« Marine Ecosystems Response In The Mediterranean Experiment »

Coordinators: [1]Xavier Durrieu de Madron, [2]Cecile Guieu and [3]Richard Sempéré
[1]CEFREM, CNRS-Université de Perpignan,
[2]LOV, CNRS-Université Pierre et Marie Curie, Villefranche-sur-Mer
[3]LMGEM/COM, CNRS-Université de la Méditerranée

2011-2014 Work Plan

submitted to the 2011 MISTRALS Call – March 2011

Table of Contents:

For additional information,visit the MerMex web site: http://mermex.com.univ-mrs.fr/

In particular, projects (such as those submitted to ANR) can be seen on the MERMEX web site

1. HISTORICAL BACKGROUND

Since 2007, French biogeochemical oceanographers have raised the issue of Mediterranean marine ecosystems response to changes in physical, chemical and socio-economical forcings induced by climate change and by growing anthropogenic pressures. This debate has focused on the current understanding of the effects of key natural and anthropogenic forcings on ecosystems (from coastal zones to open-ocean, from pelagos to benthos) and organisms (from viruses to fishes and mammals). It has further aimed to identify knowledge gaps and to contribute to the emergence of a large integrated research project, the Marine Ecosystems' Response in the Mediterranean Experiment (MerMex). This initiative complements other actions (HyMex: Hydrological Cycle in the Mediterranean Experiment, and CharMex: Chemistry-Aerosol Mediterranean Experiment) that jointly aim at studying the water cycle and dynamics of atmospheric aerosols in the Mediterranean basin, considering the coupling between compartments (continent, ocean, atmosphere), the roles of extreme events (precipitation, heat waves, Saharan dusts), and the impacts on regional climate and marine systems.

Most of the Research objectives presented here were deduced from the Mermex article (*Progress in Oceanography, In Press*) in which ~100 co-authors presented current knowledge on biogeochemistry in the Mediterranean Sea and highlighted the uncertainty on the responses to global change in the 21th Century. The general MerMex project as well as foreign similar initiatives were discussed during the Marseille international workshop, 8-9th of July 2010.

Here we present (1) the general MerMex information in the first part of the document, whereas (2) research actions and organization for each WP and (3) a short description of the projects for which funding is requested to MISTRALS are presented in the second and third part (Annex) of the document, respectively.

note: as requested, in order to produce a short document to the present call, the scientific background, is not detailed. The version of the article in press is available in the MerMex web site.

2. CONTEXT AND SOCIO-ECONOMICAL STAKES

The Mediterranean Sea is unique and evolves rapidly, with large interannual to decadal variability and abrupt fluctuations. The semi-enclosed nature of the Mediterranean, together with its smaller inertia compared to large oceans, makes it more sensitive to natural variations in fluxes (between, e.g., the air and sea, freshwater and the sea) and water flows. These natural pressures interact with the trend of increasing human activities in the coastal regions, making the sea even more sensitive. Over the past century, the population along the Mediterranean coasts has expanded substantially. Urbanization, industrialization and touristic exploitation (with associated impacts as land use change, increased demand for food and water, waste disposal, coastal erosion, etc.), intensive agriculture and aquaculture, riverine and atmospheric inputs and overfishing have exerted progressively growing pressure on the Mediterranean environment, putting their integrity at stake. In order to understand and predict the vulnerability of marine ecosystems submitted to anthropogenic and climatic changes, single effects of the main natural and anthropogenic forcings, namely hydrodynamics, solar radiation, temperature and acidification, and chemical contaminants have to be considered. Synergistic effects due to multiple forcings on the vulnerability of marine ecosystems, such as simultaneous impacts of physical factors, changes of stoichiometry in nutrient sources, changes in frequency and intensities of extreme events, have also to be studied. The positioning of the project with regards to socio-economical is the following:

Interactions Man-Environment and Climate Change Mediterranean environment: MerMex considers several forcings acting on the evolution of Mediterranean ecosystems, such as changes in stratification regime and extreme events. Those related to human activity are the inputs of contaminants, changes in nutrient emissions and pressure on resources.

The human pressures and their impacts on the Mediterranean environment: MerMex studies inputs of contaminants from land surfaces (especially through coastal megacities) and fate (transfer through food chains). Trends of nutrients inputs via rivers and atmosphere will also be assess to predict the evolution of nutrient limitations in the marine environment.

The future of biodiversity in the Mediterranean: MerMex actions focus largely on the functional diversity of marine species and on the taxonomic diversity from bacteria to fish with the aim of better understanding of the flux of elements, of the evolution of trophic systems, and of the fate of nutrient resources in the Mediterranean basin.

Coastal areas: trade and place of living: The coastal areas are not considered as such in MerMex but they are part of a continent-open sea continuum that we must study as a whole to achieve our objectives. Several ecoregions correspond to areas such as coastal zone of the Gulf of Lions which includes a highly populated coastline (inputs of contaminants), a large river (change of nutrients' stoichiometry) and important pressure on living resources. These three aspects are directly addressed by MerMex.

Natural hazards in the Mediterranean in the context of global change and increasing human pressure: MerMex will assign a significant part of its efforts on the impact of extreme events such as storms, river floods and episodes of atmospheric deposition of Saharan dust and biomass burning.

The assessment and management of water resources in the Mediterranean Basin: The observations will be obtained through MerMex, and marine observatories and associated international programs are accessible to the scientific community as well as to the public *via* an information system. One of the main objectives of the project is to integrate data from different research efforts within the same analysis to provide management tools for Mediterranean marine ecosystems and decision .

3. OBJECTIVES

There are still considerable uncertainties in our understanding of the complex interactions between the different forcings and their impacts on ecosystems. There is therefore a strong need to reach a mechanistic understanding of the relevant processes in order to predict changes in ecosystems. These changes clearly influence the cycles of major biogenic elements, biodiversity, fisheries, invasive species and ultimately have socio-economic impacts. There is a need to develop a comprehensive and holistic approach to address particular questions at the proper spatial and temporal scales. The most relevant issues for the future of marine ecosystems in the Mediterranean are listed here and constitute the main research axes that MERMEX propose to tackle in the next 10 years:

- How would changes in stratification and destratification mechanisms and in the overall thermohaline circulation alter the spatio-temporal distribution of nutrients and their budgets? More specifically, what is the influence of dense water formation on the spatial and temporal variability of biogenic elements, the triggering of planktonic blooms, and the sequestration of biogenic elements, particularly carbon)?
- How would likely changes in nutrient inputs from physical transport, rivers, the atmosphere (including extreme events) and straits affect the nutrient availability in the photic layer of the Mediterranean Sea, the relative abundance of primary producers, and the higher trophic levels?
- What are the typical concentrations of chemical contaminants in the various water masses of the Mediterranean? What are their sources and sinks (e.g., atmosphere versus rivers, especially for organic contaminants) and seasonal variations?
- What is the role of the land-sea boundary (rivers, large cities, groundwater discharge) in the material balance of the Mediterranean Sea (carbon, nutrient, contaminants) ?
- Will changes in the frequency or magnitude of extreme events lead to the dispersion or dilution of carbon, nutrients, and pollutants or, in contrast, to their accumulation in specific compartments?
- What will be the impact of changes in light radiation on biogeochemical processes, including primary production, POC-degradation processes, and degradation of DOM and pollutants?
- What is the actual rate of change of both temperature and pH in the Mediterranean Sea? How will these variables evolve and impact the Mediterranean solubility pump? What impacts will they have on the functioning of pelagic and benthic Mediterranean ecosystems?
- Will the functioning of mesopelagic and deep sea Mediterranean ecosystems be strongly affected by changes originating from surface ecosystem production and vertical fluxes or by changes in the hydrodynamics of the intermediate and deep waters?
- As the surface seawater warms, will the planktonic community of the pelagic ecosystem become dominated by nanophytoplankton and jellyfish, as suggested by several recent studies?

Such questions require international, multidisciplinary, and large-scale research investigations at different temporal and spatial scales. Priority should be given to reassessments of the budgets of C, N, P, Si in their mineral, organic, dissolved, and/or particulate forms and on characterization of their primary fluxes; this information will permit understanding, via modelling, of the past and future evolution of these elements. The sensitivity and responses of key

pelagic and benthic species to changing environmental factors, changes in the community structures of trophic food webs, the functioning and adaptation of marine ecosystems to changing environmental factors and their feedback on biogeochemical cycles should be explored. It is also crucial to study the transfer and transformation of biogenic material from rivers through the coastal zone to the open sea, on a regular basis and during extreme events. In that frame, potential fate and impact of submarine groundwater, in additions to that of rivers, should be considered. The fates of carbon, nutrients and contaminants in marine ecosystems should similarly be studied using an end-to-end point of view. The impact of urban areas on marine ecosystems should also be understood. Finally, assessments of the following key natural and anthropogenic air-sea interactions need to be completed: gas fluxes and acidification, atmospheric nutrient and particle inputs, and solar radiation. Improved knowledge of species' distributions over the entire Mediterranean is also necessary and such knowledge demands studying not only species' presence or abundance but also their chance of survival, conditions for growth and reproduction, and successful habitats in each ecosystem.

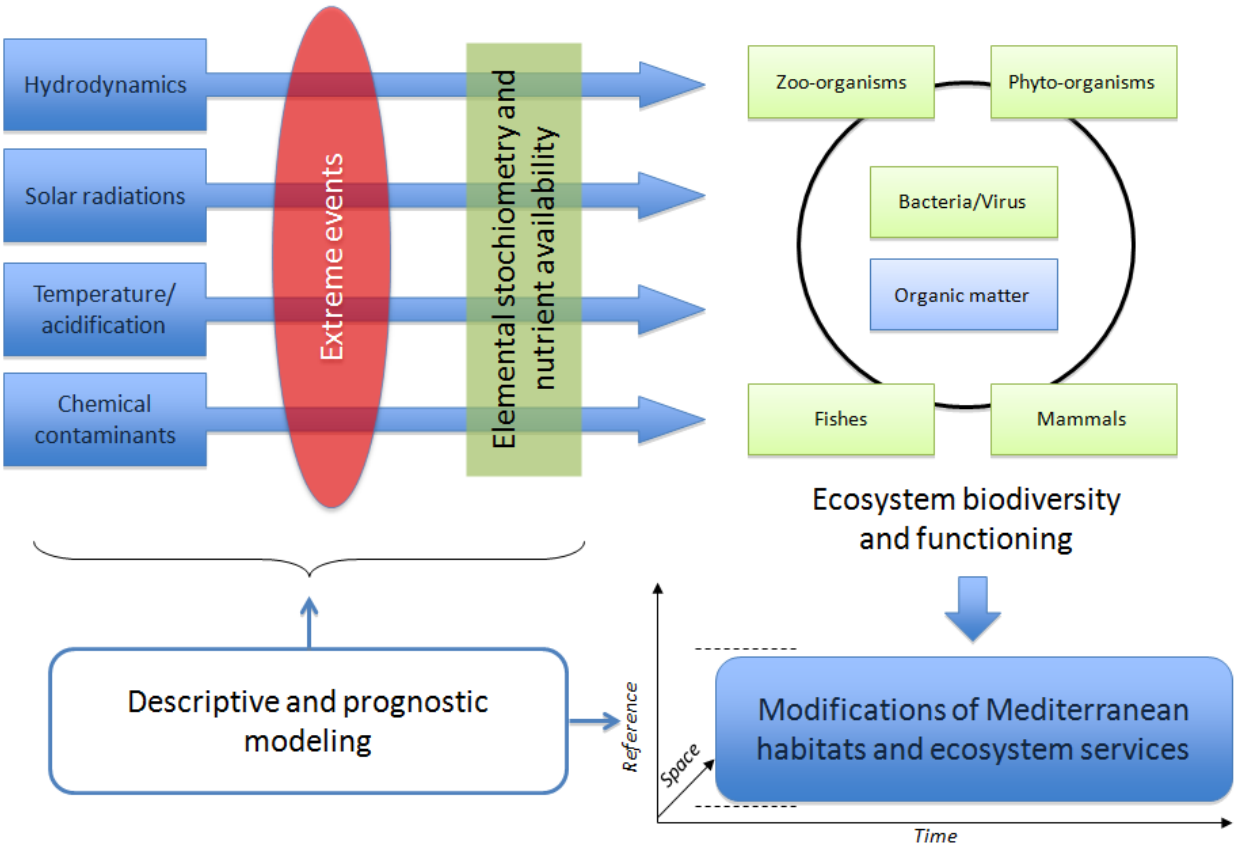

Figure 1. Schematic of the key forcing variables influencing the marine ecosystems' diversity and functioning, and use of modelling as an integrative tool at the intersection of the different objects considered in MERMEX.

4. GENERAL ORGANISATION

The goal of the Mermex project is to gather the scientific community interested by the understanding of the impacts of multiple natural and anthropogenic pressures on Mediterranean marine ecosystems. MerMex strategy is defined by the coordinators as well as the executive and the scientific committees (currently being formed) and was mainly built on the MerMex review article. The project is divided into several thematic approaches that were grouped into five work packages (WP) namely 'Impact of hydrodynamic changes on Mediterranean biogeochemical budgets' (WP1), 'Ecological processes; biogeochemistry and food web interactions (WP2), Land-ocean interactions including extreme events (WP3), Natural and anthropogenic air-sea interactions (WP4) and Ecosystem based management (WP5) (Fig. 2). Each WP is led by 2-3 coordinators and includes several actions that should be funded through different funding agencies [MISTRALS (presented in this document) ANR, FRB, UE...].

Coordinators

- **Xavier Durrieu de Madron, DR2 CNRS,** CEFREM, CNRS-Université de Perpignan *Via* Domitia, 66860 Perpignan, Tel : +33 (0)4 68 66 22 48, Email : demadron@univ-perp.fr

- **Cécile Guieu, DR2 CNRS,** LOV, CNRS-Université Pierre et Marie Curie, 06238 Villefranche-sur-Mer, OSU Villefranche/Mer, Tel : +33 (0)4 93 76 39 95, Email : guieu@obs-vlfr.fr
- **Richard Sempéré, DR1 CNRS,** LMGEM, CNRS-Université de la Méditerranée, 13288 Marseille Cedex 9, OSU COM, Tel. : + 33 (0)4 91 82 92 12, Email : richard.sempere@univmed.fr

Executive committee

The responsibilities of the executive Committee for MerMex (EC-MerMex) are to establish the implementation of MerMex by defining the scientific priorities of the different actions and by ensuring the transversality between the different WPs. EC-MerMex, which some of the members are also involved in CharMex and HyMex ensure the link and facilitate cooperation, with MOOSE as well as with CharMex and Hymex. In 2011, the EC-MerMex should also strongly cooperate with BiodivMex. Note that previous joint meetings between MerMex, CharMex and HyMex representatives gave rise to (1) selection of common observations stations (Frioul Island off Marseille city and Ersa, Corsica) and (2) common research actions (between CharMex/MerMex-WP4 and HyMex/MerMex-WP2). The Officers of the EC-MerMex are the coordinators and the WP leaders. EC-MerMEx is led by the coordinators and meets once a month by using video conferencing system.

