



axis 5

Dynamics & vulnerability of coastal zones

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Dynamics & vulnerability of coastal zones

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List of participating laboratories:

- LDO - UMR 6538 (Laboratoire Domaines Océaniques), UBO, CNRS/INSU
- LETG - UMR 6554 (Littoral Environnement Télédétection Géomatique), UBO - Nantes
- AMURE - UMR M101, Ifremer, UBO
- LOPS - UMR 6523 (Laboratoire d'Océanographie Physique et Spatiale), Ifremer, UBO, CNRS/INSU, IRD

In association with :

- CRPCC – EA 1285 (Centre de Recherche en Psychologie, Cognition et Communication), UBO - Rennes2 (we would like the CRPCC to become part of LabexMER so that the contribution of CRPCC to our axis can get adequate visibility and recognition ; naturally CRPCC can only be listed here if and once our request has been approved by our ‘tutelles’).

1. SCIENTIFIC CONTEXT, SCIENTIFIC QUESTIONS

As our world's population has been increasingly concentrating on a narrow coastal strip, the “coastal challenge”, *i.e.*, developing coherent and long-term strategies for an integrated coastal zone management, is one of the major challenges in the coming decades.

The objective of axis 5 is to observe and understand coastal vulnerability arising from the combination of natural and complex social dynamics, so as to devise sustainable management strategies. Coastal vulnerability, in particular to erosion and flooding, is related to *physical forcing* such as marine and meteorological hazards and the subsequent storm impacts on the coast, sediment transport processes in the coastal zone, or also longer-term forcing due to climate change such as sea level rise. Coastal vulnerability is also related to *human forcing* accompanying the increase of social and economic activities, urbanization, coastal defense and changes in land use as well as governance strategies, nature conservation and public policies, etc. The analysis of physical and human forcing following spatial, temporal and social multi-scale approaches will yield a knowledge base of coastal dynamics and vulnerability. Integrating these data allows a systemic analysis and the elaboration of evolution scenarios to guide coastal zones management in a long term perspective.

Research actions will mainly be focused on the following items:

- What observation and monitoring protocols need to be set up to measure and understand the mechanisms leading to critical situations in these areas highly exposed to coastal risks?
- What spatial, systemic and integrated approaches can be proposed to reproduce spatial change in these areas and support advanced collaborative management?



- How to identify past changes and present occupation that have significant impacts on the environment and society?
- How to consider changing usages and practices in the coastal zone through governance and regulation of coastal territories?
- How to model these changes and their impacts in order to qualify and quantify past processes and present state and to build reliable predictive or exploratory scenarios?

The complexity of the research topic promotes the synergetic use of different observation tools (field measurements, socio and economic surveys, satellite imagery, airborne, naval, and ground data acquisition) providing data to integrate in observing systems (databases, dedicated observatories, geographic information systems, spatial data infrastructure, etc.) and for modeling. The intended goal is to achieve an assessment of coastal vulnerability as the sum of *hazards + stakes + management + human perception of risks*.

2. OBJECTIVES FOR THE NEXT FOUR YEARS AND SPECIFIC ACTIONS

2.1. SCIENTIFIC OBJECTIVES

The objective of the axis is to gain insight on hydrodynamic and morpho-sedimentary processes involved in erosion and flooding hazards and to better understand the associated risks in terms of social and economic stakes, coastal zone management and perception of these risks, which are exacerbated in the context of climate change.

Research on coastal hydrodynamics will be continued, focusing specifically on energy dissipation, in particular in the swash zone, and on hydro-sedimentary processes at the sediment-water interface. For example, we will examine the role of infragravity waves on water levels, and the influence of such water levels on morphodynamics, depending on incident energy conditions (transformation of infragravity waves and consequences for flooding and erosion). This theme is the subject of a thesis on the morphodynamics of sandy beaches and of a postdoc on the coupling between infragravity waves and cliffs, both of which have started in September 2015. These issues are of course also important for the evolution of rocky coasts in relation to Cliff-Top Storm Deposits (CTSD).

