axis 8

Marine Social-Ecological System Management

LabexMER Research project	**2016-2019 axis 8 roadmap**	**March 2016**

Marine Social-Ecological System Management

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List of participating laboratories:

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- LEMAR – UMR 6539 (Laboratoire des sciences de l'Environnement MARin), UBO, CNRS, Ifremer, IRD
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1. Scientific context, scientific questions

When considering the big issues of the new century, including environmental crises, it becomes obvious that none of them can be adequately tackled from the sphere of specific individual disciplines: they clearly represent trans-disciplinary challenges (Max-Neef, 2005).Thus, coping scientifically with urgent life-world problems calls for interdisciplinary participatory research, which represents a new mode of knowledge production (Zierhofer and Burger, 2007). The purpose of this new axis is thus to reinforce the collaborations between social and natural sciences within the Labex to address current issues related to management of marine ecosystems which raise inter- or trans-disciplinary research questions. Marine and coastal ecosystems are nowadays subject to an increasing social demand for improved knowledge, new uses and more integrated management.

This context creates new expectations from marine sciences, which themselves necessitate trans-disciplinary approaches. Social expectations from marine sciences concern in particular the following issues:

- -as the sea is the natural realm which remains the least accessible to observation and experimentation, how can we address the complexity of marine ecological systems using available, albeit fragmented, scientific knowledge?
- -as the sea generates an increasing demand for competing uses as well as for conservation efforts, can marine science help to understand the heterogeneity of the social representations of the sea which underlie these demands?
- -as the sea has been for a long time subject to various regulations and policies which reflect the successive evolutions of these social demands, how can we build a scientific expertise in support of the new maritime policies which claim to become more coherent and integrated?

Such questions obviously lead to re-thinking the analytical frameworks which were used by each discipline of the marine science community up until now and would be better addressed by integrated approaches based on a clearly trans-disciplinary way of thinking. Attempts in this new way of building science, in particular for the purpose of understanding critical environmental problems or supporting complex decision making processes, are notably represented by "system thinking". Global changes and in particular the world environmental crisis have lead indeed to major shifts in both natural and social sciences during the years 1960s and 1970s. In natural sciences, the ecologist Crawford Holling suggested to abandon the concept of ecosystem equilibrium and to adopt the concept of "ecological resilience", which designates the complex biotic interactions that determine the persistence of relationships within an ecosystem: resilience is "a measure of the ability of the system to absorb changes of state variables, driving variables and parameters, and still persist" (Holling, 1973).

In social sciences, at a time when the equilibrium models of neoclassical economics were criticized, economist Kenneth Boulding and engineer and psychologist John Holland found similarities between social systems and biological systems: social systems, which should be considered as embedded in natural systems through flows of energy, materials and information (Boulding 1966) could also be described as complex, subject to non-linear evolutionary patterns and adaptive changes (Holland 1992). Understanding human and natural system functioning as a process of coevolution between knowledge, technology, social organization, values, and nature provides an alternative epistemological framing (Norgaard, 1995). Collaborations between ecologists and social scientists lead to the production of a "social-ecological system" as a trans-disciplinary research object. The issue of knowing why or how social-ecological systems could or should be "resilient" necessitates studying the processes by which "systems, including those of nature (e.g. forests) and of humans (e.g. capitalism), as well as combined human-natural systems (e.g. institutions that govern natural resource uses), are interlinked in continual adaptive cycles of growth, accumulation, restructuring and renewal" (Holling and Gunderson, 2002). Resilience becomes thus a key concept in environment sciences for analyzing complex adaptive systems and developing an operational strategy of risk management (Walker and Cooper 2011).