MerMex : Composition of the Executive Commitee	
Coord.	Cécile Guieu (guieu@obs-vlfr.fr) Xavier Durrieu de Madron (demadron@univ-perp.fr) Richard Sempéré (richard.sempere@univmed.fr)
WP1	Claude Estournel (claude.estournel@aero.obs-mip.fr), LA/OMP Toulouse Fabrizio d'Ortenzio (dortenzio@obs-vlfr.fr), LOV/OSU Villefranche/Mer Pascal Conan (conan@obs-banyuls.fr), LOMIC/OSU Banyuls
WP2	Capucine Mellon (Capucine.Mellon@ifremer.fr), EME/CRH Sète, IFREMER, IRD, Montpellier 2 France Van-Wambeke (van-wambeke@com.univmed.fr), LMGEM/COM, Marseille François Carlotti (francois.carlotti@univmed.fr), LOPB/COM, Marseille
WP3	Christophe Rabouille (christophe.rabouille@lsce.ipsl.fr), LSCE/IPSL, Gif/Yvette Olivier Radakovitch (rada@cerege.fr), CEREGE, Aix en Prov.
WP4	Frédéric Gazeau (gazeau@obs-vlfr.fr), LOV/OSU VIllefranche/Mer Karine Desboeufs (Karine.Desboeufs@lisa.univ-paris12.fr), LISA/IPSL Paris Marc Mallet (Marc.Mallet@aero.obs-mip.fr), LA/OMP Toulouse
WP5	Philippe Koubbi (koubbi@obs-vlfr.fr), LOV/ OSU Villefranche/Mer Stéphane Gasparini (gasparini@obs-vlfr.fr), LOV/ Villefranche/Mer

Scientific committee

This committee is currently being formed. The responsibilities of the Scientific Committee (SC-MerMex) will be to develop and prioritize specific plans for the program, to guide its implementation, in particular for the international aspects. The SC-MerMex will promote the coordination of the national and international activities and should contribute to define a common strategy for the study of the whole Mediterranean Sea. SC-MerMex will ensure liaison, and facilitate cooperation, with others MISTRALS programs and with other international organizations including IGBP-IMBER, IGBP-SOLAS and other Mediterranean programs, such as EuroARGO (EuroSITES et EMSO, European Glider Observatories) as well as the UE program such as Perseus (submitted to FP7). The Officers of the SC-MerMex are:

- MISTRALS representative
- MerMex coordinators
- INSU/INEE/CNRS, IRD, IFREMER, IRSN, Meteo France, CNES representatives
- MOOSE, CharMex, HyMex programme coordinators
- Although collaboration in the frame of MerMex with several foreign scientists have been established, final decision on the composition of the SC-MerMex regarding foreign participants will be taken following the MISTRALS Malta International Workshop early in April 2011. The Scientific Committee shall meet at least once a year with the frequency determined by the Committee.

International Positionning

MerMex should not stay a national initiative and aims to establish links with other countries in order to define a common strategy for Mediterranean research. Links have been established with scientists from different Mediterranean countries during different international meeting and following MerMex invitations in France. Indeed, MerMex has been internationally launched at the Marseille international meeting in July 2010, where several foreign scientists (Libanon, Israel, Marocco, Algeria, Italia, Spain, Spain and Greece) have been invited. In addition, MerMex has been invited to present the project, during plenary session at the CIESM (2010), at IMBIZIO II Crete (2009), and at ASLO Nice (2009) international congress (where the coordinators were co-conveners of a MERMEX-CIESM session) whereas our members directly presented MerMex in Essaouira Marocco in 2010 (C. Rabouille) in Napoli Italia (C. Guieu, F. D'Ortenzio) in Tunis in 2011 (B. Ollivier), in Palma Spain in 2009 (R. Sempéré). Several actions proposed in MerMEx are part of the FP7 Perseus proposal (under evaluation) and the success of Perseus will allow a step forward the actual internationalization of MerMex. Largely based on MerMex project, an IRD 'laboratoire mixte international (LMI)' between Tunisia and future MIO laboratory is currently in preparation and should be submitted in 2011. MerMex recently applied (March, 2011) to IGBP programs IMBER and SOLAS for endorsement. The project will be presented to IMBER meeting in Marseille (April 2011). Similarly, coordinators of MerMex will apply to the network of excellence Eur-Oceans (C. Guieu and R. Sempéré and their laboratories are already EurOceans members) for workshop organization and summer schools.

Science outreach

One mission of MerMex is to educate the public about the importance of the vulnerability of the Mediterranean Sea ecosystems and biodiversity, including ecosystem functioning, specific biological species, pollution and hydrology. One member (Katherine Walch, COM Marseille, in relation with coordinators) will be in charge of communication and will ensure communication at regional and national level. MerMex organizes suitable outreach activities such as conferences on Mediterranean Oceanography. Several public presentations of the MerMex program have been already given [C. Guieu, Année de la Terre, Marseille, 2009; R. Sempéré, Institut Méditerranéen de Recherche Avancée (IMERA) 2009 and Ecole Doctorale des Sciences de l'Environnement (Aix en Provence 2011)] and will be continued in the future. Additional information dealing with Mediterranean Oceanography will be provided from the MerMex web site in 2011.

5. ORGANISATION OF MERMEX IN WORK PACKAGES

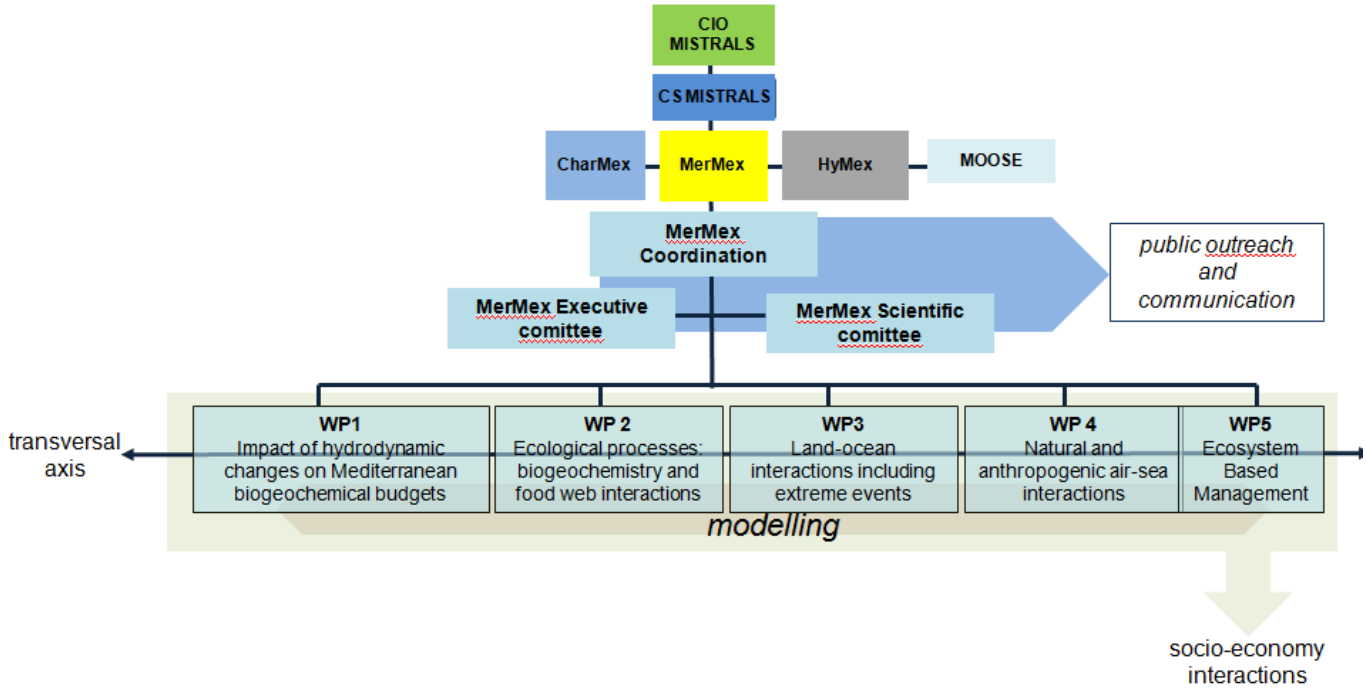

Figure 2: Organization of MerMex in relation with MISTRALS program. MerMex comprises executive and scientific committees, 5 work packages, several transversal actions and one transversal modelling approach (in addition to specific modeling aspect inside each WP).

Most of the studies will be based on the combination of *in situ* observations, laboratory and *in situ* experiments, and numerical modelling. Interactions between pressures and processes will be addressed. Observations will be used for the improvement and validation of the coupled models.

Budgets: Dedicated campaigns to assess the biogeochemical budgets in specific regions are planned. They are necessary components coupled with long-term observing systems and modelling to consider realistic modelling at regional scale.

Processes: Parameterizations of the processes that govern the biogeochemical cycles and ecosystems will be addressed. New observations at key locations and periods (productive spring period and oligotrophic summer period) will be made.

Experimental studies: A variety of experimentation in the laboratory (e.g., chemostat experiments under controlled atmosphere, light and temperature, including selected species or functional groups) and field studies in large mesocosms, including natural communities) and field studies in large mesocosms will be conducted to parameterize the changes in some processes associated to specific forcing (e.g., acidification, atmospheric inputs).

Modelling: Coupled models will be studied to simulate assess of the current and future trophic regime of the Mediterranean Sea considering different scenarios (e.g., those developed for the Marine Strategy Framework Directive to reach the Good Environmental Status by 2020). These models aim at (1) representing complex situations with multiple natural or anthropogenic pressures, and (2) responding to a broad spectrum of issues ranging from functional aspects (e.g., capacity of ecosystems to sequester carbon) to influence of contaminants along the food chain.

6. GENERAL PLANNING

The project is presented for the 2011-2014 period, as ANR and European proposals submitted in early 2011 will run for 4 years (until 2015) if they are accepted. In this proposal, we present research actions of each WP as well as a short description of the projects for which funding is requested to MISTRALS (see ANNEX). *The provisional budget for 2014 is only indicative as several actions within and between WPs are 'in project' and will develop in the coming years.* Budgets and budget projections for 2012 and 2013 are more robust and illustrate well the rise of the MerMex project. Some actions already started in 2010, with partial (ex. MerMex-Cascade, MerMex Rivers) or no (SceciMed) funding from MISTRALS. The extension of the objectives of the MerMex project will be discussed and considered within three years. The requested budget to MISTRALS is to start or continue actions that have been evaluated prioritary by the EC-MerMex.

Budgets and evolution of nutrient and some contaminants of the Mediterranean at the scale of the basin will be studied in the **WP1** through observations (in relation with MOOSE Observation program and Hymex) data analysis and modelling. Selected strategy is based on the different trophic functioning defined by D'Ortenzio and D'Alcala (2009). Main WP1 action deals with the effects of dense water formation on biogeochemical cycles (DoW-Ex action) and should start in 2012. WP1 will benefit from NAOS Equipex project (F. D'Ortenzio), which plans to deploy more than 50 biogeochemical profiling floats starting in 2012 in the whole Mediterranean area. Note that efforts in WP1 will be shared with FP7-Perseus (submitted). WP1 activity will provide a large scale-interannual scale framework for the others MERMEX actions, particularly by developing a reference model on the basis of the DoW-Ex, NAOS and Hymex observations. For this reason, timing is a crucial issue, as these two last operations are planned for 2012-2013. The reference model will be the base for further and ameliorate parameterizations developed on the framework of the others Mermex WP's (more specifically 2 and 5).

'Ecological processes; biogeochemistry and food web interactions' will be studied within **WP2**. More specifically, this WP aims to study the Mediterranean ecosystem response to environmental climatic and anthropogenic forcing in term of carbon flux intensity and in term of productivity of exploited resources (from large to small phytoplankton cells, from crustacean to gelatinous zooplankton and from large to small fishes). A significant part of this WP uses experimental approach (presently funded -2011-2012- by LEFE, EC2CO, Region and one ANR project) in order to focus in selected forcing factors on selected species (bacteria, phytoplankton, gelatinous zooplankton). Another important action of WP2 concerns a 4-year observation platform of plankton communities (MerMex-SPECIMED) at 4 stations in the Gulf of Lion, in order to develop a predictive understanding of how epipelagic communities and biogeochemical cycles will respond to the pressure of hydroclimatic and anthropogenic changes. At term, this operation should be integrated in MOOSE. Finally, the vulnerability of pelagic trophic food webs up to the main exploited resources (tuna, hake, and sardine/anchovy) will be implemented by spatial and temporal observations and

modelling (MISTRALS, ANR, FRB and UE projects). The necessity to consider of meso- and bathypelagic ecosystems is not forgotten through actions submitted to ANR, or scheduled in 2012(ERC grant).

WP3 deals with land-ocean processes including extreme events. The first action concerns the transfer and transformation of carbon, nutrients and contaminants from the rivers through the coastal zone to the open sea and its impacts on ecosystems (MerMex-Rivers and MerMex-Cascade). Such study requires satellite images from the MODIS data set and modelling and fixed observations for particle collection and current speed, oxygen and fluorescence in the Rhône River delta and near the city of Sète. Another action, which will be undertaken in second phase (following 2011) concerns the transfer and impact of contaminants through the marine food web through observation and biology-geochemical-modelling approach. The contamination pathways and spatial scale of impact of large cities (Marseille, Toulon in a first time) on the marine ecosystem will be studied in a third action. Another aspect of the WP3 concerns the characterization and quantification of the influence of the submarine groundwater discharge (SGD) on marine ecosystems.

WP4 deals with natural and anthropogenic air-sea interactions and is strongly connected to IGBP-SOLAS program and operationally connected to CharMex and MOOSE. First WP4 objective that deals more specifically with the assessment of gas fluxes (CO_2) and acidification and the impacts on ecosystems and biogeochemical cycles is strongly connected with the FP7-MedSea project and will apply for financial support for MISTRALS and 'ANR jeunes chercheurs' funding (2012). Note that such action is in line with MerMex WP3 (MerMex CarboRhone) and modelling objectives of MerMEx WP5. Assessment of fluxes of atmospheric particles to the air-sea interface and their impact on biogeochemical cycles is studied in the WP4 second objective for which 3 ANR proposals and will be presented in 2012. The influence of solar radiations on biogeochemical cycles is studied in the third WP4 objective and includes the potential effect of aerosol and tropospheric ozone attenuation on marine ecosystems. Such action started already and is largely financially supported by Conseil Géneral des Bouches du Rhône (CG13) whereas MSITRALS funding is requested in 2011 for the experimental approach and modelling of the metabolic and structural changes of the bacterial community response to the photo-transformation of dissolved organic matter.

Synthesis of data obtained from the different MerMex WPs will be used for ecosystem based management in the **WP5** which can be viewed as a transversal action based on marine regionalisation. Such task includes regionalisation based on biotic and abiotic factors followed by biogeographic regionalisation giving rise to the definition of ecoregions (by using both taxonomic and environmental data). WP5 will allow to define spatial organization as well as a functional attributes of each ecoregions and services that can be provided to society for each ecoregion. The first objective (data synthesis) comprises different actions scheduled for 2012-2015. They will be realized by gathering data from existing literature and those obtained from different running programs such as MOOSE and SOMLIT. Regionalization constitutes the core project of the second objective. Decision tools will allow the localization of sensitive areas according to their patrimonial and economical interest and summarized in maps for deciders and citizens. WP5 actions will start mainly in 2012.