Several topics will be addressed within the field of coastal morphodynamics: kinematics of the coastline (analysis of on-going time series on sandy beaches, studies on lagoon and fringing reef environments at overseas sites), gravel spits (coupled hydro-morpho-sedimentary modeling), cliff erosion (dynamics of rocky shores is relatively unknown), sediment transfers (flux measurements, Suspended Particulate Matter (SPM) dynamics, environmental impacts of Marine Renewable Energy (MRE) systems, aeolian transport contribution), foreshore dynamics including the impact of cross-shore dynamic on sediment budgets (mobility of sand deposits in littoral hydro-sedimentary cells, transient accumulations), dynamics of dunes and "ripple-scour depressions" (formation and evolution of underwater bedforms, feedback on hydrodynamics). Laboratory experiments on physical models will be carried out in some cases, such as dune dynamics with a thesis starting in 2015 as well on sediment transport and bedform dynamics under unsteady flow. The role of extreme events (and subsequent resilience) on mid- to long-



term shoreline evolution remains one of the central questions in this research field, both from a perspective of scientific knowledge and concerning accompanying public policies for coastline management.

Modeling will be emphasized along three main directions. The first point deals with the set-up of a regional-scale hydrodynamic model (propagation of waves and tide) at a fine spatial resolution over a grid covering the Iroise region, derived from bathymetric Lidar data (Litto3D in Finistère). Such model configuration will help better constraining forcing conditions in the subtidal zone, in shallow-waters where swell approaching the coastline is already significantly distorted. The second modeling focus is on beach morphodynamic, using Xbeach on our field sites consisting of small, macrotidal, pocket or embayed beaches. Finally, the third topic is the wave-to-wave modeling approach (with Swash, Mystic and Bosz models) to examine the effect of transient hydrodynamic processes on sediment fluxes and especially on sediment transport in the swash zone.

Methodological developments are one of the strengths within the coastal research community of our axis, a strength which the axis will keep contributing to broaden. The objective is to add and enhance observation tools to measure forcing and dynamics in order to unravel the underlying processes, both through optimization of existing technologies and diversification of the instrumentation and methods. Planned developments aim at strengthening the multi-proxy approach for bathymetry (and substrate characterization), water-column sensing (combination of acoustic methods to spatialize SPM measurements) and surface water analysis by optical remote sensing using instruments carried by various type of UAV platforms (bathymetric Lidar and hyperspectral imaging). Current and intended projects include high-resolution imagery for topographic surveys (Mobile Laser Scanner, for instance in the case of coastlines with sea-only access) and high-resolution acoustic imaging for autonomous navigation of submersibles (in collaboration with Télécom Bretagne).

Research on the societal dimensions of coastal vulnerability -management and planning policies, but also the perception of risk by local populations and coastal managers, will also continue, as the axis promotes an integrated approach tackling all four components of coastal vulnerability. Following upon the Cocorisco project on knowledge, understanding and management of coastal risks of erosion and flooding, multidisciplinary studies on the systemic approach to coastal vulnerability will be pursued. In particular, the axis will accompany the development of a novel monitoring paradigm meant to support comprehensive and effective coastal risk management. On these grounds, disciplinary and interdisciplinary analyzes focusing on the four components of systemic vulnerability (hazards and dynamics, assessment of the stakes, risk management and perception) to coastal risks will aim at implementing methodologies and tools of practical use for the orientation of national and local government strategies and policies regarding coastal management and defense.

While vulnerability evolves over time, in a context of climate change but also following a trend of coastal development with increasing population and usages, thus augmenting stakes in these territories, the question of quantifiable indicators serving as metrics is very rarely considered for the facets of vulnerability other than hazards. These components clearly suffer from a lack of observation of their evolution, owing to the absence of relevant methodologies and assessment tools. The challenge is thus to develop an original methodology for an interdisciplinary observatory (combining humanities, social, economic, legal and natural sciences) of coastal erosion and flooding hazards integrating all dimensions of vulnerability (its



different facets, interactions and feedbacks) by identifying or defining multi-criteria indicators adapted both to academic research and to their usage by stake-holders and managers. This task will be undertaken in the mode of co-development (researchers working together with stake-holders) of the principles of such an observatory, based on real-life experimentation and interactions with an advisory committee composed of stake-holders. The sharing and discussion efforts will be organized in part via workshops for advanced students and seminars bringing together stake-holders from diverse geographical backgrounds and expertise areas, which will allow crossing the approaches used within various relevant communities. The international dimension of this work will also come from extended stays of international collaborators (e.g., visit of Invited Professor Omer Chouinard).

