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Tender for DAM Research Mission.

"PROTECTION AND SUSTAINABLE USE OF MARINE AREAS"

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1 Mission Description

1.1 Executive Summary

The DAM Research Mission aims to develop and support options for sustainable use of marine resources and ecosystem services, and to promote good environmental status in marine systems. The mission will complement the ongoing research and fill identified research gaps to support the implementation in the second cycle of the EU Marine Strategy Framework Directive. The Mission is founded on the existing expertise of the participating German research institutions and universities and on state-of-the art knowledge. The overall aims are to supplement ongoing and planned future German marine research, to fill existing gaps, and to facilitate closer scientific cooperation by combining different knowledge types and disciplines in synergistic processes, thus promoting the sustainable use of marine areas.

Stressors on marine and coastal environments originate from naturally occurring changes superimposed to a combination of various human induced impacts. Human and environmental drivers (including changes in hydrographic conditions, physical disturbance and loss of habitats, non-native species, fish mortality, eutrophication, pollution, marine litter, sound from human activities) are highly variable both in type and on different temporal and spatial scales. Thus, this Research Mission will adopt a combination of long and short term regional and local approaches to assess overarching human and environmental drivers and their impacts on marine regions and land-ocean transition zones. The Mission will identify the various human use and planning scenarios in selected marine ecosystems and assess basin scale functionality and remote impacts thereon. The mission will further develop potential future scenarios for human use in the face of climate change, especially in terms of the future management options dealing with and developing mitigation strategies in an adaptive and integrative management framework.

This Research Mission focuses on regions in the North Sea and Baltic Sea. In addition, regions in developing countries, especially along the West African coastline, could be included. That would allow for scientifically interesting comparative studies in regions with differing use patterns and would be of developmental relevance.

In all these regions, the following potential drivers will be considered: eutrophication, fisheries, shipping (including construction and maintenance of ports and shipping ways), pollutants (including plastics and other types of debris and chemical contaminants), tourism, renewable energy production, extraction of mineral resources, dredging and deposition of sediments, coastal protection measures, and other direct economic impacts.

The Research Mission will comprise three work packages (further detailed under 2.1-2.3) and integrates the pilot-projects MGF-Nordsee and MGF-Ostsee (see 2.4):

1. Options to reduce direct impacts on marine biota and their biotic and abiotic interactions (WP1)
2. Options to reduce marine pollutants (WP2)
3. Options for management under increasing future human use and future changing climate (WP3)

The three initial work packages and pilot projects were identified as the most pressing and pertinent issues during joint scientist and stakeholder consultation events. As a whole, this Research Mission directly supports the implementation of the UN Sustainable Development Goals (SDGs) and the development of the post-2020 Global Biodiversity Framework. It aims to support activities under the UN Decade of Ocean Science for Sustainable Development and will contribute to the BMBF Africa strategy. This Mission will develop a roadmap for sustainable use and protection of marine areas. The developed options will be described considering related environmental, social and economic aspects.
Characteristic for successful operations of individual consortia and cooperation in the entire mission will be continued consultation and exchange amongst researchers and environmental practitioners.

1.2 Introduction

The ocean is a significant source of food and income for humans. Fisheries and aquaculture provide employment opportunities to more than 200 million people and seafood is a major source of protein and nutrients for more than 3 billion people worldwide. Economic activities related to oceans, seas and coastal areas are rapidly growing, with currently more than 4 million persons employed in the EU, an increase by half a million during the last 10 years, with a German contribution in EU maritime economy of about 10% (European Union, 2019: The EU Blue Economy Report). The ocean, is moreover, the world's most important transport route with steadily increasing importance and also plays a key role in the supply of raw materials and energy. Around one third of oil and gas production takes place today in regional seas and coastal regions. Rapid growth sectors are tourisms, ports and water projects, marine living resources and blue economy. Driven by a significant cost reduction and national and international decarbonization policies, it is expected that the annual deployment rate of offshore wind energy (a component of blue economy) will increase by a factor of 10 within the coming 25 years. Large ocean energy projects, which are currently at a research and development level, are announced from 2020 onwards (European Union, 2019: The EU Blue Economy Report, 2019).

The growing utilization of the marine realm is characterized by trade-offs and creates potential conflicts, as some forms of use may not be beneficial to all the stakeholders involved (e.g. industrial versus small-scale fisheries, fishing versus wind parks, etc.). Marine spatial planning aims to delineate areas for different use categories in order to prevent conflicts in the use of areas and resources (BSH, Flächenentwicklungsplan 2019). However, this is not regulated for all use types and spill-over effects are to be expected. Efforts are made to develop multiple use management options (www.jpi-oceans.eu). The increasing demand of use poses growing pressures to the marine ecosystem. Such pressures exacerbate the effects of rising temperatures, ocean acidification, and

sea level rise, thus decreasing resource production and amplifying threats to coastal areas (Schrum et al., 2016; Meier et al., 2019b). The ecological risks caused by the combination of different stressors pose a serious threat to society, as they could impair ecosystem services and natural functions of the sea and its inhabitants. In other words, the services of the seas that society relies on may change in uncontrollable ways.