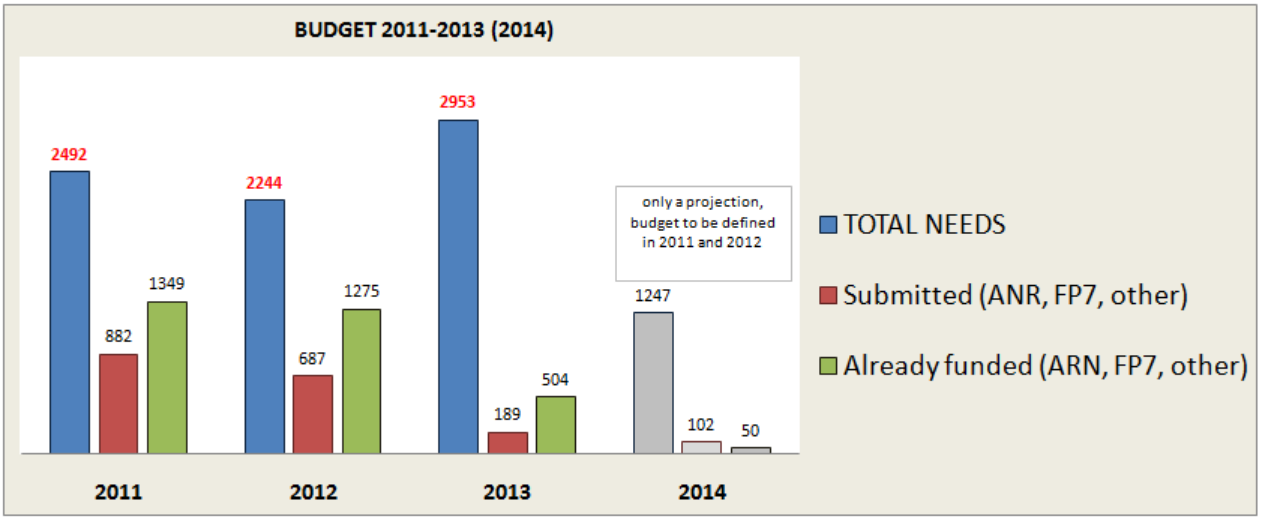

Figure 3: Total and funding plan for MerMex functioning The budget prevision for 2014 is only indicative as several actions within and between WPs are 'in project' and will develop in the coming years.

7. SUMMARY OF THE REQUIRED RESOURCES

Funding are and will be asked to different agencies (ANR, Europe, Regions) and MISTRALS. The funding requested to MISTRALS will serve mutual actions and will be dedicated to specific actions that have priority for the advancement and benefit of the whole project. Considering the limited MISTRALS funding in 2011, Priorities (1 and 2) are presented in this proposal: all the proposed action have been decided to be prioritary for 2011 in order to officially start the implementation of MerMex. For the period 2011-2013, total needs average 2.56 M€/year which is very likely the MerMex baseline funding (Figure 3). Our projections indicate that an announced MISTRALS financial support of 200 k€ will only cover 8% of the total needs of MerMex. Importantly, Figure 3 indicates that for the period 2011-2013, 3.1 M€ of research actions are already funded, suggesting active implication of the MerMex community in the project.

When considering the 2011 budget (Figure 4), it is important to notice that a significant part of the budget (17%) is requested to MISTRALS for INSU boat allowance ("ticket modérateur").

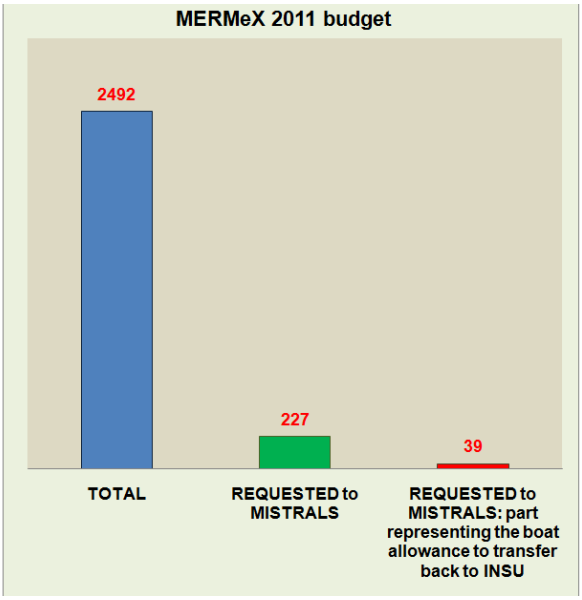

Figure 4. Total MerMex budget in 2011, part requested to Mistrals, including the part due to boat allowance that will have to be transfer back to INSU.

It is also important to note that important cut in the budget had to be done in order to go down to ~200 k€ and that in this context, it is difficult for the significant MerMex community to follow the original recommendations of INSU to 'be ambitious' and 'have large vision'. Typically, we did cut down all the budgets and in particular, for the international aspects that needs specific fundings to allow our foreign colleagues to work in our labs. In those conditions, internationalization of Mermex is a difficult – though necessary- task to accomplish.

Coordination funding

Basically, the fundings for coordinations are for (1) Meetings for coordinators (such as Malte): requested 4 k€ in 2011); (2) SC and EC meetings (a total of 5 k€). Based on our recent years experience and the generalization of use of visioconference, this mean will be used as often as possible. Funding are however necessary to organize the first EC meeting. (3) General international meetings (no funding requested in 2011): the last general meeting took place in July 2010, the followings are scheduled for 2012, 2014, no funding requested in 2011. (4) specific working group meetings: limited funds (3k€) are requested to structure the French community working on modelling in terms of biogeochemistry (Plankton Functional Types), and on trophic pelagic food webs (fish stocks dynamics). In addition to formal modelling of trophic webs, this community is interested also for modelling of spatial distribution of planktonic and pelagic organisms in relation with physical structures (mesoscale for instance, in links with larval dispersal etc…). MerMex board also aims to constitute a scientific network between modelling partners which are not necessarily involved in the same programs, but all working on Mediterranean Sea (exchange of students, post docs…) (5) Presentation by Mermex members to national and international scientific meetings: considering the limited financial support expected from MISTRALS in 2011, expenses for international meetings will be limited to 5 k€ in 2011 and most of the fundings will be obtained from laboratories resources.

Fundings: French positioning regarding 'Excellence initiatives'

Concerning French excellence initiatives, it should be notices that MerMex scientists are involved in different projects that can contribute to the success of the program. Indeed a series of autonomous platforms have been recently

obtained through the positive evaluation of the Equipment of Excellence Project (EQUIPEX; NAOS, PI ; F. D'Ortenzio LOV) and will be used in the WP1 MerMex. In addition, "Objectif Terre" Laboratory of Excellence project (Labex) in which COM/MIO partner is involved aims at the creation within multidisciplinary institute at the highest international level. This institute is currently evaluated and will be partly devoted to the study of issues concerning Mediterranean basin the environment and sustainable development and contribute to the success of MerMex. Similarly, MIO laboratory is involved in the INSU/RESOMER Equipment of Excellence project (Equipex) RIMA that will be submitted in 2011 (2nd round). RIMA project aims to the acquisition of mesocosms that, if successful should be used for MerMex.

8. SUMMARY OF THE FUNDING REQUESTED TO MISTRALS

2011		requested to Mistrals	
	total cost	Priority 1	Priority 2
Coordination (see detailed planned actions in the text above)	**17**	**17**	
WP1 (all actions)	19		
RADICAL		2	
OSMO			17
WP2 (all actions)	1003		
SPECIMED		52	9
PPNWMS		6	
TOEBTF		5	
WP3 (all actions)	693		
Mermex-Rivers		23	
Mermex-Cascade		65	
Mermex-COBEC		5	
Mermex-C3A		3	
WP4 (all actions)	774		
CARBORHONE		34	
CALIBORON		5	
PHOTOMED		10	
WP5			
no funded requested in 2011			
Total requested to Mistrals		**227**	**26**

Note: The MISTRALS funds will be managed by the LMGEM/MIO, whose director is also one of the coordinator of MerMex and transfered to WP leaders' laboratories. A 7% overhead is added to the MISTRALS contribution for the benefit of the participating laboratory for covering the "frais de gestion laboratoire"

Short description of the projects for which funding is requested to MISTRALS

ANNEX

1. Short description of the projects for which funding is requested to MISTRALS

2. Article Mermex Group, 2011 Marine Ecosystems Responses to climatic and anthropogenic forcings in the Mediterranean. Progress in Oceanography, In Press.

Other projects (such as those submitted to ANR) can be seen on the MERMEX web site (restricted access to the CS MISTRALS)

Sommaire

1. Annex WP1

ACTION MERMEX : **DoW-Ex:** Dense Water Experiment

Participants : noms, laboratoires, tâches/compétences

Pascal Conan	LOMIC	biogeochemistry
Fabrizio D'Ortenzio	LOV	physical biological interactions
Claude Estournel	LA	hydrodynamic modelling
Pierre Testor	LOCEAN	physical oceanography
Vincent Taillandier	LOV	autonomous platforms
Caroline Ulses	LA	biogeochemical modelling

Main objectives :

Phytoplankton blooms in the Mediterranean Sea are intrinsically tied to deep and bottom water formation (D'Ortenzio and Ribera d'Alcalà, 2009). The ubiquitous oligotrophy of the basin derives by the upper layer density stratification, which is primarily induced by the eastward flow of the Atlantic Water and by the relatively weak atmospheric forcing. However, in the regions where deep water formation occurs, the preconditioning mechanisms (i.e. large scale cyclonic circulation) and the intense mixing induced by local atmospheric conditions strongly increase the nutrients uptake in the surface layers, generating favorable conditions to phytoplankton growth.

The most important bloom of the basin is recurrently observed in the NW Mediterranean Sea, (Bosc et al. 2004). Bloom starts at the end of winter, when density restratification occurs and, consequently, the injected nutrients could be exploited by phytoplankton. As in all temperate areas, the evolution of the mixed layer depth and its convolution/forcing of nutricline, likely explains most of the biogeochemical variability of the region.

In the NW Mediterranean, although the general mechanisms are relatively well elucidated, the relationship between bloom and mixed layer depth (and more particularly deep convection) is still unclear. The simple equation "more convection equals more phytoplankton" is probably misleading.

Firstly, the impact on the bloom of the mesoscale processes, which have certainly a key role in modulating the nutrients redistribution after deep convection events (Levy et al. 1998), is still poorly characterized. More importantly, the characterization of the "history" of the water column and of the mixed later depth, from the first cooling occurring in fall to the definitive restratification at the end of winter, is probably a crucial factor to establish more robust cause-effect relationships between the physical forcing and the phytoplankton response in the area (Auger, 2011).

The DoW-EX experiment proposes to fill this gap, using an integrated combination of autonomous platforms, in situ ship's sampling and modeling. The central idea of Dow-Ex is to continuously sample at mesoscale the evolution of the mixed layer and of its biogeochemical material content over the whole NW Mediterranean area and for a complete seasonal cycle, in order to directly associate the "key" bloom events (i.e. its upset and decay) to the forcing mechanisms occurring in the area all along the year.

Implementation (observations at sea, experiment/ modelling):

Monitoring a large sub-basin as the NW Mediterranean Sea for a whole seasonal cycle is virtually impossible with "classical" strategies. The approach proposed by Dow-Ex is based on a four integrated and hierarchical actions: integrated as they share the parameters and the general objectives; hierarchical as the most informative actions will be performed during key periods whereas the less informative operations will be used to maintain observations between them. More specifically:

"Large" Cruise: a one month classical cruise will be carried out in February-March 2013 in the NW Mediterranean Sea, with a relatively resolved station plan and a complete sampling of ecosystems parameters (i.e. nutrients, organic matter, Chlorophyll, bacterial diversity, primary and bacterial production, pigments, plankton diversity and abundance). Main objective of the "Large" cruise is to retrieve a picture as much complete as possible of the state of the basin at the end of the winter and of the ecosystems structure at the bloom upset. The "Large" Cruise is the main operation of Dow-Ex.

"**Light" Cruises**: two 15 days-long cruises will be carried out in September 2012 and in June 2013 in the NW Mediterranean. Main objective is to obtain information on the physical and biogeochemical conditions of the area at two key moments of the seasonal cycle: September, when the destratification process increases mixed layer depth starting to homogenize nutrients in the water column; June, when stratification of the water column is well established and oligotrophy and ultraoligotrophic condition are established. They will also allow to define and characterize roughly the physical and biogeochemical conditions of the region, to furnish two observational milestones to anchor autonomous and modeling actions.

"**Autonomous" monitoring**: 8 biogeochemical gliders and 5 (+5) profiling floats will be deployed to survey the area during the winter/fall interval between the September "Light" Cruise and the February "Large" Cruise. Equipped with physical sensors, autonomous plateforms will permanently and intensively monitor the area, allowing to reconstruct the "history" of the water column during the whole period fall/winter. Additionally, biogeochemical sensors on gliders and profiling floats (i.e. Chl, CDOM, NO3, Irradiance, Oxygen) will offer a complete picture of the spatio-temporal evolution of the biogeochemical dynamics of the area, and its coupling with the physical one. Integrated with ocean color and infrared satellite sensors, "Autonomous" monitoring will generate a complete picture of the evolution of the physical environment and on the basic ecosystems parameters between the "Light" Cruise of September and the "Large" Cruise of February.

Finally, a coupled hydrodynamic ecosystem **modeling** approach in Dow-Ex will allow integrating the whole observational effort in a single framework (hydrodynamic model SYMPHONIE (Marsaleix et al., 2008) running at about 1km resolution, coupled with a biogeochemical model (Auger et al., 2011). The impact of convection on the planktonic ecosystem has been extensively studied with modelling (PhD of P.A Auger) but a number of points need to be checked with observations. Simulations outputs will be also intensively exploited before the experimental periods to better plan the sampling strategy (definition of the gliders trajectories and/or the profiling floats deployment area)s. Atmospheric forcing, key point of the modelling, will be completely characterized by an intense survey planned in the Hymex project framework mainly based on numerous measurements of air/sea parameters.

Duration :

The core period of the Dow-Ex experiment will be the fall/winter/spring 2012-2013. This year has been selected because of the Hymex initiative which plans to carry out an intense survey of the ocean and atmosphere mixed layers and air/sea fluxes in the NW Mediterranean area. Moreover, the Equipex NAOS project planned to deploy the first 5 Mediterranean profiling floats in 2012.

Timing then is extremely favorable, allowing sharing huge resources between Hymex, NAOS and Dow-Ex (see table).

Expected outcomes:

The "Large" cruise will be a "classical" cruise, with a relatively resolved station plan and a complete sampling of ecosystems parameters (i.e. nutrients, organic matter, Chlorophyll, bacterial diversity, primary and bacterial

production, pigments, plankton diversity and abundance). The innovative approach of Dow-Ex, based on the massive use of autonomous platforms, will allow interpreting the “Large” Cruise observations on the basis of the observed and reconstructed (i.e. modeling) “history” of the water properties and contents (physical and biogeochemical) in the area. The “Light” Cruises will allow to define and characterize roughly the physical and biogeochemical conditions of the region, at begin and at the end of the seasonal cycle, in order to furnish two observational milestones to anchor autonomous and modeling actions.

Dow-Ex experiment will furnish a complete observational framework to explore the role of the physical forcing and of its main processes in the area, the deep convection, on the phytoplankton bloom and, all along a complete seasonal cycle, with a particular emphasis on the fall/winter period.