Among the stakes, one can distinguish operational (prevention and intervention) and human (having a "non-negotiable" character) stakes requiring a systematic inventory, from infrastructures that can be described in terms of monetary value to assess not only their vulnerability but also the benefits associated with risk management strategies. The idea is to identify relevant approaches within the framework of an observatory, as well as scientific and technical challenges to overcome in order to integrate existing indicators in an observatory of such type. Thus, changes in land and property values assessed for these stakes, which is indicative of the degree of integration of risks in social logics, is an interesting indicator lead.

Regarding risk management, from the introduction of tools to prevent or control urban planning to improvements of handbook guidelines and operations of protection and restoration, the dynamic dimension of monitoring is essential because operations are many and texts and their application in constant evolution, with the underlying question of personal and collective responsibility, both criminal and administrative. Research on property relocation, initiated in particular in the framework of a co-supervised thesis based on real-life cases from selected sites in France and Quebec will go further towards the analysis of choices regarding the resilience of coastal communities and the relocation strategy, comparing in particular collective or individual management strategy, legislation, consultation procedures, compensation policy or social acceptability. The reflection about the approach of "strategic withdrawal", amplified by news of recent catastrophic events that motivate a national debate, is a research topic in terms of territorial reorganization.

The question of the representation of risk is certainly the most exploratory aspect of this integrated research approach on vulnerability. Representations reflect the stands taken on coastal risks, where risk, as a social construct, refers to very diverse forms of knowledge according to the people involved and their relationship to the risk considered and the territories concerned. Because of this diversity, the representations of risk that are built by individuals, yet crucial to explain some attitudes toward vulnerability are particularly difficult to grasp. The parameters related to the various types of contexts (personal, social, cultural, spatial ...) seem to be more relevant than the socio-demographic characteristics that are not adequate indicators. Possible paths towards the establishment of "observatories of thoughts" with metrics will be tested, knowing that the format that these "thoughts indicators" could take will probably be different from the format associated with other components of vulnerability.

The research theme on the implications of the occupation and uses of the coastal strip (sea and coast) by human activities will also be continued. Here, the focus is on assessing the impact of anthropogenic forcing on the natural environment and setting-up management and development strategies reconciling both the pursuit of these activities and the preservation of



environments. The importance of this theme within the axis remains to be specified in the context of the creation of an eighth axis on ecosystem management and bio-economy, also at the interface between social sciences and natural sciences.

The theme of ecosystem resource evaluation that had been introduced during Phase 1 of LabexMER with the arrival of the UMR AMURE in axis 5 as an associated laboratory will not be continued. However, we still very much welcome contributions from AMURE projects on (i) economic evaluation of stakes in relation to the vulnerability of coastal areas and on (ii) the legal foundations of management policies for coastal environments facing risks, both topics that belong in axis 5. The participation of the UMR AMURE to the scientific project of the axis as associated laboratory in order to develop such projects remain open, noting that such prospect does not seem to be topical at AMURE. It is also noteworthy that this perspective is independent of the creation of the 8th axis dedicated to resource management and ecosystem assessment: the project of the latter is largely focused on "bioeconomy", ecosystems and biological and mineral resources, subjects falling outside of the scope of axis 5.

2.2. INTERDISCIPLINARITY AND SYNERGIES BETWEEN TEAMS

The two laboratories leading axis 5 have been working together for several years on various projects in coastal geomorphology. This partnership is also reflected in the implementation of long-term monitoring sites in Porsmilin Guissény, both part of the National Observation Service (SNO) DYNALIT. Beyond this partnership that was already existing when the Labex MER started, the projects carried out within phase 1 have brought together several laboratories from Brest around (i) ambitious projects like the ANR COCORISCO on the systemic vulnerability to flooding and erosion risks, (ii) exploratory projects of more modest scale funded by the axis (e.g. projects related to the study of morphodynamics and hydrodynamics of coastal environments like CLIFF or DYNATREZ), (iii) or externally-funded projects involving several Labex laboratories, like the recruitment of a post-doc at Géomer with DGA funding on a project involving the Research Department of SHOM/DOPS/HOM/REC and LPO - Ifremer.

