axis 6

Evolution of marine habitats and adaptation of populations

LabexMER Research project	**2016-2019 axis 6 roadmap**	**January 2016**

Evolution of marine habitats and adaptation of populations

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List of participating laboratories:

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- DYNECO (DYNamiques de l'Environnement Côtier), Ifremer
- LBCM - EA3884 Laboratoire de Biotechnologie et Chimie Marines), UBS

1. Scientific context, scientific questions

During the first phase, three topics structured the activities of axis 6.

1. Functional microbial and macrobiota biodiversity
2. Physiological and adaptive response to environmental changes
3. Habitat modelling: a plural and progressive approach

On the basis of the achievements made during this first phase, we propose to continue our scientific activities and to promote the integration of approaches and scales through the following topics:

1. Towards an integrated understanding of the adaptation of marine organisms in response to environmental change. Understanding acclimation and adaptation processes of marine organisms to global change is a key objective of axis 6. Significant advances in this field have been achieved during phase 1, notably in the framework of the International Chair on Evolutionary Marine Ecology (ICEME), held by F. Nunes. Our experimental strategy included the comparison of populations living in contrasted areas and laboratory experiments. It combined ecophysiological approaches, population genetics and genomics, transcriptomics, proteomics and epigenetics. Ongoing projects also consider the joint sclerochemical and genomic analysis of ancient calcified organisms. This will be pursued during phase 2 of LabexMER, with a special emphasis on the understanding of the biological processes involved in the acclimation/adaptation of marine organisms to past- and ongoing- environmental changes, such as acidification, warming or hypoxia, as well as exposure to pathogens.

2. Integrated modelling of individual responses, population dynamics and habitat changes. In our roadmap, we defined a modelling strategy based on a step by step approach combining physics, habitat, biogeochemical, population and ecosystem models. Axis 6 has recently sponsored a few small modelling projects which address several topics: pelagic habitat, distribution of key benthic species, connectivity, benthic community, individual response to stressors. This strategy has been implemented on one study site (Bay of Brest) in order to facilitate the integration and coupling of models as well as validation against observations.

3. Functional microbial and macrobiota biodiversity. Microorganisms (virus, bacteria, archae and unicellular eucaryote) are spectacularly diverse, both phylogenetically and metabolically and the estimation of the species richness for a given environment is a crucial piece of information. The use of 'omics' represents a major breakthrough for the analysis of the functional biodiversity. During phase 1, several initiatives have been launched to increase collaborations in this growing field of research, and will make the analysis of biodiversity develop during phase 2

2. OBJECTIVES FOR THE NEXT FOUR YEARS AND SPECIFIC ACTIONS

2.1. SCIENTIFIC OBJECTIVES

The International Scientific Council recommended developing the integration of the ecophysiology, omics and modelling approaches, already undertaken during phase 1 and recognised as a major strongpoint. This encouragement fully meets our strategy which relies upon the development of projects and collaborations along the following lines.

i. Towards an integrated understanding of the adaptive capacity of marine organisms in response to environmental changes

The potential impact of ocean acidification, warming and biotic interactions (pathogens, toxic blooms) will be investigated at different levels of organization and through transgenerational studies. Strategies to estimate mechanisms of acclimation and adaptation will be focus on species comparison presenting differences of sensitivity to environmental changes. In addition to phenotypic plasticity and genetic polymorphism, we will also investigate epigenetic mechanisms through a multigenerational approach. Our involvement in this field will be facilitated by the implementation of the new "Epigen" platform for epigenetic studies in UBO with a financial support by the Brittany Region (CPER 2015-2020) and a joint coordination by researchers in medical science and IUEM researchers. Efforts will be made to better consider the adaptive strategies of organisms in the implementation of ecophysiological and ecological models (see below).

ii. Integrated modelling of individual responses, population dynamics and habitat changes

Several initiatives will foster our capacity to address key scientific questions: estimation of parameters for multiple species, formulation of environmental stressors, assessment of climate changes on biological traits, integration of ecophysiological models with models of habitat changes and communities.

The capacity of predicting habitat changes under different forcing scenarios (climate change, anthropic pressures) will be tested by using process-based models for morphological coupling and sediment dynamics, and applied to study sites for biota responses (e.g. Bay of Brest): the aim is to characterize the variability of bed elevation (in shallow waters), sediment substrates or turbidity levels at different temporal scales, from tides to seasonal changes, but also trends on longer terms (several decades, in relation with climate change). Coupling with population dynamics will be investigated in some cases of engineering species. The strategy in coupling

habitat, population and communities models will benefit from and to the 'Zone Atelier' in the Bay of Brest and Iroise Sea.