Fundings :

Europe/ANR	Region/University	Mistrals	Europe/ANR	Region/University	Mistrals
			200 (Equipex NAOS) 120 (Hymex) **96 (MOOSE)** 60 (PERSEUS modelling)		81,5
2013			2014		
Europe/ANR	Region/University	Mistrals	Europe/ANR	Region/University	Mistrals
250 (Equipex NAOS) 160 (ANR Claude)		91,5			

Nature de la dépense	Coût année 1 (en K€)	Coût année 2 (en K€)	Coût année 3 (en K€)	Coût année 4 (en K€)
Fonctionnement		55,5	55,5	
Missions + Stage		11	21	
Equipment				
Ticket Modérateur		15	15	
Total		81,5	91,5	

2. Annex WP2

WP2 - Action 2.1

MERMEX ACTION: **SPEciMed** – Structures of Planktonic Ecosystems in the North-western Mediterranean

Participants:

FRANCE

QUEGUINER Bernard, LOPB (Université de la Méditerranée), Coordinator and cruise chief scientist, Responsible for phytoplankton,

CARLOTTI Francois, LOPB (Université de la Méditerranée), Coordinator and Cruise chief scientist, Responsible for zooplankton and plankton size-spectrum modelling,

BLAIN Stéphane, LOMIC (Université de Paris VI), Coordinator for Banyuls/mer, Cruise chief scientist, Responsible for biogeochemical data acquisition,

OBERNOSTERER Ingrid, LOMIC (Université de Paris VI), Cruise chief scientist, Responsible for bacterial diversity,

ZHOU Meng, LOPB (Université de la Méditerranée), Responsible for towed captors and integration of physical and biological data and modelling,

DEVENON Jean-Luc, LOPB (Université de la Méditerranée), Cruise chief scientist, Responsible for towed captors and integration of physical data and modelling,

DOGLIOLI Andrea, LOPB (Université de la Méditerranée), Cruise chief scientist, Responsible for turbulence measurements,

PETRENKO Anne, LOPB (Université de la Méditerranée), Cruise chief scientist, Responsible for turbulence measurements,

PAIRAUD Ivane, IFREMER (Centre de Méditerranée), Responsible for ADCP implementation and satellite data,

PAGANO Marc, LOPB (Université de la Méditerranée), Responsible for mesozooplankton,

LEBLANC Karine, LOPB (Université de la Méditerranée), Cruise chief scientist, Responsible for biogeochemical data acquisition,

CHRISTAKI Urania, LOG (ULCO), Responsible for nanoflagellates and microzooplankton,

BOTHA Delphine, LOPB (Université de la Méditerranée), Responsible for gelatinous zooplankton,

DIAZ Frederic, LOPB (Université de la Méditerranée), Responsible for biogeochemical data integration and modelling,

PINAZO Christel, LOPB (Université de la Méditerranée), Responsible for biogeochemical data integration and modelling,

SALTER Ian, LOMIC (Université de Paris VI), Cruise chief scientist, Responsible for biogeochemical data acquisition,

VUILLEMIN Renaud, LOMIC (Université de Paris VI), Cruise chief scientist, Responsible for biogeochemical data acquisition,

BANARU Daniela, LMGEM (Université de la Méditerranée), Responsible for ichtyoplankton

HARMELIN-VIVIEN Mireille, LMGEM (Université de la Méditerranée), Responsible for ichtyoplankton

GREGORI Gérald, LMGEM (Université de la Méditerranée), Responsible for flow cytometry studies (Marseille sites),

VAN WAMBEKE France, LMGEM (Université de la Méditerranée), bacterioplankton studies (Marseille sites).

BELGIUM

GOFFART Anne, Laboratoire d'Océanologie (Université de Liège), Coordinator and cruise chief scientist (Stareso Marine Station, Corsica), Responsible for phytoplankton,

HECQ Jean-Henri, Laboratoire d'Océanologie (Université de Liège), Cruise chief scientist (Stareso Marine Station, Corsica), Responsible for zooplankton,

GOBERT Sylvie, Laboratoire d'Océanologie (Université de Liège), Cruise chief scientist (Stareso Marine Station, Corsica).

ALGERIA

SERIDJI Rabea, Laboratoire d'Ecologie et Environnement, Equipe d'océanologie (USTHB Alger), Coordinator for Algeria,

TOUHARIA Tarik, Laboratoire d'Ecologie et Environnement, Equipe d'océanologie (USTHB Alger), Cruise chief scientist, Responsible for phytoplankton,

HAFFERSSAS Aziz, Laboratoire d'Ecologie et Environnement, Equipe d'océanologie (USTHB Alger), Responsible for mesozooplankton,

Annex WP2

TUNISIA

DALY Nejib, Faculté des sciences de Bizerte, Coordinator for Tunisia, Responsible for zooplankton,

DALY YAHIA Ons, Faculté des sciences de Bizerte, Responsible for phytoplankton,

Main objectives:

SPEciMed is designed as a part of MISTRALS to be included to MERMEX in medium-term strategy of Enhanced Observing Periods (EOPs). In comparison with Long Observation Periods (LOPs) implemented in the framework of MOOSE (Mediterranean Ocean Observation multi-Sites on Environment), SPEciMed positions itself as an EOP designed to meet its specific scientific goals. MOOSE will benefit from SPEciMed results for its strategy implementation of long-term monitoring of biological parameters.

The rapid development of the Mediterranean basin had significant positive impacts on living standards of people but it was largely achieved at the expense of environmental balances essential to human well-being. With increasing anthropogenic pressure, the Mediterranean basin has now become an endangered environment both in terms of its ecological balance and exploitable resources and of its water systems that sustain its activities. Regarding the marine environment, despite the intensive research efforts undertaken in the Mediterranean Sea for over a century, an integrated vision of how its ecosystems function is still lacking. Yet this knowledge is indispensable to meet the expectations of the Mediterranean basin development and sustainable management issues it raises.

In the north-western Mediterranean (NWM), studies on the impact of climate on plankton communities are limited by the small number of long time series data. Nevertheless, few studies have addressed the question of the long-term drift in composition and dynamics of plankton. A long-term evolution of phytoplankton communities has been at least detected in several places of the French NWM coast, e.g. at DYFAMED station and especially in the Gulf of Lions (GoL), during the research projects EC2CO/GolPhyZ and the ongoing EU/SESAME partly devoted to plankton series data mining. The decadal variability of coastal phytoplankton in the Bay of Marseille from 1994 to 2006 suggests a close link to the North Atlantic Oscillation (via processes that still need to be assessed at the mechanistic level), a possible regime shift in the years around 1999, as well as signs of biodiversity loss.

The Mediterranean Sea is often compared to the World Ocean given its thermohaline anti-estuarine circulation. It is also characterized by an eastward gradient of oligotrophy associated with a succession of different plankton communities. Therefore it is difficult to observe the evolution of the Mediterranean as a whole. Even if trends can be predicted using numerical models, these must be validated continuously in view of ongoing climate change. Therefore, the regional level appears appropriate. At first glance, the NWM basin is a mosaic of nested ecosystems offering similarities with the general situation of the World Ocean: An estuary at the mouth of a great river, the Rhône River, which brings locally large nutrient loads on a continental shelf, the GoL, and a coastal current, the Northern Current (NC), which separates the land-to-ocean aquatic continuum from an oligotrophic gyre. The two other sites, in Tunisian and Algerian waters, are representative of the south-western Mediterranean (SWM) coastal waters influenced by anthropogenic inputs. Therefore we expect to better characterize the taxonomic and size spectra distributions of planktonic communities in 4 of the Mediterranean ecosystems types identified by d'Ortenzio & d'Alcala (2009), *i.e.* blooming, intermittently blooming, non-blooming and coastal regions.

Implementation

SPEciMed aims at establishing a 4-year observation platform of plankton communities incl. bacteria, phyto-, microzoo- and mesozooplankton and associated biogeochemical cycles of major elements (C, N, P, and Si). As a step towards operational management of marine ecosystems SPEciMed will develop a predictive understanding of how marine biogeochemical cycles and ecosystems respond to changing forcings, including how large-scale climatic variations impact regional ecosystems quantitative functioning through the changing physical dynamics and the alteration of biogeochemical cycles.SPEciMed relies on the joint expertise of oceanographers from the fields of physics, chemistry and biology to comprehend the whole reactional continuum ultimately controlling the response of ecosystems.

The 4-years project relies on the existing SOMLIT coastal stations of Marseille (SOFCOM) and Banyuls/mer (SOLA) and will implement the two shelf stations JULIO (SE entrance of the GoL) and MOLA (SW exit). Implementation also concerns the SOMLIT stations for new parameters of biodiversity observation (bacteria, phytoplankton, and zooplankton). In addition, following the dialogue with the PI of MOOSE, we plan to associate the examination of samples taken on the two sites: Antares and 42°N/5°E. Specific objectives assigned to SPEciMed include the establishment of a multi-sites plan of joined observations relying on the OSUs of the GoL, the implementation of modern methods of investigation to describe the temporal evolution of the coast-shelf continuum (moving vessel profilers equipped with *in situ* particle analyzers – LISST, LOPC, CTD –, *en route* shipboard measurements – fluorescence, flow cytometry, ADCP, CT –, discrete continuous vertical measurements at stations – LOPC, LISST, fluorescence, CTD, SCAMP), and the development of a coupled physical-biogeochemical modelling approach as a predictive tool for the temporal evolution of disturbed ecosystems.

The initial strategy rests on monthly visits using the ships of stations (Néréis and Antedon, 8 times/year over two days) and of the regional ship Tethys II (4 times/year over three days for a complete transect including the 4 sites of study in the GoL). This strategy wants to be evolutionary and a more important use of Tethys II should not be discarded. In parallel, SPEciMed wishes to gradually initiate the same type of approach in other Mediterranean sectors (Nice-Calvi transect in collaboration with the Université de Liège, transfer of competences towards the University of Bizerte then the University of Algiers, with which co-operations have been in progress with the LOPB for a few years).

The data obtained by SPEciMed will be transferred in a data base which will have to be organized within the national framework of LEFE/CYBER. The organization of the base which will include physical, biogeochemical, and "taxonomical" data, will integrate in particular the reflexion carried out within the framework of the RNSLM (Réseau National des Laboratoires et Stations Marines).

Duration:

60 months (2010-2014). The project already received a positive review in 2010 and started in May 2010. SPEciMed has not received any funding in spite of a formal approval of the project.

Table : Funding

Type of expenditure	2011	2012	2013	2014
Consumables / Analyses	31.9	31.9	31.9	31.9
Missions / Meetings	14.0	3.5	5.0	5.0
Equipment				
Allowances for Master students	10.0	10.0	10.0	10.0
Ship costs (ticket modérateur)	16.6	23.1	23.1	23.1
Personnel	41.0	41.0	41.0	41.0
TOTAL	113.5	109.5	111.0	111.0
Requested to MISTRALS (P1)	52	68.5	70	70
Requested to MISTRALS (P2)	41	20.5	20.5	41
Acquired (Recif Prado)	20.5	20.5	20.5	

Annex WP2

Justification of funding

Technician salary for : ‘Counting and identification of microplankton and mesozooplankton organisms’

The technician will support the identification and counting of microplankton and mesozooplankton. This work will be done by microscopy and image analysis at LOPB and will, from established protocols, to determine the concentrations of organisms of the major taxa encountered, assess their biomass from allometric relations to establish, and document identified communities from microphotography. The technician will also support recording results and observations, digital media, in accordance with established procedures of LOPB.

This position is already partially funded (50% incl. by the Region/University) for 2011, 2012 and 2013 by a contract between LOPB and the city of Marseille as part of the study of biological impact of artificial reefs located in the Bay of Marseille (‘Récifs Prado’ program). The extra 50% are required, if possible from MISTRALS, to cover the annual wages (priority P2).

For 2011, in addition to the half salary necessary (20.5 k euros), the missions/meetings asked for internationalisation of the project (12 k euros) as well as few requests for consumables have been also classified in P2 priority.

NB : Dealing on equipment, note that MVP has been bought by IFREMER and COM with funding of CETSM. First test will start in March 2011. Other specific equipments (SCAMP, LISST, LOPC) have been recently acquired by COM-MIO.

Annex WP2

WP2 - Action 2.2

MERMEX ACTION: **PPNMWS** : Pelagic production in the North Western Mediterranean Sea

Participants:

CAPUCINE MELLON : IFREMER, UMR EME (Sète). Co-coordinator of the project, hake specialist, trophic foodweb

FRANÇOIS CARLOTTI : LOPB (Université de la Méditerranée), Co-coordinator of the project, Responsible for zooplankton and plankton size-spectrum modelling

ISABEL PALOMERA: CSIC (Barcelone). Co-coordinator of the project, small pelagic fishs in the Catalan Sea and gulf of Lions

DAVID ROOS: IFREMER, UMR EME (Sète). Small pelagic fish in the gulf of Lions

Miguel Bernal: CSIC (Barcelone). Responsible for small pelagic in the Catalan Sea and gulf of Lions

JEAN-MARC FROMENTIN: IFREMER, UMR EME (Sète). Blue-fine tuna specialist, statistical analyses.

ANGELIQUE JADAUD: IFREMER, UMR EME (Sète). Hake fishery in the gulf of Lions.

ENRIC MASSUTI: ESPAGNE (IEO), Hake and small pelagic fishery in the Balears.

BERNARD QUEGUINER : LOPB (Université de la Méditerranée), Responsible for phytoplankton and nutrients

DANIELA BANARU : LOPB (Université de la Méditerranée), Trophic foodweb.

FREDERIC DIAZ : LOPB (Université de la Méditerranée). Biogeochemical data.

MIREILLE HARMELIN-VIVIEN : LMGEM (Université de la Méditerranée), Trophic Ecology.

PIERRE GARREAU : IFREMER (BREST). Physical model.

Main objectives :

In the NW Mediterranean Sea, anchovy and sardine are the most important small pelagic fish in term of biomass and commercial interest. Their significant biomass at intermediate levels of the food web plays a fundamental role connecting lower and upper trophic levels. High level predators like hake and bluefine tuna feed on these species. Consequently, their fluctuations due to fishing or environmental factors can impact considerably structure and functioning of whole ecosystem where they live. They are caught by purse seines and bottom trawls by Spanish fleets operating in the Balearic and Catalan Sea and by mid-water trawls by the French fleet operating in the Gulf of Lions. Recently, very low levels of landings of both species were observed. Scientific surveys carried out by French and Spanish Institutes in the three areas indicated that abundance of both species decreased a lot from several years suggesting that environmental factors may be involved. Consequently, such a decrease in abundance of key species in the trophic web may affect abundance of their preys and their predators.

Commercial importance of these species has conditioned research priorities in both countries for long time. A long series of data are available and can be coupled with other data series like environmental factors, other biological compartment like phytoplankton, zooplankton, nutrients or predators like hake and bluefine tuna. The first step of the PPNMWS project will focus on a first analyse of available data to identify potential hypothesis on mechanisms driven the inter-annual abundance fluctuations in fish stocks observed. The highlighted hypothesis will conduct to build an ANR proposal in 2012 or 2013.

Therefore, the principal aims of the study in 2011 are to realise the links:

(i) Data analysis of seasonal plankton distributions and nutrients in relation to SPF distribution in the Gulf of Lions, the Catalan sea and the Baleares and time series on biological parameters with environmental forcings,

(ii) Built an ANR proposal for a 2012 or 2013 call based on hypothesis emerging from these data analysis

Duration:

24 months (2011- 2012).

Table : Fundings

Type of expenditure	2011	2012	2013	2014
Consumables / Analyses	1 000	1 000		
Missions / Meetings	5 000	5 000		
Equipment				
Allowances for Master students		4 000		
Ship costs (*ticket modérateur*)				
Personnel				
TOTAL Mistrals	**6 000**	**10 000**	**50 000**	**50 000**
TOTAL other (planned)			**250 000**	**250 000**

WP2 - Objective 1: Sensitivity and response of key pelagic and benthic species to changing environmental factors

MERMEX ACTION : REXBIO (reseau d'études expérimentales en biologie): (lettre d'intention)

Links : WP4 actions 1.3 and 3.2 (pCO2, acidification and UV effects on targeted organisms)

Participants :

Van Wambeke France, MIO, heterotrophic prokaryotes, OM degradation, temperature vs resource control, effect of pulsed inputs of limiting resources

Lefèvre dominique, MIO, respiration, growth efficiency, metabolic budgets

Grégori Gérald, MIO, dynamics of microbial assemblages

Leblanc Karine, MIO, pCO_2 and temperature effects, impact on phytoplankton dynamics, on silicification, on C:N:P cellular stoichiometry.

Eichinger Marie, MIO, DEB model, effect of pulsed inputs on growth efficiency and DOM degradation

Lombard Fabien, MIO, jellyfish and zooplancton dynamics

Botha Delphine, MIO, jellyfish and zooplancton dynamics

Carlotti Francois, MIO, zooplankton dynamics, stoichiometry N/P between preys and predators

Tanaka Tsunéo, LOV, microbial food web, stoichiometry N/P between preys and predators

Gorsky Gaby, LOV, zooplankton, appendicularians

Frédéric Gazeau, LOV, pCO2 and acidification impacts

Sciandra Antoine, LOV, pCO2 and acidification impacts on coccolithophorids

Christaki Urania, LOG Wimereux, microbial food web, bottom/resource control.