The axis policy of supporting projects through co-funding also promotes collaboration with other research teams in Brest. The project DEXMES involving IFREMER/DYNECO/PHYSED, LDO, SHOM and the University of Rennes 1, funded by INSU (EC2CO) has benefited from the axis support (TURBID-EX project). The amendment of the Neomysis, research vessel based in Roscoff, to install a deployment pole for a multibeam sonar opens the possibility of bathymetric surveys for bedform studies in the Bay of Morlaix, in collaboration with the Marine Geosciences Department of IFREMER. Further collaboration with the Observatory of the Biological Station of Roscoff is expected. The collaboration with the CRPCC initiated during the Cocorisco project continues with the upcoming project Osirisc and thanks to PhD funding (UBO "President" scholarship) on the subject of the monitoring of social representations of coastal vulnerability.

This synergy is reflected in (i) publications involving different members of these laboratories, (ii) various scientific projects (some of which are listed below in section 2.4), or request for opening 'teaching' and 'research' positions or technicians on shared profiles (joint request by LETG-Brest Géomer and LDO), and (iii) the establishment of a reading group on the Littoral meant to promote exchanges on thematic axis between researchers from various disciplines.



2.3. INTERNATIONAL VISIBILITY

The international actions of the axis will be continued: support for incoming and outgoing mobility and stipends for internships abroad. The researchers participating in projects supported by the axis or within the research topics of the axis will be encouraged to communicate their findings at international conferences (e.g. International Coastal Symposium in Sydney in 2016). Special efforts will be made to improve the track record of the axis regarding the international postdoc program of Labex MER. Researchers will be invited to advertise the postdoc call via their international network to identify candidates with specific skills relevant to the axis research objectives. Such action, which has already started to pay off this year, is especially important since a consequence of the topologic evolution of Labex for the second phase is that the international Chair of Linwood Pendleton will be hosted in the newly created eighth axis instead of axis 5, leaving the axis without international chair while no additional chair will be opened in second phase.

Axis 5 is currently involved in the following international collaborations:

- The Icelandic Road and Coastal Administration (IRCA) and the University of Iceland (Institute of Earth Sciences - Reykjavik) via the EXTREMEVENT project on coastal morphodynamic of the Reykjane peninsula (ARED-Labex thesis in progress).
- UQAR University in Rimouski (Canada), with the co-supervision of an ARED-Labex thesis at LETG-Géomer Brest on: the option of relocation of goods and activities in response to coastal hazards: strategies and territorial issues in France and Quebec.
- The Federal Polytechnic School of Lausanne (Switzerland) with a methodological development project on hyperspectral imaging with UAV.
- Scripps Institution of Oceanography at the University of California, San Diego (USA) and the University of Plymouth (UK) with the iSWAY project funded by Brittany region, on the role of infragravity waves in cliff erosion.
- Centre for Research in Planning and Development of the School of spatial planning and regional development at the University of Laval (Québec - Canada), with the MEtalUrbain project (modeling urban sprawl) on the spatial and statistical analysis of land use changes in the coastal zone in the surroundings Brest.

2.4. LEVERAGING EFFECT

Results from research actions conducted during the first phase, in particular in the framework of the axis call for exploratory projects, have served as a basis for subsequent, more mature projects submitted to external calls, or to obtain ARED-Labex fellowships for PhD theses. The same successful leveraging effect is expected in second phase. Here are some recently funded projects emerging from actions supported by the axis:

- Exploratory project CLIFF (2014) □ project EROFALITT: Evaluation of optical, high spatial resolution and multi-angles imaging (Pleiades) to monitor the erosion of Upper Normandy chalk coastal cliffs - funded by CNES for a duration of 24 months (2016 - 2017) and associating participants from LETG-Brest and Caen and LDO.
- ANR COCORISCO (2011-2014) □ OSIRISC project - towards an integrated observatory of coastal risks of erosion and flooding submitted to the "Fondation de France" (AAP 2015 "What



coastlines for tomorrow?"), on the feasibility and implementation of such integrated observatory (interdisciplinary research, both academic and co-constructed with managers).

- Exploratory project DYNATREZ □ response to the INTERREG 2015 call “England France Channel”: Impacts of SEDiment TRANSfers in the COASTal zone on the morpho-ecological dynamics of the Channel shoreline (SEDTRANSOAST), coordinated by A. Héquette (University of the Littoral, Dunkerque) - in collaboration with the universities of Brest, Caen and Brighton.

