, L. V.S ; CRAVEIRO, C. F. F.; SOARES, A.; EDUARDO, L. N.; PASSARONE, R.; DA SILVA, E. F. B.; LUCENA-FRÉDOU, F. Reproductive biology of the shorthead drum Larimus breviceps (Acanthuriformes: Sciaenidae) in northeastern Brazil. REGIONAL STUDIES IN MARINE SCIENCE, v. 1, p. 102052, 2021.
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23. EDUARDO, L. N.; BERTRAND, A.; FRÉDOU, T.; LIRA, A.; LIMA, R.; FERREIRA, B.P ; MENARD, F.; LUCENA-FRÉDOU F. Biodiversity, ecology, fisheries, and use and trade of Tetraodontiformes fishes reveal their socio-ecological significance along the tropical Brazilian continental shelf. AQUATIC CONSERVATION-MARINE AND FRESHWATER ECOSYSTEMS, p. aqc.3278, 2020.
24. Jimenez, E.; AMARAL, M.; SOUZA, P.; COSTA, M.; Lira, A.; LUCENA-FRÉDOU, F. Value chain dynamics and the socioeconomic drivers of small-scale fisheries on the Amazon coast: A case study in the state of Amapá, Brazil. MARINE POLICY, v. 1, p. 1, 2020.
25. MELO, C.; SOARES, A.; PELAGE, L.; Nolé, L.; FRÉDOU, T.; Lira, A.; Ferreira, B.P ; BERTRAND, A.; LUCENA-FRÉDOU, F. Haemulidae distribution patterns along the northeastern brazilian continental shelf and size at first maturity of the most abundant species. REGIONAL STUDIES IN MARINE SCIENCE, v. 1, p. 1, 2020.
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28. EDUARDO, L. N.; LUCENA-FRÉDOU, F.; MINCARONE, M.; VILLARINS, B.; AFONSO, G. V. F.; FRÉDOU, T.; Lira, A.; BERTRAND, A. Length¿weight relationship of twelve mesopelagic fishes from the western Tropical Atlantic. JOURNAL OF APPLIED ICHTHYOLOGY, v. 1, p. 1, 2020.
29. EDUARDO, L. N.; LUCENA-FRÉDOU, F.; MINCARONE, M.; SOARES, A.; LE LOC'H, F.; FRÉDOU, T.; MENARD, F.; BERTRAND, A. Biodiversity, vertical niche partitioning and spatial variation of lanternfishes (Myctophidae) from in the western Tropical Atlantic. Scientific Reports, v. 10, p. 1, 2020.
30. SILVA, C.; LIRA, A.; EDUARDO, L. N ; VIANA, A. P.; LUCENA-FRÉDOU, F.; FRÉDOU, T. Ichthyofauna bycatch of the artisanal fishery of penaeid shrimps in Pernambuco, Northeastern Brazil. BOLETIM DO INSTITUTO DE PESCA, v. 45, p. 435, 2019.
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33. LOPES, D. F. C.; ASSIS, C.; SANTANNA, M.; SILVA, J ; BEZERRA, R.; LUCENA-FRÉDOU, F. Brain acetylcholinesterase of three perciformes: From the characterization to the in vitro effect of metal ions and pesticides. ECOTOXICOLOGY AND ENVIRONMENTAL SAFETY, v. 173, p. 494-503, 2019.
34. Ferreira, V.; LE LOC'H, F.; MENARD, F.; FRÉDOU, T.; LUCENA-FRÉDOU, F. Composition of the fish fauna in a tropical estuary: the ecological guild approach. SCIENTIA MARINA, v. 83, p. 1, 2019.
35. MINCARONE, M. M.; VILLARINS, B. T.; EDUARDO, L. N.; CAIRES, R. A.; LUCENA-FRÉDOU, F.; FRÉDOU, T.; LIRA, A. S.; BERTRAND, A. Deep-sea manefishes (Perciformes: Caristiidae) from oceanic islands and seamounts off northeastern Brazil, with comments on the caristiids previously reported in Brazilian waters. MARINE BIOLOGY RESEARCH, v. 15, p. 1-8, 2019.
36. PONZ, M.; LUCENA-FRÉDOU, F.; FRÉDOU, T.; MOURATO, B. Exploration of length-based and catch-based data limited assessments for small tunas. Collective volume of scientific papers - international commission for the conservation of Atlantic tunas, v. 76, p. 78, 2019.
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38. GUAZZELLI, J.; MENARD, F.; ANDRADE, H. A.; VIANA, A. P.; Ferreira, V.; LUCENA-FRÉDOU, F.; LIRA, A.; MURANON, J.; LE LOC'H, F.; FRÉDOU, T. Trophic resource partitioning of two snook fish species (Centropomidae) in tropical estuaries in Brazil as evidenced by stable isotope analysis. ESTUARINE COASTAL AND SHELF SCIENCE, v. 226, p. 106287, 2019.
39. Lira, A.; VIANA, A. P.; Nolé, L.; LUCENA-FRÉDOU, F.; FRÉDOU, T. Population structure, size at first sexual maturity, and feeding ecology of Conodon nobilis (Actinopterygii: Perciformes: Haemulidae) from the coasts of Pernambuco, north-eastern Brazil. ACTA ICHTHYOLOGICA ET PISCATORIA, v. 49, p. 389-398, 2019.
40. JIMENEZ, É. A.; BARBOZA, R.; AMARAL, M. T.; LUCENA-FRÉDOU, F. Understanding changes to fish stock abundance and

associated conflicts: Perceptions of small-scale fishers from the Amazon coast of Brazil. OCEAN & COASTAL MANAGEMENT, v. 1, p. 104954, 2019.