Joux Fabien, LOMIC, solar radiation impacts on bacterioplankton (directs vs indirects effects by photooxidation of OM, photoresistance, mechanisms of adaptation)

Main objectives :

The response to climate change can be expected to vary between functional groups and across multiple trophic levels. We propose to study sensitivity and response of key Mediterranean organisms (microbial, macrobial) to changing environmental factors (heterotrophic bacteria, phytoplankton, zooplankton, jellyfish….), trough the study of diverse key physiological parameters affected by forcing factors (for instance, growth, mortality, maintenance metabolism, calcification, egg production, growth efficiency, ectoenzyme activity…). **Specific objectives are the following**

- synergetic/antagonistic influence of forcing factors: temperature and pCO2, temperature and resources, pCO2 and resources….

- separation of direct versus indirect effects of forcing factors (for instance temperature and pCO2 can influence directly heterotrophic prokaryotes, or indirectly through changes of phytoplankton by-products, modified by impact of forcing factors on physiology of phytoplankton)

- consequence of the potential change of stoichiometry of the nutrients N/P/Si in Mediterranean Sea on predator/prey interactions examined through the quality aspect of the prey (stoichiometry in biomass)

- consequences of the expected modified phytoplankton stoichiometry on C, N and P transfer towards microzooplankton and zooplankton through the study of potential impacts on grazing, respiration, egg production, development and survival rates of juveniles and adult copepods

- consequences of the expected modified phytoplankton stoichiometry on the dissolved organic matter pools and its consequence on the quality, biodegradation rates and export of organic matter.

Implementation (observations at sea, experiment/ modelling):

Most part of this work is based on experimental work, in aquariums, batch cultures and chemostats. Modelling tool is used to focus on process study (DEB theory) and stoichiometry (ECO3M).

Duration :

The first phase 2011 and 2012 is based on individual oriented-species projects in WP2 (EC2CO DEMO2, LEFE ICARE, ANR EcoGely, program Jellywatch) for which no founding is requested to Mermex. The WP4 action 3.2 focusing on targeted species is also initiated by Mermex on a species/factor -oriented project (UV and heterotrophic bacteria, PHOTOMED) or an EU project (MedSea, WP4 action 1.3) that will end in 2014. At the same time, a new experimental platform will be built in the MIO-Oceanomed project on the campus de Luminy, Marseille, where emergent tools used by microbiologists, phytoplanktonologists and zooplanktonologists will be shared in a common facility equipped with chemostats, aquariums, rolling tanks, pCO_2/temperature/gaz/light controlled systems, continuous records with analytical instruments for nutrients, gazes, organisms. In additions with such platforms existing in Villefranche sur Mer, and chemostats, UV controlled - systems running also at Banyuls sur Mer, it will be a good opportunity to share our experience on different target species to built common more ambitious projects in ANR or EU. But before 1 or 2 intermediary years of initiative founded by Mermex would be useful in a transition phase (2013-2014).

Table : Fundings :

2011		
Europe/ANR	Region/University/INSU	Mistrals
Jellywatch en cours 150 ANR Ecogely en cours 167	LEFE ICARE en cours 7 EC2CO DEMO2 en cours 22	

2012		
Europe/ANR	Region/University	Mistrals
Jellywatch en cours 150 ANR Ecogely en cours 167	LEFE ICARE en cours 4 *EC2CO DEMO2 demandé 26*	

2013		
Europe/ANR	Region/University	Mistrals
ANR Ecogely en cours 167		*en projet 50*

2014		
Europe/ANR	Region/University	Mistrals
en projet 180		*en projet 20*

En italiques : projets demandés ou en projet

WP2- Action 2.2

MERMEX ACTION: **TEOBFT**: Trophic Ecology of Bluefin tuna in the northwestern Mediterranean Sea

Participants

Jean-Marc Fromentin: IFREMER, UMR EME (Sète). Co-coordinator of the project, statistical analyses.

Sylvain Bonhommeau: IFREMER, UMR EME (Sète). Co- coordinator of the project, statistical analyses.

Luisa Métral: IFREMER, UMR EME (Sète). Stomach Contents analyses

Blandine Brisset: IFREMER, UMR EME (Sète). Stomach Contents analyses

Capucine Mellon: IFREMER, UMR EME (Sète). Isotopes ans Stomach Contents analyses

Michel Potier: IRD, UMR EME (Sète). Stomach Contents analyses

Frédéric Ménard: IRD, UMR EME (Sète). Isotopes and Statistical analyses

Daniela Banaru: University of Marseille (Luminy). Stomach Contents analyses.

Nicolas Bierne: CNRS (station biologique de Sète). Genetic and Statistical analyses

Main objectives

The Gulf of Lions and the adjacent offshore region is one of the key feeding habitats for juveniles Atlantic Bluefin tuna in the whole Mediterranean Sea and North Atlantic. Therefore, this area has been intensively exploited by various European fleets for more a century, firstly through a bait boat fishery during the late 19th and the early 20th centuries and more recently through the purse seiner fishery. However, the strong overexploitation of this highly emblematic fish species during the last two decades has led the ICCAT commission to take strong management measure. A rebuilding plan has been established in 2007 to avoid a potential risk of collapse of this population. Among the various regulations, a major one has been to increase the minimum size limit for fishing to 30 kg which roughly corresponds to the age-at-maturity (with a tolerance for some artisanal fleet). Consequently, the northwestern Mediterranean Sea is no more exploited by the powerful purse seiner fleets (which are further submitted to a restricted fishing season) and the total catch extracted from the Gulf of Lions has decreased substantially since 2008 (by about 90%).

Scientific surveys carried out by Ifremer (through aerial spotting) indicated that higher abundance of juveniles bluefin tuna in the northwest Mediterranean could reflect the positive outcomes from this increase minimum size regulation. According to these scientific surveys, the densities of juveniles BFT in the Gulf of Lions have doubled over the last two years (2009-2010) in comparison the previous period (2000-2003). While this result is undeniably a good news for the stock-status and management of this endangered species, such an increase in abundance of this voracious and opportunistic top-predator may affect the pelagic ecosystem functioning by inducing a substantial increase in predation on small pelagic fish (anchovy, sardine, blue whiting, sprat, mackerel) and other pelagic organisms (shrimps, especially Meganyctiphanes *norvegica* , squids, pelagic crabs). This possibility has recently put forward to (partially) explain the steep decline in anchovy and sardine populations of the Gulf of Lions.

Therefore, the principal objectives of this study are to:

- Evaluate the diet composition of juvenile bluefin tuna in the Gulf of Lions through the analyses of stomach content, genetic and isotopes samples.

- Compare these estimates with information from past studies (especially those carried out by the University of Marseille during the early 2000s) to evaluate potential changes in diet composition through time.

- Compare these estimates with information from studies carried out in other feeding grounds (mostly Bay of Biscay, Adriatic Sea and Levantine Sea) to evaluate potential changes in diet composition through space/area.

- Estimate the potential predation rate of bluefin tuna on the small pelagic fish and other foraging compartments of the Gulf of Lions ecosystem.

Implementation

Collection of biological samples: To get a representative sampling, stomachs of juveniles Bluefin tuna have to be collected in different locations of the Gulf of Lions through the 3 main seasons (spring – summer – falls) and over two years. Assuming a minimum size samples of 30 fish / given temporal sample; 240 stomachs will have to be collected during the project (i.e. 40 fish * 3 seasons * 2 years). Together with the stomach, a biological sample (a piece of white muscle and liver) will be also acquired on all the fish to conduct the isotopes analyses.

Stomach Contents analyses: The identification of the different preys at the species level from stomach content is time consuming and deserves experience, but the small consortium of this project will include IRD scientists who have a large experience on the analysis of stomach contents of tropical tuna as well as scientists from Ifremer and University of Marseille having experience on the fauna of the Gulf of Lions.

The Isotopes analyses (δ13C and δ15N signatures) will be performed by an external laboratory that is specialized and well equipped for such a task (that has already worked with Ifremer and IRD teams).

The genetic analysis aims at identifying all the ingested species that cannot be detected through the standard optical procedure, especially all the species displaying a high rate of deterioration and/or do not provide hard structure, such as the jellyfish. This part of the work is important as jellyfish are suspected to provide a significant portion of the tuna diet (and other top predator such as the turtle), but this has been poorly quantified so far because of the lack of data or technique. To do so, a homogeneous sample of each stomach will be prepared and sent to a well-equipped external laboratory/plateform.

Statistical and modelling analyses: The small consortium of the project has a good expertise on bluefin tuna and a wide experience in quantitative data analysis and will therefore perform all the statistical analyses to interpret the results from stomach contents, isotopes and genetic data. These analyses will provide the diet composition and the trophic level of bluefin tuna in the Gulf of Lions and will evaluate their spatial and temporal variations. The consortium will further use ecosystem models, such as Ecopath and Osmose, to quantify bluefin tuna predation rate on small pelagics fish and other key forage species in this area.

Duration:

24 months (mi 2011- mi 2013)

Table : Funding:

Type of expenditure	2011	2012	2013	2014
Consumables / Analyses	4.5	4.5		
Missions / Meetings	0.5	0.5		
Equipment				
Allowances for Master students				
Ship costs (ticket modérateur)				
Personnel				
TOTAL Requested to MISTRALS	5	5		

3. Annex WP3

WP3- Action 1.1

MERMEX ACTION : **MERMEX-RIVERS :** Influence of extreme events on river delivery of particulate organic carbon, nutrient and contaminants, their fate in the delta and continental shelf and their impact on ecosystems :

Participants :

C. Rabouille, N. Tisnerat, JL. Reyss, B. Bombled, F. Toussaint LSCE, Gif sur Yvette Carbon recycling, 14C measurements, radionuclides in sediments

Pruski A., Charles F., Vetion G., K. Guizien LECOB, Banyuls sur Mer Organic matter tracers, benthic fauna

M. Arnaud, S. Charmasson, F. Eyrolle, C. Antonelli IRSN, La Seyne et Cadarache Radionuclides in river and marine particles

D. Cossa, I. Pairaud, C. Mevel, R. Verney IFREMER, La Seyne and Brest Mesurho station, Hg cycle, and particle dispersion in the coastal zone

O. Radakovitch CEREGE, Aix en Provence Particulate contaminants

P. Kerhervé, CEFREM, Perpignan Isotopic signature of organic matter

C. Estournel, C. Ulses LA, Toulouse Modelling

D. Doxaran LOV, Villefranche Satellite observation

P. Raimbaut, C. Grenz, R. Sempéré, B. Charrière COM, Marseille River nutrients, sediment diagenesis, DOC

Y. Leredde, E. Berthebaud, engineer X OSU OREME, GM, Montpellier BESSète, Sète Observatory

Main objectives :

The Rhone is the largest carrier of particles and freshwater to the Mediterranean Sea, but the coastal rivers can also bring a large amount of particles during extreme events on the south Cevennes or East Pyrenean mountains. The fate of dissolved nutrients and carbon and of organic particles, terrigenous matter and associated contaminants is poorly understood despite large efforts carried out during the last 5 years in large programmes such as CHACCRA or EXTREMA. One of the explanation is the fact that extreme events such as floods represent a major share of the inputs and their deposition/remineralization processes are largely understudied and that secondary transport and dispersion on the shelf is poorly documented, especially for the transformation of particles during this transport (remineralization, contaminant desorption, interaction with benthic fauna).

The action 1.1 is dedicated to:

1- develop and maintain multidisciplinary observatories at the Rhone River mouth and on the shelf offshore of Sète for continuously measuring the delivery and deposition/mineralization/resuspension of particles especially during extreme events,

2- Investigate transfer and transformation of particles on the adjacent shelf by carrying out regular ship transects on the continental shelf from the Rhone River to the Catalan Coast using towed instruments and discrete sampling,

3- Integrate large scale patterns on the Gulf of Lions using satellite imagery and coupled physical-biological models (and possibly ProvBio floats) .

Implementation (observations at sea, experiment/ modelling):

Specific coastal stations must be maintained and developed during the Mermex programme to insure the monitoring of extreme events and their impacts on the coastal water column. These monitoring systems will complement the MOOSE program both for the spatial covering and for the type of measurement performed. Thus, two specific stations are proposed within Mermex : the Mesurho station at the immediate outlet of the River Rhone and BESSète, on the inner shelf of the Gulf of Lion.

The Mershuro station is already running with CTD-fluorescence-turbidity sensors 2m below the water surface and 2m above the seabed. A moored ADCP is installed with altimeters for studying particle load, resuspension and sediment deposition. A new benthic station will be deployed to monitor continuously the oxygen demand of the sediment, a proxy of organic carbon mineralization. CARIOCA pCO2 sensors and pH sensors could be deployed in relation with WP4 to monitor the acidification of the Mediterranean Sea. This buoy will be complemented by the continuous measurements performed in Arles at the SORA station (MOOSE), some parameters (POC, radionuclides, DOC) will be measured in the framework of Mermex. Field campaigns are needed to maintain the existing instruments and to sample the delta region for particles and sediments. Namely 4 field campaigns of 6 days (one every three months) would be required to perform these tasks and could serve as a platform for the different tasks around the observatory. An additional mooring should be developed further on the shelf (a distance of 5-10 km from the river mouth) to complement the observation of the Mesurho buoy and describe the fate of river input further on the shelf. The preparation of this mooring should be achieved during the first two years of the project with an active observation during the last 3 years.

The BESSète (Bottom Experimental Station Sète) is already running with a moored ADCP installed in a trawl resistant bottom mount. This station is part of the Sète Marine Observatory supported by OSU OREME Montpellier wich main objective is to monitor exchanges between Thau lagoon, its watershed and open sea. The station used for Mermex purposes is the BESSète observatory located on the open shelf near Sète. This station is used to measure long-term (at least 10 years), high-frequency (hourly) variables: hydrodynamics (waves and currents), meteorological and spectral measurement of solar radiation: monitoring of air temperature, atmospheric pressure, direction and wind speed and rainfall, spectrum and intensity of ultraviolet B radiation incident, physical (pressure, temperature, salinity), chemical (dissolved O2, dissolved CO2 partial pressure, turbidity and CDOM) and biological (eg pigment biomarkers: Chla and phycoerythrin). These measurements will be accompanied by sampling of some variables analyzed with conventional methods (e.g. oxygen, pH, CDOM, pigments). Observations on the watershed will be conducted at the Vène outlet and measured variables will be accessible through collaboration with colleagues from Montpellier HydroSciences and OSU OREME (daily rainfall, daily flows, temperature, pH, conductivity and turbidity).

The permanence of these observatories with periodic cruises to collect samples (both for background and after-event) will allow the monitoring of extreme events such as floods and storms and understand the fate of river particles after such events including the relaxation of the delta system.

Understanding the transfer of particles on the shelf will require short (4 days) regular (every three months) transect cruises through the Gulf of Lion, from the Rhône river mouth to the Catalan Coast (Joint cruises for all the WP3 1.1). Surveys will consist in continuous water column profiles conducted with the Scanfish device, a towed instrument equipped with a CTD and fluorescence and turbidity sensors. Regular vertical profiles (including CTD, extensive optical measurements, floc size measurements) and water sampling will complete the survey at key locations within the Gulf of Lion. Water samples will be analysed to characterize SPM such as their origin and degradation (concentration, chlorophyll-a, organic matter content, 13C / 14C / 15C). Finally, autonomous profilers (Provbio / Arvor-C) will be deployed during these campaigns within the Gulf of Lion to provide a complete view of its dynamic. In addition to these observations into the water column, bed sediment samples will be collected with an interface corer in order to investigate sediment features, similarly to SPM. A first series of 2 surveys will be conducted in 2011, and will be repeated every 3 months from 2012 to 2014. Results from these cruises will contribute to i) estimate transport pathways within the Gulf of Lion ii) validate the new satellite-based algorithm for SPM/Chl-a estimations and iii) establish process-based models detailed in the next task.