2.5. GOVERNANCE

The governance principle and mode of operation of axis 5 will remain the same as for phase 1. There will be two axis coordinators from the two UMR at the origin of the axis: UMR 6538 - LDO, and UMR 6554 - LETG-Brest Géomer. The steering committee in charge of scientific questions will be reduced to 8 members, instead of 11 at present: both coordinators and three representatives from each unit, LETG and LDO. The coordinators will make sure to strengthen the involvement of young researchers in the governance of the axis, as recommended by the CSI. A PhD student and a postdoc working on a subject related to the axis topics may be invited to meetings of the steering committee, both to represent their colleagues and to contribute to their own training. The steering committee will meet twice a year to (i) feed reflections on the strategy of the axis, (ii) review and rank the funding applications in response to the annual call and (iii) assess on-going scientific actions and outline future projects. A public presentation of research projects carried out within the scope of the axis will be organized annually.

3. ANSWERS TO CSI RECOMMENDATIONS

The scientific theme of axis 5 remains unchanged, however, the scientific project is re-centered around the main topic of the axis, systemic vulnerability to erosion and flooding of coastal environments, as recommended by the members of CSI: *“our recommendation is that Axis 5 should reassert its focus on the key themes of coastal processes and vulnerability from a geographic perspective, by extending and articulating work between coastal hydrodynamic processes, including hydrodynamic modeling (pursuit of collaboration with Axis 7), coastal sediment dynamics (collaboration with Axis 4) and the attendant hazards such as coastal erosion and flooding, and the perception and mapping of potential hazards, including aspects such as flood and inundation maps, and outreach to the public and local authorities, which, we believe, in this day and age of climate-change effects on coasts, could be a strong point of this axis”*. Collaborations with the axes 7 and 4 already initiated in Phase 1 will be strengthened around the study of coastal hydrodynamic processes (axis 7 - Laboratory LPO) and of sedimentary transfers from coastal to the supra-littoral zone (axis 4 - Laboratory LDO).

The theme of ecosystem resource assessment (mainly shellfish) will not be continued. The issue was discussed at length during the CSI meeting and this scientific question was deemed too far from the main objectives of axis 5, while inducing a certain dispersion: *“the range of research issues covered by Axis 5 somewhat gives the impression [however] of a certain degree of dispersion in the types of projects undertaken, and a lack of sharp focus on the core theme of*



the axis. It is hard to see, for instance, the relevance of mapping of maritime routes based on multi-agent analysis, or of the fate of pollutants. The articulation with socioeconomic evaluation and valuation, as well with ecosystem services, also appears fuzzy.”

4. IMPLEMENTATION PLAN AND RESOURCES

A yearly call for proposal with a budget of 45,5k € will be made at the beginning of the year (between January and February) in 2016, 2017 and 2018. Eligible actions will follow the scheme initially defined in phase 1 roadmap:

- Post-doc and/or fixed-term contract and/or thesis co-financing€
- Support for exploratory or on-going projects
- Incoming/outgoing mobility of faculty
- Stipend for Master2 internship abroad

To ensure that the projects selected can be carried out and evaluated within the timeframe of LabexMER, there will be no call in 2019, the last year of LabexMER, except for incoming/outgoing mobility and stipend for internship abroad. In practice, part of the allocated budget will be spent in 2019. As in phase 1, mobility requests will be examined year-round, within the limit of the annual budget allocation for the action, to provide more flexibility.

A budget will be dedicated to complementary support of the thesis and post-docs co-funded by Labex (ARED-Labex and international post-doc). An envelope called "flexibility" funds, will be allocated in response to specific requests for projects that (i) are critical to meet the scientific objectives of the axis or for the attractiveness of the axis, and (ii) require co-funding on a timeframe that is out-of-phase with the annual call. These funds may be used to co-finance a post-doc, fixed-term contract or thesis, or possibly for an ambitious project that has been submitted in response to external funding calls but without success. This call for projects will be posted by the steering committee early in phase 2. The intention is that this particular set-up will provide some flexibility to the scientific committee of the axis in order to ensure the implementation of ongoing projects and achieve the targets set for the axis.