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43. PEIXOTO, S ; CALAZANS, N.; SILVA, E. F.; Nolé, L.; SOARES, R.; LUCENA-FRÉDOU, F. Reproductive cycle and size at first sexual maturity of the white shrimp Penaeus schmitti (Burkenroad, 1936) in northeastern Brazil. LATIN AMERICAN JOURNAL OF AQUATIC RESEARCH, v. 46, p. 1-9, 2018.
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FORMATION

1992 – 1996 – DSc. Physisque et Chimie de l´Environement, INPT, France.
"Circulations de Langmuir et turbulence sous une houle cisaillée para le vent"
1991 – 1992 – DEA Physisque et Chimie de l´Environement, INPT, France.

"Aproche 2D pour la modelisation des interactions turbulence-gradient thermique dans les écoulements cisaillés par des vents faibles"
1986 – 1991 – MSc. Hydraulics and Sanitation, EESC-USP, Brazil.

"Modelagem matemática no gerenciamento da qualidade da água em reservatórios. Uma primeira estimativa das futuras tendências na qualidade da água durante as fases de enchimento e estabilização de reservatórios tropicais. O caso da UHE Porteira"
1981 – 1985 – Licence in Civil Engineering, UFPE, Brazil.

INTERNATIONAL INSERTION

- Member of the National Committee PIRATA Brazil Project (from 2003 to present);
- Member of the PIRATA International Scientific Steering Group (from 2008 to present);
- Member of the Conseil d´Orientation Stratégique e Scientifique de la Flotte Océanografique Française - COSS-FLOTTE (from 2012 to 2017);
- Co-chair of the INCTAmbTropic – Brazilian National Institute of Science and Technology for Tropical Marine Environments (from 2014 to present);
- Co-chair of the WG1 Scientific basis of the Brazilian Panel on Climate Changes – PBMC (from 2012 to present);
- Member of the CLIVAR-Atlantic Implementation Panel (WCRP) (from 2013 to 2016);
- Co-chair of the Prediction and Research moored Array in the Tropical Atlantic project - PIRATA and member of the International Scientific Steering Group (from 2014 to 2020);
- Chair of the Brazilian Research Network on Global Climate Change – Rede CLIMA (from 2016 to present);
- Member of the Brazilian Committee on Ocean Sciences – MCTI (from 2016 to present);
- Member of the International Scientific and Technical Advisory Board (ISTAB) EU Horizon 2020 project AtlantOS: Optimizing and Enhancing the Integrated Atlantic Ocean Observing System (from 2015 to 2019);
- Member of the Author Team for the Atlantic Ocean Observing System BluePrint 2019 (from 2017 to 2019);
- Member of the Author Team for the Tropical Atlantic Observing System - TAOS Review (2018-2021);
- Expert Reviewer do Working Group I (WGI) do IPCC Sixth Assessment Report (AR6-IPCC) (2020);
- Co-lider do WP1/CT1 - Large-scale circulation, eddy dynamics, upwelling and mixing of the H2020 TRIATLAS Project (2019-2024);
- Member of the Brazilian Commission on Antarctic Research (CONAPA) from 2021 to present).
- Co-Coordinator of LMI TAPIOCA Brazil-France

SUPERVISION

- Ph.D students – 3 ongoing and 17 finalized
- MSc. Students – 1 ongoing and 22 finalized
- Pos-doc – 2 on going and 8 finalized

PROJECTS

50+ projects (9 ongoing) - 55 as coordinator with national and international cooperation see complete CV for project list.

ISI - H_{index} = 24	**Number of citations = 2,054**	**Total papers = 124** Total in the last 05 years = 55