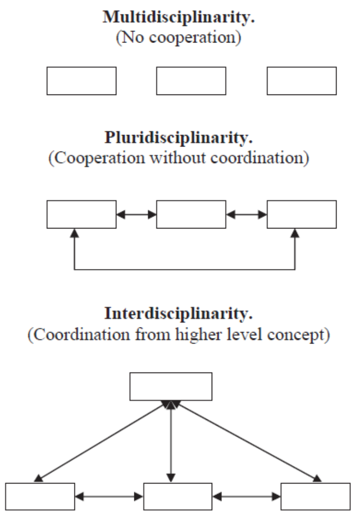

Figure1: From multidisciplinarity to interdisciplinarity (Max-Neef, 2005)

These approaches and concepts, which originated in the 1970s, have nowadays gained influence over some aspects of the new analytical and regulation frameworks which are currently proposed to address marine scientific and management issues. These are the reasons why, as with other components of natural and social systems, marine and coastal environments as well as marine and coastal activities are nowadays scrutinized through approaches such as the ecosystem services approach, which is expected to be developed by both ecologists and social scientists, and subject to management policies, such as ecosystem-based management, which claim to be more integrated and adaptive. However, many controversies and methodological gaps remain in these emerging science and management realms. Most of the current debates arise from insufficient understanding of what inter- or trans-disciplinary science really is (Figure 1). While multidisciplinarity means working on the same subject without integration, pluridisciplinarity implies cooperation without coordination. Interdisciplinarity means coordination of the empirical work of each discipline to feed a higher level concept. Transdisciplinarity would mean coordination at all the higher levels, which are the pragmatic one (addressing a common problem), the normative one (proposing together solutions for society) and the ethical one (sharing common values or philosophical view related to the subject) (Max-Neef, 2005).

The ecosystem services approach is a typical example of how trans-disciplinary science may be built in support of various social goals. The modern concept of “environmental services”, that is the use of this long-standing idea in the context of the current environmental crisis, emerged when an expert group from the Massachusetts Institute of Technology were asked to produce a “Study on Critical Environmental Problem” (SCEP, 1970): the management purpose here, was to estimatewhether threatened ecological services could be restored or replaced. Later on, the ecosystem services approach was adopted by scientific networks and international organizations acting for the “conservation biology” movement for the purpose of demonstrating the benefits from nature protection. This institutionalization of the new concept by both science and politics culminated in the Millenium Ecosystem Assessment (MEA) initiative, which made 1300 researchers from various fields collaborate. However, despite the acceptance of the ecosystem services approach as a useful framework for organizing research on ecosystem management, controversies remain on the evaluation of these services and on the relevance of the approach beyond raising awareness, when operational management purposes are at stake.

Pragmatic problem-solving approaches have attempted to develop methods and tools for dealing with risk and uncertainty in social-ecological systems. The key issue at stake here is to forecast adaptive management potential, which requires analyzing institutional change (lato sensu) in response to ecological dynamics and environmental hazards. Controversies remain on the methodologies used to estimate human pressures, identifying the risk these pressures generate and the governance system retained.

Interest in ecosystem-based management in the marine realm has developed recently in response to increasing recognition of the declining state of ocean ecosystems (Millennium Ecosystem Assessment, 2005) resulting from climate change, overfishing, nutrient and chemical pollution from land runoff, coastal development, habitat destruction, disease outbreaks and other human activities (Levin & Lubchenco 2008). To ensure that human activities are carried out in a sustainable manner, numerous international maritime policies have been implemented, including the European Union ‘Water Framework’ and ‘Marine

Strategy Framework' (MSFD) Directives, the Canadian 'Oceans Act,' the US 'Ocean Action Plan,' and the Australian 'National Strategy for Ecological Sustainable Development.' These legislations and policies mandate that decision making and marine management should include as nested components: a knowledge-based approach, an ecosystem-based approach, and an integrative management framework that includes economic, environmental, social, and equity considerations (Cranford et al. 2012). Controversies remain on the kind of scientifically founded integrated approach which may support ecosystem-based management for fisheries, aquaculture and more broadly the whole marine environment which has to be preserved through the MSFD.