Objective 3 will rely on satellite imagery developed in Villefranche on regional algorithm for reconstructing turbidity and POC from MODIS satellite images. New development will be carried out for estimating Chl-a and CDOM from satellite images on the Gulf of Lion and North Western Mediterranean. This will provide regional maps of these parameters in the sea surface layer. Physical-biogeochemical models coupling Symphonie and ECO3M with a benthic module and a full sedimentological module will be used to simulate the observed fields of particles and sediment composition and recycling. These model outputs will be compared to a more specialized model (MARS3D) and approaches will be combined. The calibration of the models will then be used to run scenarios of future evolution of river floods, storm-linked resuspension, river drought stopping the particle delivery during summer.

Duration :

60 months (2010-2014). This action will be a long observing period from observatories (similar to EOP) coupled to cruises and satellite observations. Due to the erratic nature of extreme events which effect will be tracked, the minimum duration of the EOP is 4-5 years. Complementary funding will be searched from ANR (see CEPS-ACCESS).

PhDs and post-doct :

1 Ph.D.: 2010-2013 (F. Toussaint)

Assistance from the «division technique de l'INSU » :

ProvBio Floats from LOV-Villefranche

Funding

Years Projects	2011	2012	2013	2014
Mermex-Rivers	**20 k€ Mistrals** 77.5 k€ Other	**59 k€ Mistrals** 75 k€ ANR	**59 k€ Mistrals** 75 k€ ANR	**59 k€ Mistrals** 75 k€ ANR

Annex WP3

WP3- Action 1.2

MERMEX ACTION : **MERMEX-CASCADE** Dynamics of dense shelf water cascading and shelf-slope exchange: Impact of the ventilation of intermediate and deep water and the sequestration of elements :

Participants :

X. Durrieu de Madron CEFREM (Perpignan), Coordinator and cruise chief scientist. Responsable for hydrology et hydrodynamics

P. Kerherve, CEFREM (Perpignan) Responsible for particulate organic matter, stable isotopes

D. Aubert, CEFREM (Perpignan) Responsible for metallic contaminants

D. Cossa, LBCM (La Seyne/mer) Responsible for mercury

P. Testor, LOCEAN (Paris) Responsible for glider operation

C. Tamburini, LMGEM (Marseille) Responsible for bacterial production, degradation flux, oxygen

P. Conan, LOMIC (Banyuls/mer) Responsible for primary production, nutrients, DOM, pigments

L. Stenman, LOV (Villefranche/mer) Responsible for zooplankton

T. Calafat, GRGM-UBarcelone) Responsible for sedimentological analysis

P. Puig, CSIC-ICM (Barcelone) Responsible for mooring lines

R. Danovaro, DISMAR (Ancone) Responsible for benthic biology

F. Touratier, IMAGES (Perpignan) Responsible for CO2 analyses

C. Estournel, LA (Toulouse) Responsible for modelling

B. Ferrari, AAMP (Perpignan) Responsible for relationship with the marine protected areas monitoring programme (Parc marin de la Côte Vermeille)

Main objectives :

The region of Cap de Creus Canyon and its adjacent open slope is the main outlet of the dense water formed during winter on the continental shelf of the Gulf of Lions. Linkages that exist between this physical mechanism, the pelagic productivity, the resuspension and deposition of sediments, produce a large and rapid export of matter from the shelf to the slope and eventually the basin. It influences undoubtedly the structure and function of benthic ecosystems of the canyon and beyond. This study aims at determining the characteristics of the physical mechanism and its multiple impacts.

From the perspective of physics, it is to study the spreading and mixing of a plume of dense water (also considering its content in particulate material) during its progress from the continental shelf and its sinking along the continental slope.

From the sedimentological standpoint, it is (i) to characterize the evolution of the concentration and size of suspended particles, (ii) to quantify the transport of particulate matter along the path of the dense water plume, and (iii) identify areas of erosion and sediment on the shelf and slope.

From a biological standpoint, it is (i) to characterize the planktonic development that occurs simultaneously on the shelf, (ii) to monitor the evolution of biomass, biodiversity, and the transformation kinetics (degradation, remineralization) of organic matter by microorganisms in the dense water plume along its track. Particular attention will be paid to the diversity and activity of the microbial fractions (free and attached to the particles) and their relative

importance in the transformation of organic matter when transported to the deep-sea. The sequestration of anthropogenic CO2 will be estimated.

From the sedimentological biogeochemistry standpoint, it is (i) to characterize and quantify the input of particulate and dissolved matter by resuspension of sediments and pore water release to the dense water plume. The studied elements will be particulate and dissolved organic matter, nutrients, and metallic trace elements (including mercury). The biodiversity of microbenthos (viruses, bacteria) will also be studied. This study is partly supported by the integrated European programme HERMIONE (Hotspot Ecosystem Research and Man's Impact on European Seas).

Implementation (observations at sea, experiment/ modelling):

Observations at sea : A large pluri-disciplinary cruise will carried out during March 2011 on the R/V l'Atalante. All the information on the cruise are available at http://cefrem.univ-perp.fr/index.php/fr/campagne-cascade.

Dense shelf water cascading in this area is well documented and the month of March is the best period. We will sample more or less intense event, but it will nevertheless contain all the sought after features:

- Concomitant development of phytoplankton on the shelf and dense water cascading;

- Erosion of fine sediment and releasing of dissolved elements contained in pore water;

- Transport and export of suspended particulate and dissolved matter;

- Degradation of organic matter by microbial activity in the aphotic layer;

- Deposition of particulate material along the upper slope;

- Dynamics of the dense water plume, and mixing with ambient waters.

This experiment will also take advantage of the permanent monitoring performed at the nearby SOLA, POLA and MOLA stations by the Laboratoire Arago in Banyuls that will document the hydrological conditions and biogeochemical core parameters across the shelf and thus provide background informations on the temporal variability.

Modelling : This data set will supply and validate the coupled model (hydrodynamic / sediment dynamics / biogeochemistry / early diagenesis) model developed by LA. This experiment will provide a coherent data set, offering a synoptic view of this complex mechanism during the experimental period. These observations will allow a quantitative assessment of the ability of coupled models to reproduce realistic flow patterns and transport of biogeochemical elements, and identify the dominant processes on which to focus improvement efforts. The model can then be used to study the evolution of physical and biogeochemical characteristics of a plume of dense water, determine regions of erosion and deposition on the slope for different extreme conditions (cold or warm winters) and estimate the export range of elements from the coastal zone to the deep sea.

Duration :

36 months (2010-2012)

PhDs and post-doct :

3 funded PhDs (CEFREM, Perpignan) (1xDGA-HERMIONE cofinancing, 2xMRT grants). 1 expected PhD (LOMIC, Banyuls/mer)

Assistance from the « division technique de l'INSU » :

Use of 2 gliders for the duration of the experiment

Funding

Years Projects	2011	2012	2013	2014
Mermex-Cascade	**65 k€ Mistrals** 177 k€ Europe + Other	**5 k€ Mistrals** 67 k€ Europe + Other	50 k€ Europe + Other	50 k€ Europe + Other

WP3- Action 2.1

MERMEX ACTION : **MERMEX-COPEC** Contamination of pelagic chain

Participants :

Jacek TRONCZYNSKI, Jean François CHIFFOLEAU, Jean Louis GONZALEZ, Céline TIXIER, Véronique LOIZEAU, Catherine MUNSCHY IFREMER / Département Biogéochimie et Ecotoxicologie - Laboratoire LBCO

François CARLOTTI, Bernard QUEGUINER, Mireille HARMELIN-VIVIEN, Université de la Méditerranée - OSU/COM- LOPB (Laboratoire d'Océanographie Physique et Biogéochimique, UMR 6535).

Olivier RADAKOVITCH, Alain VERON CEREGE, Univ P Cézanne. UMR 6635

Nathalie BODIN, François Le LOC'H, IRD Centre de Recherche Halieutique Méditerranéenne et Tropicale (CRH) ; UMR 212 - Écosystèmes Marins Exploités (EME)

Véronique CORNET-BARTHAUX, Université de la Méditerranée - OSU/COM- LOPB (Laboratoire d'Océanographie Physique et Biogéochimique, UMR 6535)

David ROOS, IFREMER /Département Halieutique Méditerranéen et Tropical (HMT) - Laboratoire RH

Bénédicte THOUVENIN, Romaric VERNEY, IFREMER / Département Dynamique de l'Environnement Côtier (DYNECO) - Laboratoire PHYSED

Main objectives :

L'implication nécessaire de nombreux scientifiques et de nombreuses analyses sur de tels projets ne peut être couverte par les financements actuels de Mistrals et requiert la recherche de fonds complémentaires. Cependant, cette action dans Mermex doit permettre le prélèvement récurrent des différents maillons de la chaîne et leur analyses en certains sites afin de constituer une base de données temporelles des teneurs en contaminants. Ce prélèvement doit fortement s'appuyer sur les demandes du WP2. Par ailleurs, des expérimentations spécifiques peuvent être envisagées. Elles sont soient à mettre en place sous forme de campagnes, d'expérimentation en laboratoire ou mésocosme ou de compléments analytiques (nouveaux contaminants (médicaments, tritium…) ou nouveaux types de traitement sur les échantillons déjà obtenus).

Duration :

36 month (2014-2016) : this action will be the follow up to ANR-COSTAS which is finishing in 2012. It will be performed in relation with WP2 for the trophic network.

Funding

Years Projects	2011	2012	2013	2014
COPEC	150k€ ANR (COSTAS)	50k€ ANR (COSTAS)		

Annex WP3

WP3- Action 2.2

MERMEX ACTION : **COBEC** Contamination of benthic chains

Participants :

Olivier Radakovitch, CEREGE, metal geochemistry, sedimentology, radionuclides

Alain Véron, CEREGE, metal geochemistry

Olivier Pringault, Ecolag Montpellier, microbial biogeochemistry

Mireille Harmelin-Vivien, COM, benthic food webs

Fabien Joux, OOB, microbiology

Daniel Cossa, IFREMER, metal geochemisrty, Hg

Jacek Tronczynski, IFREMER, organic geochemistry

Larence Méjanelle, OOB, organic geochemistry

François Charles, OOB, benthic biology

Christophe Rabouille, Bruno Bombled, Flora Tousaint: benthic biogeochemistry, early diagenesis, porewaters, in situ measurements

Main objectives:

The impact of contaminants on the benthic chain is poorly understood. This is due to numerous difficulties including the influence of local and episodic inputs of particulate contaminants, the difference of bioavailability for the same contaminant in different areas, the biogeochemical reactions affecting the contaminants during diagenesis, the poor knowledge of the trophic chain levels up to the benthic fish or the influence of the large diversity of microorganisms on contaminants speciation and their own response to contamination.

Such problems require different approaches including in-situ and laboratory experiments and time-series analyses.

1) The consequences of sediment contamination on the diversity of marine microorganisms will be studied by laboratory simulation of in situ contamination of various Mediterranean sediments (lagoons, cities). The degree of short-term toxicity of this multi-contamination on microbial communities observed in the lagoon and the consequences on microbial carbon dynamics but also on model species, in order to compare the toxicity level determined with the newly proposed approach with the toxicity estimated with standardized methods. A specific attention will be given to the role of abiotic (light) and biotic (microorganisms) factors on the fate of the contaminants.

2) Benthic fish food webs will be investigated in the Rhone prodelta. These fish species, like the common sole, which live on the sediment and feed on macrobenthic organisms, could be accumulators of the contaminants discharged with river particles. A special emphasis should be given to benthic processes which can concentrate trace metals or organic pollutants by diagenetic processes in the sediment (Hg, ..) and their transfer to macrobenthos. A precise description of redox conditions is required since metal mobility is largely affected by this parameter. The food web of the common sole is exclusively benthic and very short, representing a simple model to study the transfer of contaminants from the sediment up to fishes. The main preys of the common sole are the depositivorous polychaetes which consume the organic particles, and their associated contaminants, carried by the river and settled at the sediment surface.

Implementation (observations at sea, experiment/ modelling):

The approach of the benthic chain requires specific expeditions to collect both sediment and organisms. These expeditions must be multidisciplinary including sedimentologists, geochemists, biologists and microbiologists. Fishes must be collected in parallel.

Preliminary and additional sampling will also be conducted in cooperation with action 1.1 and action 3 in order to benefit from vessels and start in some points a long-term monitoring. Interactions with these actions will be discussed in 2011.

The extent of contamination in benthic fishes will be studied by coupling different approaches including: (1) quantification of contaminant concentrations in benthic fish species according to size and sex, (2) determination of C and N stable isotope ratios in fishes in order to evaluate their trophic position, (3) analysis of their feeding behaviour to determine their principal prey, (4) determine the isotopic signatures and contaminants contents of their principal prey, (5) determine metal speciation and mobility in the sediment in relation with redox conditions (O2, H2S) and (6) estimate trophic transfers from bacteria to macro-invertebrates and bioaccumulation in the trophic food web. These data will allow tracing the transfer of contaminants in the ecosystem from particles up to benthic fishes.

We will determine the relative importance of the main routes possible for contaminant transfer, directly via the integration of river POM in the trophic webs, or indirectly via their assimilation by marine phytoplankton and its later sedimentation.

Duration : 2011-2015

2011 : preliminary measurements for microbial uptake of metals

2012-2015 : 48 months.

Two ANR projects are or will be submitted (Microtox was already submitted in 2011, COBEC will be in 2012), which should allow ambitious scientific work to be carried out.

Funding

Years Projects	2011	2012	2013	2014
COBEC	**5 k€ Mistrals**	**10 k€ Mistrals** 210 k€ ANR	**35 k€ Mistrals** 210 k€ ANR	**30 k€ Mistrals** 210 k€ ANR

WP3- Action 3

MERMEX ACTION : **MERMEX-C3A** Contaminant inputs from large Cities in the Coastal Area

Coordinators : C. Garnier, I. Pairaud

Participants :

IFREMER – LER/PAC, La Seyne s/mer, France

IFREMER – LBCO, Nantes, France

IFREMER – LBCM, Nantes, France

IFREMER – DYNECO-PHYSED, Brest, France

PROTEE - Université du Sud Toulon Var –

COM – LOPB, Marseille, France

COM – LMGEM, Marseille, France

COM – service d'observation, Marseille, France

IRSN – La Seyne s/mer, France

Main objectives:

Impacts of large coastal cities on the marine ecosystem started to be studied few years ago in France in the Toulon and Marseille areas. These works were performed by different laboratories without defined interactions and an exhaustive summary of the knowledge already achieved by the various partners in the framework of in-progress research programs (CARTOCHIM, COSTAS, GIRAC/PACA, IBISCUS, MARSECO, MASSILIA, METROC, …) have to be carried out. However, the main objective of this work is to complete these studies in order to constrain the specific mechanisms of contaminant inputs related to coastal cities (origin, nature), the main biogeochemical processes (adsorption/desorption, complexation, photodegradation, biota absorption/assimilation, sedimentation/remobilisation, early diagenesis, …) controlling the contaminants fate (net fluxes to the open sea, trophic transfer, sediment storage, …) and their long term behavior. This step will allow the set-up of federative projects, associating different partners and disciplines, in response to various calls (local authorities, ANR, FP7, …), eventually leading to human and financial support, and also associating scientific skills not managed by the implicated partners for the moment. This synthesis and structuring work will benefit from meetings in 2011 that will lead to the redaction of a complete synthesis document.