PUBLICATION IN THE LAST 5 YEARS

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2. VARONA, HUMBERTO L.; ARAUJO, M.; SILVA, M.; MAIDA, M.; FERREIRA, B.E P. Database of oceanographic anomalies and atmospheric surface fluxes for the study of climate change in the Brazilian Northeast. LATIN AMERICAN DATA IN SCIENCE, v. 2, p. 1, 2022.
3. VARONA, H.L.; HERNANDEZ, F.; BERTRAND, A.; ARAUJO, M. Monthly Anomaly Database of Atmospheric and Oceanic Parameters in the Tropical Atlantic Ocean. DATA IN BRIEF, v. 1, p. 107969, 2022.
4. CARREIRA, R. S.; ZANARDI-LAMARDO, E.; MASSONE, C. G.; ARAUJO, M.; NOBRE, P.; YOGUI, G. T. The mysterious oil spill in the northeastern coast of Brazil: tracking offshore seawater and the need for improved vessel facilities. OCEAN AND COASTAL RESEARCH, v. 70, p. 1, 2022.
5. CAPUANO, T. A.; VARONA, H. L.; Araujo, M.; KOCH-LARROUY, A. High-resolution hydrodynamics and TS structure database of the Brazilian continental shelf and adjacent waters. DATA IN BRIEF, v. 1, p. 108210, 2022.
6. DIMOUNE, M. D.; ARAUJO, M.; HERNANDEZ, F. Investigating of the two-core structure of the Atlantic North Equatorial Countercurrent with the GLORYS12V1 reanalysis. TROPICAL OCEANOGRAPHY (ONLINE), v. 49, p. 1, 2022.
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11. NORIEGA, C.; MEDEIROS, C.; Araujo, M.; SILVA, A. X.; COSTA, M.; PEREIRA, N. A.; DE LIMA, E. E. S.; DA SILVA, D. S. T.; DE CAMPOS PEREIRA, S.; ROLLNIC, M. Long-term water quality conditions and trends in 12 tropical coastal rivers in Northeast Brazil. ENVIRONMENTAL MONITORING AND ASSESSMENT, v. 193, p. 308, 2021.
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15. GOMES, A. M.; ARAÚJO FILHO, M. Qual universidade pública é requerida para defesa dos valores republicanos?. ESTUDOS UNIVERSITARIOS, v. 38, p. 17, 2021.
16. FOLTZ, G. R.; HUMMELS, R.; DENGLER, M.; PEREZ, R. C.; ARAUJO, M. Vertical turbulent cooling of the mixed layer in the Atlantic ITCZ and trade wind regions. JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS, v. 1, p. 1-54, 2020.
17. ASSUNÇÃO, R. V.; SILVA, A. C.; ROY, A.; BOURLÈS, B.; HENRIQUE S. SILVA, C.; TERNON, J.; ARAUJO, M.; BERTRAND, A. 3D characterisation of the thermohaline structure in the southwestern tropical Atlantic derived from functional data analysis of in situ profiles. PROGRESS IN OCEANOGRAPHY, v. 187, p. 102399, 2020.
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NBC rings using AMEDA algorithm: observations from 1993 to 2016. JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS, v. 1, p. 1, 2020.
21. BORGES, G. C. P.; DE AQUINO, E.; ESKINAZI-LEÇA, E.; DE CASTRO SANTOS-JUNIOR, A.; SANTIAGO, M. F.; FERREIRA, L.; NORIEGA, C.; ARAÚJO, M.; DA SILVA GREGO, C. K.; DA SILVA-CUNHA, M. Cell biovolume and carbon biomass of phytoplankton in degraded tropical estuaries in Northeastern Brazil. REGIONAL STUDIES IN MARINE SCIENCE, v. 1, p. 101522-18, 2020.
22. DOSSA, A. N.; COSTA DA SILVA, A.; CHAIGNEAU, A.; ELDIN, G.; Araujo, M.; BERTRAND, A. Near-surface western boundary circulation off Northeast Brazil. PROGRESS IN OCEANOGRAPHY, v. 1, p. 102475, 2020.
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31. QUEIROZ, S.; FAZEKAS, L.; SILVA, M. A.; ARAÚJO, M. Simulation of oil spills near a tropical island in the equatorial southwest Atlantic. TROPICAL OCEANOGRAPHY (ONLINE), v. 47, p. 17-37, 2019.
32. CLAUDET, J.; BOPP, L.; CHEUNG, W. W.L.; DEVILLERS, R.; ESCOBAR-BRIONES, E.; HAUGAN, P.; HEYMANS, J. J.; MASSON-DELMOTTE, V.; MATZ-LÜCK, N.; MILOSLAVICH, P.; MULLINEAUX, L.; VISBECK, M.; WATSON, R.; ZIVIAN, A.; ANSORGE, I.; ARAUJO, M.; ARICÒ, S.; BAILLY, D.; BARBIÈRE, J.; BARNERIAS, C.; BOWLER, C.; BRUN, V.; CAZENAVE, A.; DIVER, C.; EUZEN, A.; GAYE, A.; HILMI, N.; MÉNARD, F.; MOULIN, C.; MUÑOZ, N.PATRICIA ; PARMENTIER, RÉMI ; PEBAYLE, ANTOINE ; PÖRTNER, HANS-OTTO ; OSVALDINA, SILVA ; RICARD, PATRICIA ; SANTOS, R.; SICRE, M.; THIÉBAULT, S.E ; THIELE, T.; TROUBLÉ, R.; TURRA, A.; UKU, J.; GAILL, F. A Roadmap for Using the UN Decade of Ocean Science for Sustainable Development in Support of Science, Policy, and Action. ONE EARTH, v. 2, p. 1, 2019.
33. GASPAR, F.; FLORES-MONTES, M. J.; PINHEIRO, B. R.; NORIEGA, C. E. D.; ARAUJO, M.; N. LEFEVRE. Alkalinity, inorganic carbon and CO2 flux variability during extreme rainfall years (2010-2011) in two polluted tropical estuaries NE Brazil. BRAZILIAN JOURNAL OF OCEANOGRAPHY (ONLINE), v. 66, p. 115-130, 2018.
34. ALMEIDA, L.; AZEVEDO, J.; KERR, R.; ARAUJO, M.; MATA, M. M. Impact of the new equation of the state of seawater (TEOS-10) on the estimates of water mass mixture and meridional transport in the Atlantic Ocean. PROGRESS IN OCEANOGRAPHY, v. 1, p. 1, 2018.
35. NEUMANN-LEITÃO, S.; MELO, P. A. M. C.; SCHWAMBORN, R.; DIAZ, X. F. G.; FIGUEIREDO, L. G. P.; SILVA, A. P.; CAMPELO, RENATA P. S.; MELO JÚNIOR, M.; MELO, NUNO F. A. C.; COSTA, A. E. S. F.; ARAÚJO, M.; VELEDA, D.; MOURA, R. L.; THOMPSON, F. Zooplankton from a reef system under the influence of the Amazon River Plume. FRONTIERS IN MICROBIOLOGY, v. 9, p. 1, 2018.
36. SILVA, T.; VELEDA, D.; Araujo, M.; TYAQUIÇÃ, P. Ocean-atmosphere feedback during extreme rainfall events in eastern Northeast Brazil. JOURNAL OF APPLIED METEOROLOGY AND CLIMATOLOGY, v. 56, p. 1, 2018.
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S.; ARAÚJO, M.; NUNES, J. L.; SILVA, M. H. L. Physicochemical properties and distribution of nutrients on the inner continental shelf adjacent to the gulf of maranhão (brazil) in the equatorial atlantic. APPLIED ECOLOGY AND ENVIRONMENTAL RESEARCH, v. 16, p. 4829-4847, 2018.