Integration of disciplines may be improved through the public participation in scientific research (Zierhofer and Burger, 2007), also referred to as community science. Indeed, another paradigm shift is also needed, wherein scientists and nonscientists work collaboratively to contend with emergent, large-scale environmental issues (Theobald et al., 2015). Public participation in science is one possible component of the solution for future evidence provision to underpin marine policy and management, but needs to be addressed as part of an integrated overall scheme (Hyder et al. 2015), which includes i.e. remote sensing, mathematical and statistical models. If marine biodiversity science does not engage nonscientists, as biodiversity and ecosystem services continue to erode, it runs the risk of becoming irrelevant in the eyes of a public that may offer local solutions to global problems.

Considering this wider context and in particular the new social expectations that face marine science, the research program of Axis 8 is based on the following 3 themes:

- **Theme 1: Assessment of marine ecosystems and delivered services,**
- **Theme 2: Integrated approaches in support of ecosystem-based management,**
- **Theme 3: Change in ecosystems and adaptation.**

Within each theme, the research to be developed will aim at producing new insights for inter- or trans-disciplinary work, innovative and integrative models to support analysis and decisions, and strategic approaches for facilitating the use of scientific advices for operational purposes, while incorporating when possible the results of public participation in research programs and adopting when needed the perspective of post-normal science.

2. Objectives for the next four years and specific actions

2.1. Scientific objectives

i. Theme 1: Observation, assessment and monitoring of marine ecosystems and delivered services

The observation of the sea can no longer be seen as the collection of physical and biological data only. The observation of the sea includes nowadays a human dimension for two reasons. First, most of the indicators of the ocean wealth include pressures or threats indicators which denote that some ecological features cannot be separated from the influence of human activities. This issue of observing the diversity of uses and analyzing the changes in pressures involves reflecting on the construction of data and appropriate systemic indicators. Second, due to the vast number of parameters to be collected and monitored, the inclusion of more stakeholders in marine ecosystem observation should be considered. This creates opportunities for developing public participation in scientific research, which can be defined as scientific research and monitoring projects for which members of the public collect, categorize, transcribe or analyze scientific data (Cigliano et al. 2015) across a wide range of disciplines.

The ecosystem services (ES) approach has typically created an interdisciplinary framework for analyzing social-ecological systems (Levrel et al, 2014). The ES approach was initiated by ecologists who were interested in the resilience of ecosystems facing high levels of pressure and degradation (Ehrlich and Mooney, 1983). They felt it necessary to adopt a holistic view of the issue at stake, resulting from complex ecological but also social processes. From this perspective, while it is important to understand whether and how ecosystems could endure the pressures they face, it is almost as important to understand why society fails to adapt to the threats its own evolution induces (Costanza et al., 1993). Some of these ecologists, such as Robert Costanza and Leon Braat, decided at the end of the 1970s to pursue their analyses in the field of economics. Robert Costanza et al. published their famous paper on the "value of world's ecosystem services and natural capital" in 1997, and Leon Braat was later one of the leaders of the TEEB initiative ("The Economics of Ecosystems and Biodiversity", TEEB 2010), which was the follow-up of the MEA in the field of economics (Figure 2). The ecosystem services approach, which was basically a joint production of ecologists and economists who shared the common goal of raising awareness regarding the need for more biodiversity and ecosystem preservation, has now to face new challenges. One objective of the Labex Axis 8 will be to bring a marine contribution to the ongoing debates regarding the future development of the ecosystem services approach.