Among the biological modelling approaches that we propose, Dynamic Energy Budget (DEB) has been currently used in a number of projects developed by a group of researchers in and outside the Labex community. For instance, some DEB activities are sponsored by an International Group of Research launched in 2014 between France and Canada, which aims at understanding the impact of global changes on marine resources (fish, shellfish). One consortium on the Dynamics of the Humboldt Current System (2015-2019) will involve LEMAR and Peruvian partners. Its objective is to understand the regional impacts of climate variability of the marine ecosystem in the Humboldt Current System, with a focus on the continental shelf and coastal embayment areas. A transverse axis on species lifecycle, including DEB modelling for aquaculture and small pelagic species will be coordinated by one partner of LabexMER/axis 6. Another consortium will involve Peru, Mexico, Senegal and France (LEMAR), in the Inter-regional pluridisciplinary program (RPP) frame and will deal with Coastal and Upwelling Ecosystems. With this respect, axis 6 will support workshops that will reinforce the building capacity of the partners, the visibility and usage of modeling tools by a wider scientific community.

Besides, multi-scale models will be developed to integrate responses at different spatial, temporal, physical and ecological scales in the context of climate change. Integrated models are needed to simulate changes of species habitat, to account for the connectivity between populations, the plasticity and the adaptive capacity of single species, and to predict the structure of biological communities emerging from the trade-offs between life history traits and competition for resources. We will target PhD and postdoc proposals that will address such issues.

iii. Functional microbial and macrobiota biodiversity

Thanks to the progress made in meta-type barcoding and metagenomic approaches, we will aim at monitoring microbial diversity (bacteria, archaea and eukaryotic microorganisms) in connection with the physical / biological coupled models. A long-term goal will be to develop a microbial observatory in the Bay of Brest and Iroise Sea. One other goal will be to favour collaborations with other international coastal observatories "Microorganisms and environment" (Guanabara Bay in Brazil; Halifax in Canada). With a lot of exchanges of PhD student, postdocs, and engineers, we will promote new tools in axis 6, such as metagenomic and metatranscriptomic analyses to explore biodiversity. The goal is to create further one or more "laboratoires mixtes internationaux" (LMI) focusing on ecogenomic approaches.

2.2. INTERDISCIPLINARITY AND SYNERGIES BETWEEN TEAMS

The contribution of axis 6 to local, regional and national initiatives will rely upon the following tools and opportunities:

- Interdisciplinarity will be emphasized within the modelling strategies, either through real models coupling or through the building of global change scenarios, relevant for habitat dynamics and population responses.
- Through the funding of modelling and field work during phase 1, Axis 6 has been contributing to 'Zone Atelier Brest/Iroise (ZABrI)' which is the sole Marine Zone

labelled by CNRS/INEE as part of its long term and interdisciplinary research program on the interactions between environment and human society. The outputs of our research projects will benefit to/from the synergies also built in the ZABrI.

- The implementation of the new "Epigen" platform for epigenetic studies in UBO with a financial support by the Brittany Region (CPER 2015-2020) will facilitate the study of processes involved in the acclimation/adaptation of marine organisms to past- and ongoing- environmental changes.
- The possibility to make links with other Labex will increase our capacity to address complex issues - e.g. integrated modelling. LabexMER is already participating to the SEACS (Stochastic modEl-dAta-Coupled representationS for the analysis, simulation and reconstruction of upper ocean dynamics) joint project setup by CominLabs and Lebesgue Labex in the Brittany Region. Some scientists involved in axis 6 recently participated to a seminar organised by this group and found some shared interest in stochastic modelling applied biological and physical processes.
- Axis 6 is also interested in building synergies with Labex COTE ("Evolution, Adaptation et Gouvernance des Ecosystèmes Continentaux et Côtiers"). We share interests in the responses of organisms to environmental perturbations through the use of DEB theory and modelling. Past collaborations between actual partners of Labex COTE and MER will allow building synergies through joint training workshops and seminars. Labex funding schemes will be used to organise seminars and workshops and address shared issues.