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Dr. Arnaud BERTRAND, born in 1970 (51 years-old)

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FORMATION

1997 – 1999 – PhD in Halieutique, Ecole Nationale Superieure Agronomique de Rennes-ENSAR, França. "The system [tuna - environment] in French Polynesia: characterization of the pelagic habitat, study of tuna distribution and catchability, by acoustic and fisheries methods".

INTERNATIONAL INSERTION

- Coordinator for IRD of the UE Project "Tropical and South Atlantic - climate-based marine ecosystem prediction for sustainable management (TRIATLAS, 2019-2023), 2019-2023.
- Coordinator (with Moacyr Araujo, UFPE and Flávia Lucena-Frédou, UFRPE) of the International Joint Laboratory 'Tropical Atlantic Interdisciplinary Laboratory on physical, biogeochemical, ecological and human dynamics' (LMI TAPIOCA, 2018-2022, https://tapioca.ird.fr/).
- WP leader of the EU-H2020 RISE Project: Planning in a liquid world with tropical Stakes: solutions from an EU-Africa-Brazil perspective (PADDLE). PI: M. Bonnin, 2017-2021.
- Participation to the INCT AmbTropic: Tropical Marine Environments: Spatial-temporal heterogeneity and Responses to Climate Change. 2017-2021.
- PI of the scientific Program 'Acoustics along the BRAzilian COaSt' (ABRACOS): two oceanographic surveys performed in Northeast Brazil in Sept.-Oct. 2015 and April-May 2017 (doi.org/10.17600/15005600 and doi.org/10.17600/17004100).
- Chief scientist of the survey AMAZOMIX (https://doi.org/10.17600/18001364).
- Coordinator IRD of the 'Jeune Equipe Associée à l'IRD' "Ecologia Marina Cuantitativa del Ecosistema de Afloramiento Peruano (EMACEP, 2014-2017)", Peru.
- Main coordinator of the inter-Regional Pluridisciplinary Program 'Coastal and Upwelling Ecosystems' (RPP CUTE) 2013-2015.
- Coordinator IRD in the European Project "Hydrography and Jack Mackerel stock in the South Pacific" (HYDROJM), 2012-2014.
- PI of the Project funded by the British Embassy in Peru. Climate change impact on ocean dynamics, ecosystem functioning and fisheries of Peru: projection scenarios and socio-economic impacts. http://ukinperu.fco.gov.uk/resources/es/pdf/5933461/cambio-climatico-pesqueras.
- Director (France) of the International Joint Laboratory 'DISCOH' (Dynamics of the Humboldt Current system), 2010-2014.
- Honorarium professor at the University Nacional Mayor de San Marcos, Peru since 2009.
- IRD representative in Peru, Jan-Feb 2008. IRD representative per interim March 2008 – July 2011.
- Main convener of the International Conference "The Humboldt Current System: Climate, ocean dynamics, ecosystem processes, and fisheries" Lima, Peru, Nov. 27 – Dec. 1, 2006. Partners: IRD, IMARPE, FAO, CNES, GLOBEC, ICES, MAE, NASA and PICES. 300 participants from 27 countries; 210 scientific works.

TEACHING

Honorius Professor of the UNMSM, Peru, Invited Professor in four other Universities (Chile, Peru, Brazil); more the 1300 hours of teaching including 1240 h in Southern countries (Brazil, Chile, Colombia, Cuba, Peru, and Senegal) and 60h in French overseas countries.

SUPERVISING

42 students (5 PostDoc, 14 PhD, 15 Master, 8 BSc) from Benin, Brazil, Chile, Colombia, France, Spain, Peru).

FIELD EXPERIENCES

More than 400 days at sea on oceanographic and fishing vessels in Brazil, France, French Guyana, French Polynesia, Mexico, and Peru.

PROJECTS

50+ Six projects ongoing with international cooperation (ABRAÇOS, AMAZOMIX, TAPIOCA, SMAC, TRIATLAS and PADDLE – see complete CV for project list.