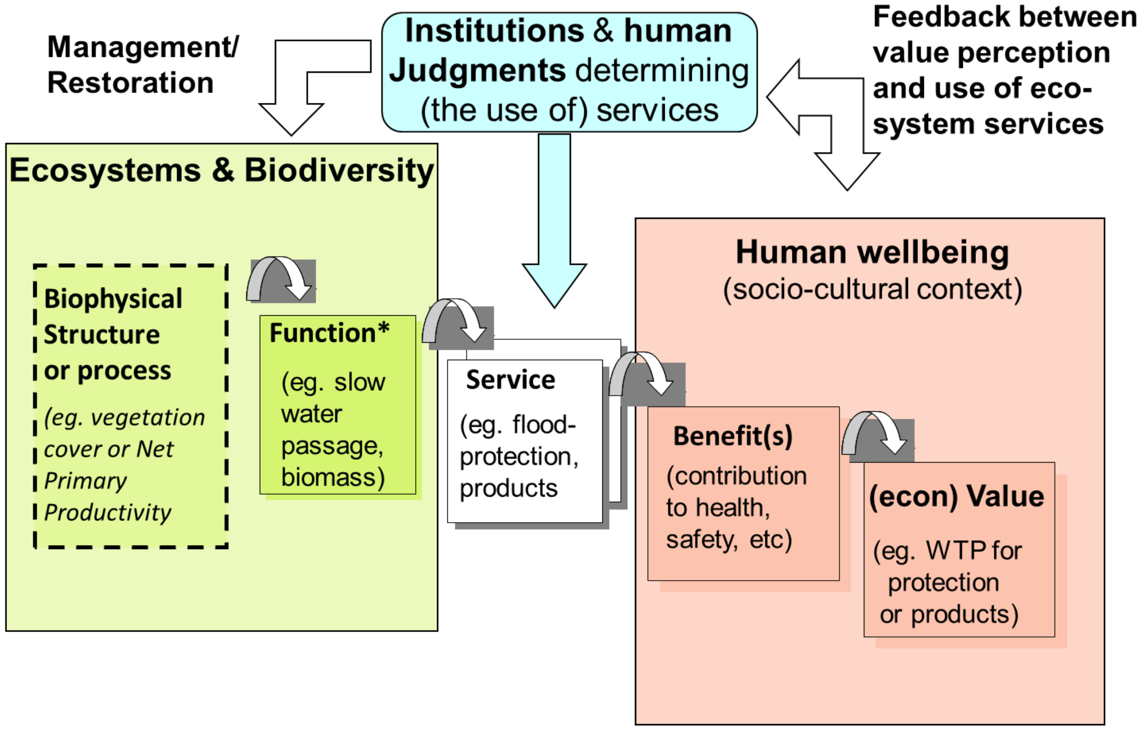

Figure2: Contribution of the ES approach to management (TEEB, 2010)

First, the approach is now discussed within a wider range of disciplines, in both natural and social sciences. This expansion of the scientific realm interested in the approach leads to the emerging issues. Natural sciences are now expected to further explore the links between habitats, functions and services, but also the notion of "disservices". Social sciences are only about to begin the research on methodological pluralism that requires any appraisal of the "value of nature" or the social demands for nature use and conservation. Second, the approach is now expected to go one step further and to prove whether it could be useful for real operational management purposes. Up until now, the approach is mentioned in political programs framing very broad objectives (e.g. the European Strategy for Biodiversity) but has not been translated into the wording of environmental laws.

Some recent initiatives have opened new perspectives for the marine domain, in response to specific social concerns (IFRECOR) or in the context of local management schemes (VALMER), using a strategic decision making approach (Pendleton et al., 2015). Growing interest for deep exploration will also stimulate research on the actual and potential services which could be delivered by those ecosystems (Dyment et al. 2014, Rogers et al. 2015). The excellence chair of Linwood Pendleton is already implementing a series of projects in this realm. ECOPOTENTIAL seeks to use earth observation data to assess and monitor marine ecosystem services with a focus on the Mediterranean and Caribbean Seas. This project is also looking at "essential variables" (EV), in the European context, including Ocean EVs, Biodiversity EVs, and ES EVs. The GEF "Blue Forests" project includes many pilot projects to assess the carbon storage potential and ecosystem service co-benefits of coastal areas in Ecuador, Mozambique, Kenya, Madagascar, Indonesia. The "Extra-local ecosystem services" project (which is part of Mapping Ocean Wealth) seeks to find new ways of mapping the contribution of ecosystem when some services are enjoyed far from the ecosystem where they are produced.