Besides of this future workplan, scientific questions have been already identified which require complete studies from sampling campaign up to modelisation.

A/ Marseille site – contaminants behaviour in the coastal zone: the research programs still in progress aim at estimating contaminants inputs from the agglomeration (GIRAC/PACA, IBISCUS, MARSECO, METROC, ...), studying their transfer to the biota (COSTAS, MASSILIA, ...) linked to their chemical speciation, and finally simulating the net fluxes to the open sea using a 3D transport model (associating physical, chemical and biogeochemical compartments). To achieve this goal, some biogeochemical processes have to be focused, influencing the chemical compounds transfer at the continent/marine interface. Through field sampling associated to lab experiments followed by analysis, this action will consist on: (1) studying the particles fate (main vector for most of the pollutants) transferred to the coast in terms of sedimentation (sediment storage), direct biologic assimilation (organic particles), in association to their chemical contamination; (2) studying contaminant behaviour in freshwater (river, urban effluent) – seawater mixing zone; (3) through by a more precise definition of the organic matter (dissolved/particulate) role on contaminant transport, speciation and bioavailability. The obtained results would allow a better modelling of contaminants transfer to the open sea. Moreover, the identified processes will be of interest to understand the main mechanisms responsible for contaminants transfer to the food chain (MERMEX WP2).

B/ Marseille and Toulon sites – contaminants transfer mechanisms at the water/sediment interface: preliminary studies (CARTOCHIM, GIRAC/PACA, IBISCUS, METROC, …) have shown the strong contamination level (metals, PAH, PCB, ...) of the sediment compartment in both sites (Marseille: in front of sewage network, urban watercourses and urban rivers discharges, harbour and industrial zones; Toulon: north of its small bay – harbour zone). This contamination is linked to historical agglomerations inputs, especially from industries. One of the main specificities of such coastal zone submitted to urbanisation probably relies on the multiplicity of the transferred chemical compounds (metals, metalloids, hydrocarbon, PAH, PCB, pharmaceutics, …). It has to be understood if the sediment compartment only plays a role of sink, or contrarily in some specific conditions could become a non-negligible contaminant source to the water column, and subsequently to the biota. Numerous processes influencing contaminants transfer at the water/sediment interface could occur: particles re-suspension/sedimentation (hydrodynamic forcing, large boat traffic, dredging activities, …), chemical reactivity (complexation, sorption, precipitation, redox, …) in part controlled by early diagenesis (bacteria activities), … . This action will consist on: (1) selecting in each working site a studied zone representative of the contamination state (cartography), the main inputs and the hydrodynamic; (2) characterizing the sediment physico-chemical properties (surface, depth); (3) in association to the action A/, defining the main origin of particles constitutive of the sediment (needed for a correct simulation of sediment dynamic); (4) measuring by in-situ techniques (peepers, passive samplers, FRAME station) the contaminant fluxes at the interface; (5) performing lab experiments to understand the mechanisms of particles re-suspension and associated contaminant remobilisation; (6) modelling the studied processes, for a better understanding and an integration in the 3D hydro-sedimentary modelling; (7) testing the interest of captors in contaminant measurements to apprehend some exchange processes occurring at high spatial and/or temporal frequency. The comprehension of such processes will also be of interest for the 1st action (large river inputs) of MERMEX WP3.

Duration : 48 months, 2011-2014

Funding

Years Projects	2011	2012	2013	2014
Mermex-C3A	**3 k€ Mistrals** 135 k€ Other	**15 k€ Mistrals** 117 k€ Other	**15 k€ Mistrals** 120 k€ Other	**15 k€ Mistrals** 120 k€ Other

WP3- Action 4

MERMEX ACTION : **Mermex-SGDE** Submarine groundwater discharges and exchanges in the coastal zone

Participants :

C. Claude, O Radakovitch, B. Hamelin, J Goncalves, C. Vallet-Coulomb, CEREGE, géochimie, modélisation

J.F. Ghiglione, J.M. Amouroux, F. Charles, K. Guizien, OOB, benthos, microbiologie

Bruno Arfib, GSRC- univ provence, hydrogéologie

Main objectives :

This action is dedicated to study the influence of submarine groundwater discharges on the ecosystem of the coastal zone. It will be concerned by both local studies and a general evaluation at the scale of the Gulf of Lion.

The first objective of this action is to estimate the flux of submarine groundwater introduced into the water column of a continental shelf through direct inputs from continental aquifers (groundwater discharges) or through exchanges of pore waters at the sediment interface (groundwater exchanges). Important SGD at such a scale have been reported by recent publications and can have an influence on geochemical budgets. Up to now, such evaluation can be done only by estimation of geochemical budgets of some tracers, more particularly the radium isotopes which are produced within the pore water. Based on 226Ra and 228Ra activities for example, Ollivier et al (2008) calculated that the amount of SGD exchanges on the Gulf of Lion shelf is approximately 10% of the river flow, a value probaby underestimated because few 228Ra values were available at this time and because of a large uncertainty in the activity used for the groundwater end-member. A better estimation will benefit from new 228Ra data at a better defined scale as well as from new data of 224Ra and 223Ra activities. These two isotopes have a shorter half-life and will give better information on water mixing at the scales of the days or weeks.

The second objective of this action is to define more precisely the influence of SGD on coastal ecosystem, and this must be done at local scale. Two sites will be studied within the next years, corresponding to the main kind of coastal aquifer encountered in the Mediterranean sea: porous and karstic aquifer.

The Salses-leucate lagoon system characterized by a hydro-geological setting compatible with high rate of submarine groundwater discharge will be used a study site for porous aquifer. The lagoon is bordered by an important karstic system having a watershed of 160 km2. Groundwater flows in the lagoon through two karstic springs, Font Dame and Font Estramar at rates ranging from 1 to 10 m3/s depending on the season. Because the lagoon is covered by sandy plio-quaternary permeable sediments, diffuse SGD is also expected to seep as diffuse flow across the lagoon floor. On its sea-side, hydraulic exchanges between the lagoon and the Mediterranean Sea occur through three small inlets (“Graus”) and in the sub-surface through the dune system. Preliminary data set of radioisotopes activities in the Gulf of Lion and in the lagoon is consistent with the contribution of SGD (karstic and diffuse through sediments) in the lagoon and the coastal zone. The first step will be to evaluate the importance of groundwater fluxes in the lagoon based on radioactive nuclides (222Rn, 224Ra, 223Ra) and stable isotopes. Once the budget defined, the hydrosystem will be modelized.

Once the fluxes and location of inputs will be defined, the second step will be to evaluate the influence of these fluxes on the ecosystem. Competition between phytoplankton and bacteria for key nutrient utilisation and limitation (bottom-up control) in the pelagic system will be assessed by phytoplankton production measurements as well as bacterial remineralisation of POM and DOM from both particle-attached and free-living fractions (Pujo-Pay et al., 2006; Ghiglione et al. 2007). The importance of top-down control in the microbial loop will be assessed by flagellate counts and grazing experiments .

The relative importance of terrestrial (direct SGD input) vs. biological (primary production) organic matter sources will be also addressed quantitatively and qualitatively by fingerprinting terrigeneous and marine biomarkers (pigments, bioavailable amino acids, fatty acids) in the sediments and mixing models based on isotopic δ13C values of potential OM sources. The impact of SGD in the food web structure of the Salses-Leucate lagoon will be assessed

through the study of the structure of the meio- and macro-benthic communities. The isotopic (δ13C and δ15N) and molecular (lipidic tracers) approaches will be used to assess the impact of SGD on the strength of the relation between the potential food sources and the detritus-feeders present in the sediments.

The karstic site corresponds to the Port-Miou spring located in the Calanque around Cassis. It is part of the limestone karst extending from Marseille to Toulon where about ten springs were studied by hydrogeologists. The brackish water injected by this spring in the coastal area is results from a mixing of fresh and seawater within the karst. The site is presently studied and equipped to determine the variation of water flux in link with continental hydrosystem. Data are available online in the framework of the project Karst-eau. However few works were done on the quality of the brackish waters (nutrients) and on the influence of these waters on the adjacent coastal area.

Implementation (observations at sea, experiment/ modelling):

- The main part of this action at the beginning of Mermex will be to conduct one or two large sampling campaign over the Gulf of Lion for the analyses of dissolved isotopes in order to quantify and characterize SGD or SGE. This could be done within the framework of other WP depending on their strategy. In case of impossibility, specific campaigns

- Sampling campaigns at local scales for biogeochemistry (trace elements, stable isotopes radioactive elements, nutrients) and biology (microbiology, benthos).

Duration : 2012-2014

This action will start with the first step of the evaluation at the scale of the Gulf of Lions. Analytical techniques will be implemented in 2012 and a large sampling campaign could be conducted in 2013. Sampling could also benefit from other Mermex cruise at this time.

Funding

Years Projects	2011	2012	2013	2014
Mermex-SGD		**13 k€ Mistrals**	**40 k€ Mistrals**	**5 k€ Mistrals**

4. Annex WP4

MERMEX ACTION: **CALIBORON**: CALIbration of paleo-pH reconstruction technique based on BORON isotopes in calcareous species (corals and bivalves) from the Mediterranean Sea: quantification of surface water acidification due to industrial era

Participants:

Eric Douville (LSCE, Eric.Douville@lsce.ipsl.fr), Paolo Montagna, Cécile Gonzalez (LSCE), Fréderic Gazeau (LOV), Patrizia Ziveri (UAB, Barcelona), Carles Pelejero, Lorenzo Bramanti (CSIC-ICM, Barcelona), Stéphanie Reynaud (CSM, Monaco), Jason Hall Spencer (Univ. of Plymouth)

Main Objectives:

Due to the absorption of anthropogenic CO_2 by the ocean, seawater pH has already declined by 0.1 unit compared with pre-industrial values (Orr et al., 2005) and is projected to decrease by another ~0.3-0.4 pH-unit by the end of the century (Caldeira and Wickett, 2003). This process, i.e. ocean acidification, will most likely have profound impacts on marine biota. In particular, this pH decrease will certainly have severe consequences for those organisms (fossil or alive) that build their external skeleton out of calcium carbonate ($CaCO_3$) due to the induced decreasing availability of carbonate ions (CO_3^{2-}). As pH datasets from monitoring programs are extremely scarce around the world and especially in the Mediterranean Sea, the reconstruction of recent past (annuals to decades) pH changes through paleo-pH techniques appears an essential issue to develop. The boron (B) isotopic composition ($\delta^{11}B$) of marine carbonates has been established as a tracer for paleo-pH changes (Vengosh et al. 1991; Hemming and Hanson 1992; Spivack et al. 1993; Sanyal et al. 1996, 2000, 2001). Dissolved B exists in the oceans in two dominant species, boric acid $B(OH)_3$ and borate $B(OH)_4^-$. Their relative abundances and their respective isotopic compositions in seawater change with pH, these changes being controlled by the equilibrium constant (pK_B) and the isotopic fractionation factor "alpha" respectively. The $\delta^{11}B$-pH technique relies on the fact that, when calcifying organisms are incorporating B in theirs structures, they would incorporated preferably the borate species by the substitution of the bicarbonate ions (Hemming and Hanson 1992; Sanyal et al. 1996, 2001). As a result, the $\delta^{11}B$ measured in carbonate skeleton would reflect the $\delta^{11}B$ value of borate ions in seawater and consequently pH conditions during the carbonate growth. Despite of our lack of fine knowledge concerning incorporation processes of B in carbonate skeletons (Pagani et al. 2005), 3 distinct laboratory calibration exercises verified the pH-dependence of $\delta^{11}B$ for the tropical coral species Porites and Acropora (Reynaud et al., 2004; Hönisch et al. 2004; Krief et al., 2010). Recent field calibrations on the same coral genus (both modern and ancient corals from the sub-Equatorial Pacific) confirmed the reliability of the $\delta^{11}B$-pH technique (Pelejero et al., 2005; Douville et al., 2009, 2010) with an apparent isotopic fractionation factor "alpha" off 0.981-0.9804. Such alpha values match the value empirically deduced by Hönisch et al. (2007). All these studied also revealed an isotopic offset for B isotopes depending on the biogenic carbonate species studied. Consequently, to develop the $\delta^{11}B$-pH technique for a new oceanic basin (here the Mediterranean Sea) involving new carbonate species (bivalves or corals), laboratory and field calibration exercises remain crucial and unavoidable. In the North Atlantic and high latitudes ecosystems, a major initiative for developing paleo-pH techniques based on boron isotopes using deep-sea corals has been launched in 2008 in the frame of the FP7 European project EPOCA. Equivalent studies for tropical areas and shallow corals are also occurring based on field or lab calibrations (French project INSU PHARE 2008-2010).

Implementation

In the framework of MISTRALS program, we propose here to develop and apply the paleo-pH technique based on boron isotopes for new specific calcifying species (bivalves and corals) for the reconstruction of recent past pH changes in the Mediterranean Sea. This relatively closed oceanic basin is necessarily under the influence of greenhouse gas and the potential consequences of decreasing pH levels on bivalves or corals present in this basin are still totally ignored. Thus we suggest here through national and international collaborations between geochemist and biologist experts to develop new laboratory and field calibrations of the boron isotope technique for such species. This calibration procedure is an important pre-requisite for a precise quantification of the rate of acidification and its impact

on calcareous organisms in the Mediterranean Sea. This project clearly integrates the objectives of the WP4 of the Mermex project that mainly focus on the evaluation of anthropogenic pressure (through air-sea interactions) on Mediterranean marine ecosystems. Some evident links will be also done with the Paleomex project for paleo-pH reconstruction for the older pre-entropic period. Laboratory cultured species of bivalves or corals reared at various pH or pCO_2 conditions will be analyzed for boron isotopes and trace elements (B/Ca). Field calibrations will also be performed by using existing seawater pH measurements (MOOSE, MedSea) coupled to the sampling of specific species of interest. Finally, physiological studies will be also be conducted by the biologists partners (size, shape, growth rate, density, etc.).

Expected scientific outcomes:

1) Laboratory calibration exercises, evaluation of the paleo-pH technique based on boron isotopes for each studied species. Determination of the fractionation factor "alpha" usable for the reconstruction of paleo-pH by measuring boron isotopes and boron concentrations: a) Mussels (*Mytilus galloprovincialis*): an annual study focusing on the effect of ocean acidification and warming on the growth and metabolism of Mediterranean mussels will be conducted at the Institute of Marine Science in Barcelona (PI: LOV) in the frame of the European MedSea project (FP7, coord: P. Ziveri). Specimen of this experiment will be dedicated to the Boron/pH calibration, b) Corals (*Leptopsammia pruvoti, Astroides calycularis, Cladocora caespitosa, Oculina patagonica*): Culture experiments are already performed for the two last species or are starting in 2011 in aquaria at 2 or 3 pH levels and at 1 or 2 temperatures (PI: CSIC, C. Pelejero). Samplings for $\delta^{11}B/[B]$ were already planned.

2) Field calibration exercises, verification of the validity of the technique and deduced pH values on calcareous organisms collected from the Mediterranean Sea at variable conditions of temperature, salinity: a) Bivalves would be collected in the vicinity of pH monitoring sites (coastal areas) ex: MESHURO, See project CARBORHONE submitted to MISTRALS, Station VIDA in the N. Adriatic Sea (MedSea project), b) Corals (*Cladopora capitosa*) and other carbonates species close to Ischia and Vulcano (Italy) as well as Methana (Greece) hydrothermal sites. In the frame of the MedSea project (WP4 -PI: Univ. Plymouth, J. Hall Spencer), we propose here to investigate the effects of increasing seawater CO_2 levels on boron (isotopes/concentrations) incorporation in coral skeleton (2 or 3 Mediterranean CO_2 vent sites).