ISI - H_{index} = 38	**Number of citations = 5,047**	**Total papers = 147** Total in the last 05 years = 55

PUBLICATION IN THE LAST 5 YEARS

1. SALVATTECI, R.; SCHNEIDER, R. R.; GALBRAITH, E.; FIELD, D.; BLANZ, T.; BAUERSACHS, T.; CROSTA, X.; MARTINEZ, P.; ECHEVIN, V.; SCHOLZ, F.; BERTRAND, A. Smaller fish species in a warm and oxygen-poor Humboldt Current system. SCIENCE, v. 375, p. 101-104, 2022.
2. ARIZA A., LENGAIGNE M., MENKES C., LEBOURGES-DHAUSSY A., RECEVEUR A., GORGUES T., HABASQUE J., GUTIERREZ M., MAURY O., BERTRAND A. 2022. Global decline of pelagic fauna in a warmer ocean. NATURE CLIMATE CHANGE. In press
3. FARIAS, G. B.; MOLINERO, J.; CARRÉ, C.; BERTRAND, A.; BEC, B.; MELO, P. Uncoupled changes in phytoplankton biomass and size structure in the western tropical Atlantic. JOURNAL OF MARINE SYSTEMS, v. 227, p. 103696, 2022.
4. GIACHINI TOSETTO, E.; BERTRAND, A.; NEUMANN-LEITÃO, S.; NOGUEIRA JÚNIOR, M. The Amazon River plume, a barrier to animal dispersal in the Western Tropical Atlantic. SCIENTIFIC REPORTS, v. 12, p. 537, 2022.
5. VARONA, H.L.; HERNANDEZ, F.; BERTRAND, A.; ARAUJO, M. Monthly Anomaly Database of Atmospheric and Oceanic Parameters in the Tropical Atlantic Ocean. DATA IN BRIEF, v. 41, p. 107969, 2022.
6. ALVES-JÚNIOR, F. A.; ANDRADE, L. F.; BERTRAND, A.; NEUMANN-LEITÃO, S. Further record of the deep-sea euphausiid, Thysanopoda cristata G. Sars, 1883 (Euphausiacea, Euphausiidae) from the southwestern Atlantic: with comments on morphological variations. CRUSTACEANA, v. 95, p. 137-146, 2022.
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8. VILLARINS B., DI DARIO F., EDUARDO L.N., LUCENA-FRÉDOU F., BERTRAND A., PROKOFIEV A., MINCARONE M. 2022. Deep-sea dragonfishes (Teleostei: Stomiiformes) collected from off northeastern Brazil, with a review of the species reported from the Brazilian Exclusive Economic Zone. Neotropical Ichthyology, 20: e220004. https://doi.org/10.1590/1982-0224-2022-0004
9. MINCARONE M.M., EDUARDO N.L., DI DARIO F., FRÉDOU T., BERTRAND A., LUCENA-FRÉDOU F. 2022. New records of rare deep-sea fishes (Teleostei) collected from off northeastern Brazil including seamounts and islands of the Fernando de Noronha Ridge. Journal of Fish Biology, DOI: 10.1111/jfb.15155
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11. PECK, M. A.; ALHEIT, J.; BERTRAND, A.; CATALÁN, I. A.; GARRIDO, S.; MOYANO, M.; RYKACZEWSKI, R.; TAKASUKA, A.; VAN DER LINGEN, C. D. Small pelagic fish in the new millennium: A bottom-up view of global research effort. PROGRESS IN OCEANOGRAPHY, v. 191, p. 102494, 2021.
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31. ASSUNÇÃO, R. V.; SILVA, A. C.; ROY, A.; BOURLÈS, B.; HENRIQUE S. SILVA, C.; TERNON, J.; ARAUJO, M.; BERTRAND, A. 3D characterisation of the thermohaline structure in the southwestern tropical Atlantic derived from functional data analysis of in situ profiles. PROGRESS IN OCEANOGRAPHY, v. 187, p. 102399, 2020.
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36. DE ALMEIDA ALVES-JÚNIOR, F.; BERTRAND, A.; DE Á LEITÃO CÂMARA DE ARAÚJO, M.; DE CARVALHO PAIVA, R. J.; DE SOUZA-FILHO, J. F. First Report of the Ectoparasitic Isopod, Holophryxus acanthephyrae Stephensen 1912 (Cymothoida: Dajidae) in the South Atlantic: Recovered from a New Host, the Deep-Sea Shrimp, Acanthephyra acanthitelsonis Spence Bate, 1888. THALASSAS, v. 35, p. 13-15, 2019.
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38. EDUARDO, L. N.; MINCARONE, M.; VILLARINS, B. T.; FRÉDOU, T.; LIRA, A. S.; BERTRAND, A.; LUCENA-FRÉDOU, F. Length-weight relationships of eleven mesopelagic fishes from oceanic islands of the Southwestern Tropical Atlantic. JOURNAL OF APPLIED ICHTHYOLOGY, v. 35, p. 605-607, 2019.
39. SALVATTECI, R.; GUTIERREZ, D.; FIELD, D.; SIFEDDINE, A.; ORTLIEB, L.; CAQUINEAU, S.; BAUMGARTNER, T.; FERREIRA, V.; BERTRAND, A. Fish debris in sediments from the last 25 kyr in the Humboldt Current reveal the role of productivity and oxygen on small pelagic fishes. PROGRESS IN OCEANOGRAPHY, v. 176, p. 102114, 2019.
40. ALVES-JÚNIOR, F.; SILVA, E.; DE ARAÚJO, M.; CARDOSO, I.; BERTRAND, A.; SOUZA-FILHO, JESSER F. Taxonomy of deep-sea shrimps of the Superfamily Oplophoroidea Dana 1852 (Decapoda: Caridea) from Southwestern Atlantic. ZOOTAXA (ONLINE), v. 4613, p. 401-442, 2019.
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Meso- and Bathypelagic Prawns of the Superfamilies Penaeoidea Rafinesque, 1815 and Sergestoidea Dana, 1852 (Crustacea: Decapoda: Dendrobranchiata) from Southwestern Atlantic: New Records and Bathymetric Distribution. THALASSAS, v. 35, p. 465-484, 2019.