ii. Theme 2: Ecosystem-based management

Ecosystem-based management (EBM) is an integrated approach of management that considers the entire ecosystem including humans (Slocombe 1993, Crowder et al. 2006). The objective of ecosystem-based management is to maintain an ecosystem in a sustainable, healthy, productive and resilient condition so that it can provide the services humans want and need. Therefore, EBM is not solely of natural obedience since human actions are extensively involved. It requires trans-disciplinary approaches that encompass the natural aspect of ecosystems and the social aspects of drivers, impacts and regulation. The purpose of Axis 8 will be to develop and support research approaches which associate systematically and in balanced way social and natural sciences for dealing with EBM challenges and issues.

Historically, ocean management has focused on individual sectors (Crowder et al. 2006). For instance, separate regimes for fisheries, aquaculture, conservation, shipping, oil and gas were used to resolve conflicts within sectors, ignoring other sectors. It has been argued that place-based management and marine spatial planning (MSP) can provide a far more promising approach to implementing ecosystem-based management. Rather than individual sectoral agencies managing their activities everywhere, responsible sectoral authorities could work together to manage all the human activities in a given area (Crowder et al. 2006, Leslie & McLeod 2007, Levin et al. 2009). These places could align with ecosystem, socio-economical, and jurisdictional boundaries. Ecosystem-based approaches include but are not limited to place-based management strategies, ecosystem-based climate adaptation and restoration efforts, and interdisciplinary research that generate the rich biophysical and socioeconomic information needed to proactively manage coupled human-ocean systems (Bernhardt & Leslie 2013). Place-based management approaches include not only EMB, but also marine spatial planning (MSP), fully protected marine reserves, and other types of marine protected areas (MPAs).

Ecosystem based management in the marine realm has been considered for coastal areas, open ocean and deep-sea ecosystems (Leslie & McLeod 2007, Morgan et al. 2007). Deep sea ecosystems provide an upcoming case study for EBM studies as anthropogenic pressures are increasing (Ramirez-Llodra et al. 2011). Exploitation of resources, pollution, acidification, hypoxia and shifts in primary productivity may drive deep-sea ecosystems into unpredictable states. The management of deep-sea ecosystems, when it exists, is fragmented by sectors and by jurisdictions. Mismatches between flows of matter/energy across natural systems and sectorial and jurisdictional boundaries and between services provided by deep sea ecosystems and the lack of social awareness make the deep sea a complex and challenging environment where to address social-ecological system management by means of trans-disciplinary approach.

Natural and social scientists can respond to the challenge of implementing marine EBM in marine ecosystems by (1) addressing crucial research needs, (2) building interdisciplinary scientific capacity, and (3) synthesizing and communicating scientific knowledge (Leslie & McLeod 2007). Although the first point is covered in other axes of the Labex, points 2 and 3 are objectives of axe 8. However, EBM is generally driven by a great divide between the natural and social sciences which is entrenched in differences of research methods, approaches and languages (Byron et al. 2011). The resulting fragmentation of knowledge currently hinders progress in understanding and defining management of marine ecosystems. Also, EBM is limited by human and social constraints such as lack of appropriate funding and resources, poor organization, and communication barriers (Byron et al. 2011). As a consequence, despite the efforts of managers, researchers, and policy makers, EBM often falls short of its intended purpose, resulting in inadequate protection of resources.