3) pH change monitoring during the industrial period: apply on modern carbonate species recovering the recent entropic period in order to determine pH decrease due to ocean acidification and evaluate potential impact on physiology and biology of each organism. Preliminary geochemical analyses concerning long-lived (about 100 years) corallites already collected in two locations of the Med Sea (P. Montagna) will be initiated via this incubating project. Function of sample availability, corals or bivalves in the vicinity of rivers would be also analyzed in order to evaluate δ11B-pH changes and identify potential influence of continental freshwaters.

Duration:

Most of the samples already collected by the partner teams and available for the geochemical measurements will be analyzed in 2011 and 2012. Some laboratory cultures that will start in 2011 (bivalves or corals) impose to perform this project over the next three years (2011-2013) with geochemical analysis in 2012 and 2013. Result dissemination and valorisation in 2013 (publications/international meetings).

Annex WP4

Table : Fundings:

2011			2012		
Europe/ANR	**Region/University**	**Mistrals**	**Europe/ANR**	**Region/University**	**Mistrals**
5k€ (EPOCA)	10 k€	5 k€	2.5 k€ (EPOCA)	2.5 k€	5 k€
2013			**2014**		
Europe/ANR	**Region/University**	**Mistrals**	**Europe/ANR**	**Region/University**	**Mistrals**
	2.5 k€	5 k€			

Budget	**2011**	**2012**	**2013**
Fonctionnement	5 k€	7.5 k€	5 k€
Missions	5 k€	2.5 k€	2.5 k€
Equipment	10 k€		
Ticket modérateur			
Gratification stages			
Total	**20 k€**	**10 k€**	**7.5 k€**

MERMEX ACTION : **CARBORHONE** : Carbon Cycle in the Rhône Estuary and Gulf of Lions

Participants:

Yann Bozec, UMR CNRS/UPMC 7144-Chimie Marine, Station Biologique de Roscoff; **Christophe Rabouille**, LSCE/IPSL, Laboratoire des sciences du climat et de l'environnement, Gif s/Yvette.

Main Objectives:

The constraint of air–sea CO_2 fluxes and their variability at various time and spatial levels remain a central task in global carbon and climate studies. Over the past decade, the coastal oceans have been the focus of several studies highlighting the key role of these ecosystems in the global budget of air-sea CO_2 fluxes (Thomas et al. 2004; Borges et al. 2005; Cai et al. 2006). The spatial variability in air-sea CO_2 fluxes is large from one coastal ecosystem to the other and Chen and Borges (2009) recently proposed to classify continental shelves as sinks (-0.7 ± 1.2 molC m^{-2} yr^{-1}, Laruelle et al., 2010) and near-shore ecosystems as sources (21.0 ± 17.6 molC m^{-2} yr^{-1}, Laruelle et al., 2010) of atmospheric CO_2. However, the latest estimates of air-sea CO_2 fluxes in coastal ecosystems are subject to large uncertainty. At present, the lack of sufficient data is the major limitation in the quantification of the spatial and temporal variability of these CO_2 fluxes in coastal environments (Laruelle et al., 2010). This lack of data is even more relevant in coastal ecosystems impacted by estuarine plumes. While there is an emerging agreement on the role of inner estuaries as source of CO_2 to the atmosphere, estuarine plumes (e.g. outer estuaries) can either act as sources of CO_2 such as the Scheldt (+1.9 molC m^{-2} yr^{-1} (Borges and Frankignoulle 2002)) and the Kennebec (+0.9 molC m^{-2} yr^{-1} (Salisbury et al., 2009)), or as sinks for atmospheric CO_2 such as the Amazon (−0.5 molC m^{-2} yr^{-1} (Körtzinger, 2003)) and the Changjiang (−1.9 molC m^{-2} yr^{-1} (Zhai and Dai, 2009)). In the case of the Loire estuary, Bozec et al. (2011a) showed that the strong emissions from the inner estuary (+33.8 molC m^{-2} yr^{-1}) could be offset by the sink (-0.3 molC m^{-2} yr^{-1}) observed in the plume because of its much larger surface area thus underlying the key role of these ecosystems in air-sea CO_2 fluxes estimates. To accurately constrain the present impact of estuarine plumes in global air-sea CO_2 fluxes, additional investigations must be carried out in a greater diversity of ecosystems. The air-sea CO_2 fluxes in Mediterranean coastal ecosystems impacted by estuarine inputs have been poorly investigated (Borges et al., 2006). A recent effort carried out within the SESAME project focused on the Eastern Mediterranean Sea with several cruises carried out in the Aegean and Levantine basins. Krasakopoulou et al. (2009) showed that during winter the Aegean Sea absorbs atmospheric CO_2 at a rate ranging from -1.2 to -2.0 molC m^{-2} yr^{-1}. More recently, Turk et al. (2010) showed that estuarine plume present in the Gulf of Triest had a major impact on the overall air-sea CO_2 fluxes of the Adriatic Sea. However, given the large heterogeneity of coastal ecosystems in the Mediterranean Sea, a robust estimate of air-sea CO_2 fluxes can only be achieved by an important observational effort. Furthermore, processes underlying theses sources and sinks of CO_2 to the atmosphere (production/mineralization of organic matter, calcium carbonate dissolution/precipitation both in the pelagic and benthic compartments) are poorly known in these delta/estuarine environments.

The Gulf of Lions is a coastal ecosystem considerably impacted by freshwaters inputs from the largest estuary surrounding the Mediterranean Sea namely the Rhône. In CARBORHONE, we propose to investigate the processes controlling the air-sea CO_2 fluxes from the inner estuary, to the estuarine plume located within the 200 m isobath of the Gulf of Lions. This project is directly integrated into the WP4 on "natural and anthropogenic interactions" with a strong link to the WP3 on "Land-Ocean interactions including extreme events". More specifically, our project will address the main questions of WP4/Action 1 ("Gaz fluxes and acidification in the Mediterranean Sea-Impact on Ecosystems and Biogeochemical cycles") by quantifying the present air-sea CO_2 fluxes from the inner Rhône estuary to the inner Gulf of Lions impacted by freshwater inputs (Objective 1.1, WP4).

Implementation:

Our approach will rely on both time-series observations and seasonal cruises: 1) 4 seasonal cruises will be carried out in 2011/2012 from the inner estuary to the inner part of the Gulf of Lions limited by the 200 m isobath. 2) pCO_2 and pH sensors will be installed on the Mesurho buoy located at the estuary mouth as part of the observing network deployed within the MERMEX framework. The Mesurho buoy is already equipped with sub-surface sensors for temperature, salinity, dissolved O_2, turbidity and fluorescence measurements. Bozec et al (2011b) recently showed

that such high-frequency measurements combined with similar pCO_2 datasets were powerful tools to unravel the processes controlling the daily to annual pCO_2 dynamics in coastal environments. The additional comprehensive datasets (pCO_2, DIC, TAlk, O_2, nutrients, Chl *a*) collected in the entire water column during the seasonal cruises will allow determination of the physical, biological and chemical (mixing, NCP, thermodynamic) processes driving the air-sea CO_2 fluxes. 3) In addition to our CARBORHONE cruises, the cruises planned in WP3 will focus on the sediment/water interface. In situ pH and oxygen measurements coupled to alkalinity measurements in porewaters will be performed. This additional dataset will allow us to investigate the effect of sediment carbonate dissolution in buffering the DIC inputs from the river as well as the effect of alkalinity production in porewaters on the air-sea CO_2 exchange (Thomas et al., 2009). Our combined approach corresponds to the global strategy of MERMEX, which supports *in situ* observations within an innovative observing network as well as repeated seasonal oceanographic cruises. This strategy is imperative for a comprehensive spatio-temporal understanding of the CO_2 system dynamics from daily to seasonal scale from the inner coast to the continental margin.

Expected scientific outcomes:

Firstly, the main scientific outcome from CARBORHONE will be the assessment of the present day air-sea CO_2 fluxes in the Rhône estuary and Gulf of Lions. This outcome corresponds directly to the objective 1.1 of the WP4. The strategy chosen will allow a precise estimation of these fluxes based on a novel approach of daily to annual scale observations at a fixed location combined with a spatial process study at a seasonal scale. Secondly, we will assess the physical, biological and chemical (mixing, NCP, thermodynamic) processes controlling the inorganic carbon variability in the Rhône/inner Gulf of Lions (WP4/Objective 1.1). CARBORHONE will have a strong link with the WP3 ("Land-Ocean interactions including extreme events") by constraining the impact of winter floods, carbon fixation and alkalinity production in porewaters on both the inorganic carbon inputs and air-sea CO_2 fluxes variability for the entire ecosystem. Finally, our project will provide the pH/pCO_2 in-situ variability required for testing the impact of ocean acidification in the Mediterranean Sea on planktonic and benthic species in experimental conditions (WP4/Objective 1.4). CARBORHONE will thus provide a first assessment of the processes controlling the carbon dioxide system in the extremely heterogeneous coastal ecosystem "Rhône estuary/Inner Gulf of Lions". This first assessment will constitute a basis for a future understanding of the carbon dioxide system alteration under global change.

Duration:

3 years: Year 1: 3 seasonal CARBORHONE cruises, Year 2: 1 seasonal CARBORHONE cruise + installation of the new pH sensor, Year 3: Maintenance of pH sensor, data processing, conferences and peer-reviewed publications.

Table : Fundings:

2011			**2012**		
Europe/ANR	**Region/University**	**Mistrals**	**Europe/ANR**	**Region/University**	**Mistrals**
		34 k€			38 k€
2013			**2014**		
Europe/ANR	**Region/University**	**Mistrals**	**Europe/ANR**	**Region/University**	**Mistrals**
		19 k€			

Budget	2011	2012	2013
Fonctionnement	8 k€	8 k€	12 k€
Missions	10 k€	5 k€	7 k€
Equipment		15 k€	
Ticket modérateur	15 k€	10 k€	
Gratification stages	1 k€		
Total	**34 k€**	**38 k€**	**19 k€**

Hired or needed contractual employees: 1 PhD student.

Technical assistance or means from l'INSU or IFREMER: Request for shiptime already accepted.

MERMEX ACTION : **PHOTOMED** Metabolic and structural changes of the bacterial community in response to the phototransformations of dissolved and particulate organic matter in Mediterranean Sea

Participants:

JOUX Fabien, GHIGLIONE Jean-François, SUZUKI Marcelino, ORIOL Louise, CAPARROS Jocelyne. Laboratoire d'Océanographie Microbienne (LOMIC), UMR CNRS 7621, Université Paris 6, Observatoire Océanologique de Banyuls; SEMPERE Richard, RONTANI Jean-François, CHARRIÈRE Bruno, PANAGIOTOPOULOS Christos. Laboratoire de Microbiologie, de Géochimie et d'Ecologie Marines (LMGEM), UMR CNRS 6117, Centre d'Océanologie de Marseille

Main Objectives:

Due to high solar radiation, Mediterranean Sea is the place of intense photochemical transformations of dissolved and particulate organic matter (DOM & POM). The climatological prediction from current models is for an increase in stratification expected in 21st century Mediterranean Sea (Somot et al., 2006) leading to an increase of the photochemical processes at the surface of the Med. Sea. The photochemical modifications of DOM have two major consequences in terms of biogeochemistry:

1) they can participate to the mineralization of organic carbon through direct production of carbon monoxide (CO) and CO_2.

2) they can modify the bioavailability of DOM for bacteria and hence the CO_2 fluxes via respiration.

Due to its high concentration of colored dissolved organic matter (CDOM), riverine DOM is highly sensitive to photochemical transformations. Photodegradation is considered to be a major sink of riverine DOM by direct photomineralisation or increase of its bioavailablity after phototransformation with the production of more labile substrates like monocarboxylic acids and carbonyl compounds (Mopper and Kieber, 2000). To date, very little is known about the importance of these processes that can take place in the river plume of the Rhône River in the Mediterranean Sea (Joux et al., 2009 ; Para et al., 2011).

Other sources of DOM can be phototransformed either directly or indirectly via a photosensitization process induced by CDOM, nitrates or nitrites. These phototransformations have contrasted effects (stimulation or inhibition) on bacterial metabolism according to the initial quality of the DOM, the degree of photoalteration and may be the composition of the bacterial community. More recently different studies have underlined that DOM phototransformations can also modify the structure of the bacterial community by selecting some specific species (e.g., Abboudi et al., 2008). These species can be either more adapted to the use oxidized organic molecules or less sensitive to short-lived reactive oxygen species (ROS) generated during photochemical reaction (Glaeser et al., 2010).

POM is also sensitive to solar radiation. Due to the presence of chlorophyll, which is a very efficient photosensitizer, visible-light induced type II photosensitized processes (i.e. involving singlet oxygen) act intensively during the senescence of phytoplanktonic cells (Rontani, 2001).The role played by UVR on photochemitry of POM is however much less studied (Christodoulou et al., 2010). As for DOM, ROS produced during POM oxidation could inhibit particle-attached bacteria, and thus contribute to a better preservation of algal organic matter during the sedimentation (Christodoulou et al., 2010; Rontani et al., 2010).

Implementation

The **PHOTOMED** project proposes to use experimental approaches in order to better constraint the effect of solar radiation on the fate of two contrasted organic matter: one originating from the Rhône River and the other from a phytoplanktonic culture (*Emiliana huxleyi*). DOM and POM will be considered for both organic matter origins. The photochemical changes will be monitored during irradiation under a solar simulator using different parameters to characterize DOM (amino acids, sugars, organic acids, excitation-emission matrices) and POM (lipids, chlorophyll and sterol oxidation products). The changes will be connected to the doses of UV and visible radiations received during the exposure in order to appreciate the importance of these processes occurring in the field. The other part of

the project concerns the response of the bacterial community to these photochemical changes. Metabolic changes will be studied by the mesurements of the production and respiration activities, which will lead to the calculation of the bacterial growth efficiency. Moreover, changes in bacterial community will be determined by DNA&RNA fingerprintings and pyrosequencing for some selected samples.

Expected scientific outcomes:

By focusing on UV radiation effect on organic matter and air-sea interactions, the PHOTOMED project is highly connected to the WP4 "Natural and anthropogenic air-sea interactions" Action 3 "Assessment of the influence of solar radiation on ecosystem and biogeochemical cycles". It will give new insights in the understanding of current and expected effects of solar radiation on DOM and POM and their consequences on the bacterial metabolism and diversity. More specifically, the objectives of PHOTOMED are:

1) to characterize the main photochemical changes occuring during the irradiation of DOM and POM from two origins (riverine, phytoplankton)

2) to characterize the metabolic and diversity changes of free and particle-attached bacteria in response to the DOM and POM phototransformations.

3) to produce results (apparent quantum yield) that could be used by modelizers to estimates the consequences of an increase of the solar irradiation due to longer stratification on these processes.

The results obtained during the PHOTOMED project will be used to propose a larger project to the ANR in **2013** which will include a metatransciptomic approach to describe the genomic and transcriptional responses of the microbial communities to the photochemical transformation of DOM and POM and an intercomparison of different river-ocean systems (Duration: 3 years. Budget: 225 k€)

Duration:

2 years: 2011: June-July – Experiment with Rhône water. DOM and POM irradation and response of bacteria, September-October – Experiments with *E. huxleyi*. DOM and POM irradation and response of bacteria; 2012: June-July – Complementary experiment with Rhône water. High DOM *vs.* total DOM

Annex WP4

Table : Fundings:

2011			**2012**		
Europe/ANR	**Region/University**	**Mistrals**	**Europe/ANR**	**Region/University**	**Mistrals**
		10 k€			10 k€
2013			**2014**		
Europe/ANR	**Region/University**	**Mistrals**	**Europe/ANR**	**Region/University**	**Mistrals**

Budget	2011	2012
Fonctionnement	9 k€	9 k€
Missions	1 k€	1 k€
Equipment		
Ticket modérateur		
Gratification stages		
Total	**10 k€**	**10 k€**