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44. EDUARDO, L. N.; TEIXEIRA VILLARINS, B.; RODRIGUES MARTINS, J.; LUCENA-FRÉDOU, F.; FRÉDOU, T.; SOUZA LIRA, A.; TRAVASSOS, P.; BERTRAND, A.; MINCARONE, M. Deep-sea oceanic basslets (Perciformes, Howellidae) from Brazil: new records and range extensions. CHECK LIST, JOURNAL OF SPECIES LIST AND DISTRIBUTION, v. 15, p. 965-971, 2019.
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3. Description of the infrastructures and equipment provided by the partners

Contribution UFRPE

Two Departments (Fisheries and Aquaculture, and Statistics and Informatics) of the UFRPE (www.ufrpe.br) will participate to the IJL TAPIOCA. The Department of Statistics and Informatics has three main areas: Statistics, Informatics and Computing Systems. It is responsible for the Post-Graduate Program in Biometry and offers statistics course to undergraduate and postgraduate students of others Departments of UFRPE. The Department of Fisheries and Aquaculture occupies an area of 4500 m2 and has two auditoriums with capacity of 40 and 100 places. It has been contributing to the formation of professionals in fisheries, aquaculture, fishery technology, oceanography and applied ecology since 1970. It was pioneer in Brazil for the formation of undergraduate Fisheries Engineers. This Department is also responsible for the Post-Graduate Program in Fisheries Resources and Aquaculture (Master and PhD), created in 2000. Currently about 100 students develop their studies with a multidisciplinary approach

Personal: Professors and Technicians based in Brazil dedicated to work on common scientific subjects and participate to capacity building.

Laboratory facilities: Seven laboratories of the UFRPE are involved in the proposal (BIOIMPACT, LOP, Laboratory of Ichthyology, LEMAR, LATEP, AIMMO lab, DIMAR). They cover approximately 300 m^2 of area with undergraduate and postgraduate students' room permanence, wet laboratories and reference collection room. Laboratories are equipped with freezers for storage of samples, computers for data analysis, equipments for histology, microscopes, liofilizator, fume hood, and stoves. In relation to the field collection, the necessary equipment such as, multi-analyzer, GPS, box-core, fishing nets, etc and specific equipment for tagging and scuba diving, are available. During the first phase of TAPIOCA, two specific laboratories were adapted to study the ecology, movements and connectivity of marine species. The Laboratory of natural markers (BIOMPACT/UFRPE) has equipments for preparing samplings for isotopes, microchemistry, metal and plastic contamination. The second Laboratory (Laboratory of artificial markers (LEMAR/Biologging) (UFRPE), specialized in the research on behavior, physiology and habitat use were also adapted through the use of electronic tags (e.g. acoustic telemetry, pop-up tag, miniGPS, others). Moreover, a permanency room (25m^2), were adapted in the Department of fisheries and Aquaculture, to receive researches and students

Laboratory of natural markers (BIOMPACT/UFRPE)

Laboratory of artificial markers (LEMAR/Biologging)

Scholarships In terms of staff in UFRPE, PhD, Master and Graduate students (Post-graduation in Biometry, Fisheries Resources and Aquaculture, and Biodiversity) will facilitate the practical execution of the activities predicted in the project.

Contribution UFRPE

At UFPE (www.ufpe.br), the Department of Oceanography (DOCEAN) is the oldest, largest and most reputable center of Oceanography in North and Northeast of Brazil. Created in 1952, the DOCEAN is the second oldest Oceanography center in Brazil, now completing 63 years. The Department of Oceanography of UFPE has over 3.000 m^2 located in the Technology and Geoscience Center (CTG/UFPE). The DOCEAN is constituted by nine research laboratories: Phytoplankton, Zooplankton, necton, phytobenthos, zoobenthos, Sea Water Chemistry, Physics, Geology, Mariculture, and also an Oceanographic Museum. The Master/PhD Program in Oceanography (PPGO) is also the oldest in the North and Northeast of Brazil, completing 33 years of existence. This program has contributed to the formation of 300 masters and 110 PhDs. The team of the Project is developing research directly with the Department of Oceanography - DOCEAN and also with the Center for Studies and Essays in Environmental Modeling and Risk - CEERMA located at UFPE.

CEERMA-UFPE.

The DOCEAN/UFPE Oceanographic Museum.

Scientific collection in the Museum of Oceanography.

Personal: Professors and Technicians based in Brazil dedicated to work on common scientific subjects and participate to capacity building.