EBM can be improved when it is informed by ecological science and considers the socio-economic needs of the community. Communication between scientists and stakeholders can help to prevent adverse outcomes while enhancing protection and sustainability of the coastal environment. Therefore, the objective of the Axis 8 is to support trans-disciplinary projects which bridge the gap between biological and social sciences in the context of EBM of aquaculture, fisheries and deep-sea resources.

iii. Theme 3: Change in ecosystems and adaptation

The changes that coastal and marine and coastal areas have been experiencing for several decades were addressed within the frame of Integrated Coastal Zone Management (ICZM) since the 1980s. ICZM provided a strong conceptual basis for improved marine governance, including the production of approaches which necessitate collaboration between disciplines (Shipman and Stojanovic, 2007); however, its implementation remains limited in both scope and geographical coverage (Kerr et al., 2014). The European Union has recently decided to broaden the scope of its stimulation of more coherent marine governance practices by launching its Integrated Maritime Policy (IMP), which is based on the idea that the EU can draw higher returns from seas and oceans with less impact on the environment by coordinating its policies. The IMP encompasses the Marine Strategy Framework Directive, which targets the good ecological status of marine waters on a mainly scientific basis, and the Maritime Spatial Planning Directive, which was designed to replace the current fragmented system of sectoral decision making with a coordinated, coherent, and joined-up system of allocating space to marine users, on a mainly political basis (Brennan et al., 2014).

This context of growing political demand for a more integrated expertise to face rapid environmental changes in marine and coastal areas open the way of new research actions in different directions. A first important challenge for the science to be produced in support of these two directives will be to account for the possible mismatch of the ecological time-scale and the one of the adaptation of maritime activities (Gilbert et al., 2015). Blue economy is an emerging field which will necessitate collaborations between disciplines working on technological innovation, its impact on marine environment and its appropriation by coastal societies. Renewable energy or deep-sea mining are typical examples of these activities that will necessitate new insights from interdisciplinary scientific projects. Hazards, which include flooding, erosion and tsunamis, generate risks for society which may be exacerbated by the human tendency to disturb or even destroy natural ecosystems and to build on vulnerable coasts (Elliot et al., 2014): the impacts of extreme events on coastal societies (Pendleton et al., 2013) as well as the risk analysis and the capacity to cope provide other fields for inter-disciplinary research. At last, participative science is a valuable form of research that addresses tasks and topics that would not be addressed by scientists alone.

The Intergovernmental Panel on Climate Change analysed global climate observations and concluded that "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level" (IPCC 2011). Rising greenhouse gas concentrations have triggered a series of changes in the ocean. The upper layers of the ocean have warmed by approximately 0.6◦C over the past 100 years (IPCC 2011). Along with warming comes a set of additional abiotic changes in marine ecosystems, including sea level rise, more intense storms, changes in wind strength and upwelling patterns and current systems. Aside from warming, increased concentrations of anthropogenic CO2 in the atmosphere have led to ocean acidification (Orr et al. 2005). Rapidly rising greenhouse gas concentrations are driving ocean systems toward conditions not seen for millions of years, with an associated risk of fundamental and irreversible ecological transformation. The impacts of anthropogenic climate change so far include decreased ocean productivity, altered food web dynamics, reduced abundance of habitat-forming species, shifting species distributions, and a greater incidence of disease (Edwards & Richardson 2004, Hoegh-Guldberg & Bruno 2010), so that a warmer world could be a sicker world (Harvell et al. 2002).

Adaptation to climate change in marine and coastal areas is thus generating new research needs, which are in particular currently addressed by Linwood Pendleton excellence chair (Pendleton et al., 2012). The "Blue Carbon Think Tank" is a proposal for a LABEX-based think tank on blue carbon science and policy with a focus on francophone countries. The project "Using Indicator Analyses to Understand the Impacts of Ocean Acidification and Climate Change" has examined impacts to US shellfish (Ekstrom et al., 2015), contributed in December 2015 to the Ocean Climate Platform with a report on using indicator approaches to target climate investments (Comte et al., 2015), and will continue to work on the use of indicator approaches to understand the impacts of climate change on coral reefs.