2.3. INTERNATIONAL VISIBILITY

International training

Some LabexMER members are involved in teaching modules in foreign Universities. Master courses dealing with Dynamic Energy Budget (DEB) theory are already operated in Brest University (SML Master) and new Master modules have been setup in Lima Universidad Peruana Cayetano Heredia (Peru) and La Paz (CIBNOR, Mexico). International DEB telecourse are being organised every 2 years by the DEB international community and members of LabexMER are very active in this area. This activity on DEB modelling also concerns the supervision of PhDs who participate to DEB symposium every 2 years. Five PhDs are actually addressing issues in ecophysiology of marine species with DEB theory, 1 is supported by the LabexMER.

International networking

Agreements with several countries give rise to International Mixed Laboratories and bilateral collaborations on topics related to axis 6 activity. Regarding DEB modelling, networking includes partnership from Peru, Mexico, Senegal and France. LabexMER partners from Ifremer, UBO and the Canadian Department of Fisheries and Aquatic Sciences are also present in the International Group of Research (RECHAGLO). In the field of microbial diversity, new collaborations with international coastal observatories in Brazil and Canada will allow developing new microbial observatories at IUEM and will foster interdisciplinary approaches in the field of marine biodiversity. We will also be active in the support of LabexMER to the

Canadian initiative "Safe and Sustainable Development of the Ocean Frontier" supported by Dalhousie University within the recently created Ocean Frontier Institute.

Through the activity of his partners, Axis 6 will benefit from and contribute to the afore-mentioned networking. Following our funding scheme in the first phase, we will continue to invite foreign scientists to facilitate training, exchanges of ideas and setup innovative projects.

2.4. LEVERAGING EFFECT

The networking and training activities facilitate the setup of bilateral collaborations through joint proposals (e.g. the ANR-CONACYT France/Mexico bilateral call), organization of workshops (e.g. DEB workshops in 2016 co-sponsored by LabexMER and RECHAGLO), co-supervision of PhDs and postdocs regarding axis 6 topics (e.g. DEB modeling, development of metagenomic and transcriptomic tools). We expect that the capacity building of cutting edge scientific tools and methods will increase our participation to European and International consortia.

Axis 6 members are already involved in applied EU projects making the bridge between advanced science and societal needs and showing our capacity to contribute to the European research agenda. Through the achievements of EMODNET phase 2 (finishing in 2016), Seabed Habitats will create a homogeneous seabed habitat map covering all European seas that will be freely available through a WEB portal – thus allowing the use of habitat maps for the modeling of species distributions for instance. VIVALDI (starting in 2016) will provide innovative knowledge related to pathogens infecting marine bivalves and develop practical approaches for the control of infectious diseases and resulting mortality outbreaks induced by these pathogens. AQUASPACE (started in 2015) will use the best of scientific knowledge regarding the interactions between cultivated species and their environment to produce a range of tools that will enable effective implementation of Ecosystem Approach to Aquaculture and Marine Spatial Planning to support the aquaculture sector in Europe.

2.5. GOVERNANCE

The governance of axis 6 is based on a Steering Committee (SC) composed of 7 members (including the 2 coordinators of the axis) representing the main Research Units (DYNECO, LEMAR, LBCM) and different skills in ecology, biology, physics and modelling. All decisions are subject to discussions by the SC which meets on demand - e.g. preparation of internal calls, evaluation of PhD and postdocs proposals, reporting to the LabexMER directorate, organisation of seminars. The SC has been partly renewed : departure of V. Pichereau (LEMAR), arrival of G. Charrier (LEMAR) and A. Bazire (LBCM).

3. ANSWERS TO CSI RECOMMANDATIONS

The International Scientific Council recognized the high quality science supported by axis 6 and recommended developing the integration of the ecophysiology, omics and modelling approaches. This recommendation is fully taken into account by our implementation plan detailed below.

4. IMPLEMENTATION PLAN AND RESOURCES

During the first phase, axis 6 has funded a large number (ca. 20) of small projects from 4 k€ up to 15 k€ and invitations of foreign scientists. It has supported 2 postdocs with extra-funding.

In the second phase, we will focus on more integrated projects in the 3 topics that have been defined. One single call for ideas will be launched by the end of 2015 and responses will be used to co-construct 3 projects. Such projects are expected to start in 2016 and 2017 and be achieved by the end of 2018. Besides, axis 6 will maintain funding for inviting scientists and provide support to PhDs and postdocs on demand.