Laboratory facilities: In DOCEAN/UFPE Seven research laboratories are involved in the proposal: phytoplankton, zooplankton, CEERMA, necton, phytobenthos, zoobenthos, Sea Water Chemistry, Physics, and also an Oceanographic Museum and and one floating laboratory "Vessel Ciências do Mar IV" - description below. All research laboratories are connected by internal and external (optic fibber) network, rooms for teachers, offices for visiting professors and researchers (such as post-doctoral students), 1 room with 26 bays equipped with individual computers for students, 1 auditorium with capacity for 100 people, 12 laboratories for classes and lectures.

Scholarships: TAPIOCA will benefit from scholarships provided by the Brazilian Government for post-graduate students available for the course of "Oceanography" (36 scholarships for MSc. Students and 28 scholarships for PhD students). All TAPIOCA researchers are eligible to have student awarded with scholarships.


At-sea physical oceanography - UFPE/LOFEC

Scientific Vessel "Ciências do Mar IV".

The vessel, available for Northeast Brazil has the following main technical characteristics - Length: 32 m; Moulded breadth: 7,85 m; Molded depth: 4,30 m; Maximum draft: 2,83 m; Maximum speed: 10 knots; Hold: 50 m3; Autonomy: 10 days; Oil tank capacity: 49.640 liters; Water capacity: 35.330 liters; Propulsion: two SCANIA Mod. DI 1259M Diesel engines each with 450 HP and 800 rpm; Gearbox: two Mod. MGX 516, with reduction ratio 4,59:1; Propeller: two with diameters of 1080 mm; Generator: two CUMMINGS MARINE Type/Three-phase Voltage, 220V - 60 Hz of 140 kVA of power; two Electro-hydraulic Units Mod. UEH 2 x 25 x 120 x 180 x A2BI. Max. flow 120 LPM and max. pressure regulated at 180 bar. To feed the fishing winch and the Oceanographic; One Electro-hydraulic Unit Mod. UEH 20 x 40 x 180 x A2 B1 C12. Max. flow 37 LPM and max. pressure regulated at 180 bar. To feed the crane and anchor winch.

The ship is basically divided into three decks:

1) The Upper where are the Passageway (Command Room), the Commander and XO's Staterooms, the Hydroacoustics Room, and the Rear Command. On this deck is the Oceanographic Winch on the starboard side;

2) The Main Deck where the Dry and Wet Laboratories are, the Kitchen, the Mess Hall, three cabins with two berths each: the Engine Room, the Infirmary and the third one for two (2) Professors. All the collections are made on this deck and;

3) The Lower Deck where are the Engine Room and 5 more cabins. One for two professors and four more for four people each.

Laboratories and classrooms:

The ship has laboratories and rooms, divided into Hydroacoustics Laboratory, Sampling Dry Laboratory and Wet Laboratory and classroom.

Hull Scientific Equipment:

The main Hull Scientific equipment are: SIMRAD scientific sounding unit, model EK-80, 38 AND 120 KHz, SIMRAD PI-50 network probe, BATHY 2010 PC 3.5 kHz seismic profiler, FURUNO CSH-5L 360° sonar from 55 to 68 kHz, TELEDYNE Workhorse 300 kHz ADCP, FURUNO FVC-1900 Fish Finder probe from 28 and 200 kHz, SBE 21 Sea Cat thermosalinograph and acoustic probes.

Distribution of cabins:

The Ship has 26 seats being 09 (12) crew and 17 (14) passengers. These will be distributed in 10 cabins. These cabins have bathrooms with individual showers and the vessel is fully air conditioned.

Scientific Vessel "Ciências do Mar IV"

4. Estimated budget
showing the financial contributions of each stakeholders to the overall implementation of the project as well as specific needs foreseen (equipment, infrastructures, etc.)

The tables presented below describe only the use of the IRD direct support to TAPIOCA (40 k€/year). The total annual budget (40 k€) will be split as following: 25% for Animation (10 k€) and 25% for each Axis (10 k€ /Axis). Additionally to this funding, TAPIOCA will benefit from a diversity of complementary funding decomposed as follow:

Scholarships: scholarships provided by the Brazilian Government for post-graduate students available in UFPE (28 and 36 scholarships for MSc. and PhD students, respectively) and UFRPE (25 and 20 scholarships for MSc. and PhD students, respectively). All TAPIOCA researchers are eligible for student scholarships. Additionally, co-funded scholarships (for student exchanges and co-badging) are available in both universities, and the consortium will look for additional co-funding (e.g. CAPES-COFECUB proposal, and PrInt UFRPE, UFPE and UFRN). Scholarships are not described in the detailed budget.

At-sea surveys: the team already benefited from a large amount of data acquired during recent large-scale multidisciplinary surveys (e.g. ABRAÇOS 1 and 2, and AMAZOMIX surveys). Small-scale surveys with local facilities are also planned, in particular in Fernando de Noronha and coastal areas of North and Northeast Brazil financed by other projects from TAPIOCA participants.

Material: Several materials and equipment have been acquired during TAPIOCA 1st phase, and are then available in the multi-user laboratories. For additional small equipment, TAPIOCA will help acquiring them, but for expensive ones (e.g. Ftir), the consortium should find specific proposal during the 2nd phase of TAPIOCA. As during TAPIOCA 1st phase, the participants will use equipment available in French partners' laboratories for more sophisticated analysis (e.g. microchemistry).

Analyses: TAPIOCA may fund small specific analyses, but most analyses should be funded by the Projects acquired and associated with TAPIOCA.