2.2. Interdisciplinarity and synergies between teams

Several recent experiences demonstrate the interest and abilities of the Axis 8 members for trans-disciplinary approaches. Among many others, the following can be cited:

- SPICOSA (AMURE-DYNECO) developed a system approach as well as integrated simulation modeling in support of the management of sustainability issues in the coastal zone;
- GIGASSAT (LEMAR-DYNECO-LEMNA) applied the ecosystem approach to shellfish farming in order to address ecological and economic sustainability;
- VALMER (AMURE-DYNECO) was dedicated to the operational assessment of marine ecosystem services in support of management purposes;
- EFESE (AMURE-DYNECO) is a scientific expertise on the marine ecosystem assessment for the French Ministry of Environment;

Ongoing projects are now discussed to reinforce the synergies between teams, for instance in the realm of deep-sea research, in relation with the international chair of Linwood Pendleton, or through new partnerships with marine stakeholders for developing operational bio-economic models or communication actions on marine science advancements.

2.3. International visibility

As regards its work on ecosystem services, Axis 8 will benefit from the international chair of Linwood Pendleton, who will reinforce its visibility in international networks such as the Ecosystem Services Partnership (ESP) and its marine component (MESP).The ongoing participation to the EFESE project will also increase Axis 8 visibility in the European project MAES (Mapping and Assessing Ecosystem Services). Many other organizations and institutions are calling for new trans-disciplinary research work, for instance the ICES which has launched working groups on ecosystem approach or integrated management.

In the deep-sea realm, EEP is part of the European project MIDAS (Managing Impacts of Deep-seA reSource exploitation - http://www.eu-midas.net/) which involves 32 partners across Europe. EEP is also a member of two international initiatives: INDEEP and DOSI. The International network for Scientific investigation of deep-sea ecosystems (INDEEP, http://www.indeep-project.org/), whose aim is to develop and synthesize our understanding of deep-sea global biodiversity and functioning and provide a framework to bridge the gap between scientific results and society to aid in the formation of sustainable management strategies. The Deep Ocean Stewardship Initiative (DOSI, http://dosi-project.org/) seeks to integrate science, technology, policy, law and economics in order to both guide ecosystem-based management of resource use in the deep ocean and to formulate strategies to maintain the integrity of deep-ocean ecosystems within and beyond national jurisdiction. The international chair leads an international webinar series on Deep Sea Science and Policy and is on the Steering Committee of the Deep Ocean Stewardship Committee.

2.4. Leveraging effect

Axis 8 will target an active participation in international preparatory initiatives for new research calls on ecosystem approach, ecosystem services assessment and integrated coastal zone management based on integrated approaches and deep-sea research in relation to social issues.

2.5. Governance

The Axis 8 involves five laboratories from both social and natural sciences. Its steering committee, which is still in the process of being completed, will meet at least four times a year. Depending on offices availability, it would be beneficial to obtain shared space in one of the IUEM buildings to create a “collaboratorium” between social and natural sciences.

3. Implementation plan

A first series of actions will target the strengthening of trans-disciplinary practices within the Labex community. During the year 2016, internal workshops on various transversal concepts or approaches will be organized in order to help researchers from the Labex who come from different scientific disciplines to refine concepts and to share a common language. During the year 2017 senior scientists with a recognized experience in trans-disciplinary approaches will be invited. Their stay will give the opportunity to receive advice on our approaches, and to be better informed on ongoing initiatives in the field. These first actions will serve for the organization of an international workshop on trans-disciplinary holistic approaches in Marine Sciences, to be organized in 2018.

In parallel, a series of small project initiatives will support innovative additional work in existing project which would envisage broadening the scope of their work, in relation to the assessment of marine ecosystems and delivered services, the integrated approaches in support of ecosystem-based management and the changes in ecosystems and adaptation. This could also cover communication actions. Finally, co-funding will be provided for at least two post-doctoral fellowships focusing on the Axis 8 research themes. Other small financial mechanisms to support PhD and post-doctoral fellowships will target publications in multi-disciplinary journals or communications to multi-disciplinary conferences.