The main funding agencies that the team will solicit are (but see the progress report for the list of current projects):

- Brazilian: CNPq, CAPES, States foundations (FACEPE, FAPESPA, etc.), foundation Boticario, FUNBIO.
- French: French Oceanographic fleet, INSU, ANR PRC.
- French-Brazilian: CAPES-COFECUB, IRD-CNPq funds, FAPs-IRD funds, ANR PRCI.
- International: Horizon Europe proposals.

Animation budget *= 10 K€ / yr*

Year	Networking and Workshops	Capacity building	Outreach
2023	**4 k€**	**3 k€**	**3 k€**
2024	**4 k€**	**3 k€**	**3 k€**
2025	**3 k€**	Summer school = **5 k€**	**2 k€**
2026	**4 k€**	**3 k€**	**3 k€**
2027	**2 k€**	TAPIOCA meeting = **6 k€**	**2 k€**

***Axis 1 "Tropical Atlantic climate and dynamics" budget** = 10 K€ / yr*

Year	Material / Analyses	Capacity building	Dissemination
2023	Thematic activities and analyses* = **7 k€**	Workshop/Training** = **2 k€**	Database and exchanges with stakeholders = **1 k€**
2024	Thematic activities and analyses* = **7 k€**	Workshop/Training** = **2 k€**	Database and exchanges with stakeholders = **1 k€**
2025	Thematic activities and analyses* = **7 k€**	Workshop/Training** = **2 k€**	Database and exchanges with stakeholders = **1 k€**
2026	Thematic activities and analyses* = **7 k€**	Workshop/Training** = **2 k€**	Exchanges with stakeholders = **1 k€**
2027	Thematic activities and analyses* = **7 k€**	Workshop/Training** = **2 k€**	Exchanges with stakeholders = **1 k€**

* "Thematic activities" funds aim at paying for small equipment, material, consumables or sample analyses to support ongoing research projects in link with Axe 1, or to initiate new ones. Each year, eligible activities will be identified during Axis 1 annual meetings.
** "Workshop/Training" funds aim at spreading knowledge and at building capacity in a specific field of research undertaken within Axis 1 and 2, among TAPIOCA members and Brazilian university students. Topics for each year will be selected during Axis 1 annual meetings.

***Axis 2 "Biodiversity dynamics" Budget** = 10 K€ / yr*

Year	Material / Analyses	Capacity building	Dissemination
2023	Thematic activities and analyses* = **6 k€**	Workshop/Training** = **2 k€**	Database and exchanges with stakeholders = **2 k€**
2024	Thematic activities and analyses* = **7.5 k€**	Workshop/Training** = **1.5 k€**	Database and exchanges with stakeholders = **1 k€**
2025	Thematic activities and analyses* = **6 k€**	Workshop/Training** = **2 k€**	Database and exchanges with stakeholders = **2 k€**
2026	Thematic activities and analyses* = **7.5 k€**	Workshop/Training** = **1.5 k€**	Exchanges with stakeholders = **1 k€**
2027	Thematic activities and analyses* = **5 k€**	Workshop/Training** = **2 k€**	Exchanges with stakeholders = **3 k€**

* "Thematic activities" funds aim at paying for small equipment, material, consumables or sample analyses to support ongoing research projects in link with Axe 2, or to initiate new ones. Each year, eligible activities will be identified during Axis 2 annual meetings.
** "Workshop/Training" funds aim at spreading knowledge and at building capacity in a specific field of research undertaken within Axis 2, among TAPIOCA members and Brazilian university students. Topics for each year will be selected during Axis 2 annual meetings.

***Axis 3 "Uses and impacts" Budget** = 10 K€ / yr*

Year	Material / Analyses	Capacity building	Dissemination
2023	Thematic activities and analyses* = **6 k€**	Workshop/Training** on 1 specific activity = **2.5 k€**	Database or exchanges with stakeholders and managers = **1.5 k€**
2024	Thematic activities and analyses* = **6 k€**	Workshop/Training** on 1 specific activity = **2.5 k€**	Database or exchanges with stakeholders and managers = **1.5 k€**
2025	Thematic activities and analyses* = **6 k€**	Workshop/Training** on 1 specific activity = **2.5 k€**	Database or exchanges with stakeholders and managers = **1.5 k€**
2026	Thematic activities and analyses* = **6 k€**	Workshop/Training** on 1 specific activity = **2.5 k€**	Meetings or policy brief or photos with/for stakeholders and managers = **1.5 k€**
2027	Thematic activities and analyses* = **5 k€**	Meeting for responses to call for proposal = **2 k€**	Meetings or policy brief or photos with/for stakeholders and managers = **3 k€**

* "Thematic activities" funds aim at paying for small equipment, material, consumables or sample analyses to support ongoing research projects in link with Axe 3, or to initiate new ones: e.g. contaminant concentration analyses, satellite images, participatory interviews, etc. Each year, eligible activities will be identified during Axis 2 annual meetings.

** "Workshop/Training" funds aim at spreading knowledge and at building capacity in a specific field of research undertaken within Axis 3, among TAPIOCA members and Brazilian university students. Topics for each year will be selected during Axis 3 annual meetings.

5. Cover letters from directors of main research partners involved in the IJL as well as letters of support from the representatives of the institutions to which the project leaders belong