Human activities are increasingly moving offshore as, in for example, the recently announced largest wind farm project world-wide on the Dogger Bank in the North Sea (https://doggerbank.com/) and ecosystems within the German national exclusive economic zone (EEZ) will be increasingly influenced by man-made pressures outside the EEZ. The spatial and temporal variability of marine ecosystems necessitates a regional focus and basin scale (North and Baltic Seas) approaches to enable a holistic assessment of climate and man-made pressures on the ecosystems and the services they provide. Such an approach will enable the identification of effective management strategies and policy implementation on national and EU levels to conserve and sustainably use the oceans, seas and marine resources (SDG14). The conditions in North Sea and Baltic Sea differ due to physical aspects (tides, salinity, characteristic exchange time scales, sensitivity to climate change), use patterns, and biodiversity. In both regions marine uses are regulated via a diverse and complicated set of local, provincial, national, European and international institutional structures including different national interpretations of Maritime Spatial Planning (MSP) and different priorities among countries. Despite coordination efforts through EU legislation, such as the Marine Strategy Framework Directive (MSFD) and NATURA 2000, it remains to be determined what the long-term and cumulative impacts of emerging use patterns might be, which alternative modes of utilization of marine resources may exist, how the functioning of marine ecosystems can be safeguarded and how approaches such as MSP and development of marine protected areas (MPAs) can be improved to support sustainable development. In contrast, the Western African waters are characterized by the effects of the Benguela current in the south and by the Canary Current and Gulf of Guinea Large Marine Ecosystems in the center-north. These exceptionally fertile waters are still home to some of the world's largest fish stocks, which form the basis for many bilateral fisheries agreements with the European Union. Nonetheless, the management regimes of these and other socio-economically and culturally highly diverse coastal regions are substantially under stress by national and international exploitation practices and weak enforcement capacities of regulatory frameworks. As a consequence, regulatory vacuums result in destructive competition between different stakeholder groups in the management of marine natural resources, e.g. industrial versus small-scale fisheries, fisheries versus oil and gas industries, small scale natural resource users versus political/economic elites (Belhabib et al. 2015). This leads to a range of formal, informal, partly illicit, coping and adaptation practices, which further undermine the regulatory capacities on the level of nation states and the region (i.e. under the Abidjan convention).

To achieve the overall goal of the Research Mission, i.e. to identify and suggest options of actions to protect, use and manage marine areas in a sustainable way, the following major questions need to be addressed:

- What are the most important stressors (in terms of human-use, environmental change, and forms of marine pollution) and what are the cumulative impacts of multiple stressors on ecosystems and key species?

- How can these stressors - and hence the impacts - be reduced? Which mitigation and reduction concepts and strategies are most effective and feasible (considering e.g. social acceptance and cooperation behavior, as well as economic aspects)?
- How effective are marine protected areas in safeguarding the integrity of habitats, what are the effects on neighboring habitats and which further suggestions can be made to enhance their intended effects?
- Which types of climate and human-use scenarios do we have to deal with in the future, what are the options for management?
- How is the increasing competition for marine natural resources being negotiated by different stakeholder groups across local to international management levels?
- Which governance structures on regional, national and international level are required for a successful implementation of the options of actions?

By answering these questions, the Research Mission will provide a roadmap for a sustainable use and protection of marine areas.

1.3 Overarching Goals based on Stakeholder Consultation

The first stakeholder consultation, which was held in Berlin in July 2019, included primarily offices of ministries, relevant regional authorities, as well as Non-Governmental Organizations (NGOs) focusing on the North and Baltic Seas. These consultations identified the overarching goals for the DAM Research Mission. These were further discussed with selected scientists and ocean-focused policymakers from West Africa. In short (and taking up the questions from the previous section), the Research Mission was designed to be able to advise policy makers and society on options for actions on following topics:

- Reduction of direct impacts of human-use in the North Sea, Baltic Sea and off the coast of West Africa (focus on Ghana, Senegal, Mauritania)
- Reduction of or avoidance of harmful substances in the sea
- Achieving good environmental status (GES)
- Prevention of collapse of the small-scale fisheries in Coasts including e.g. West Africa
- Prediction and assessment of future developments under different scenarios

Close interactions with stakeholders are imperative for fulfilling the Research Mission.

Differing from other typical science funding formats, the thrust of the mission is in equal parts engaged with filling knowledge gaps with respect to interactions of diverse (but manageable) anthropogenic stressors and climate change, and on delivering science-based practical guidance for governance of the coastal zone in the North and Baltic Seas.

1.4 Potential Work-Package Structure

The Research Mission comprises three work packages, which address the questions above. After extensive discussions of the scientific and management challenges three major topics were

identified as the most urgent to be addressed. In addition, two pilot projects DAM-P-MGF-Nordsee and DAM-P-MGF-Ostsee will be integral parts of the mission.

WP1 will follow a living lab-type approach, to study, in key regions, how multiple use impacts on biodiversity and abiotic and biotic interactions, locally, and how these impacts can be mitigated through protection measures and management strategies.

WP2 will focus on the impacts of pollutants on the marine environment. It will create the basis to prevent and significantly reduce marine pollution from different sources, but in particular from land-based activities.

WP3 will address the impacts of current and future use on physical, chemical and biological systems on basin scales, and will develop and assess the effectiveness of management options under future climate conditions.

The two Pilot projects DAM-P-MGF-Nordsee and DAM-P-MGF-Ostsee will record the present status and impacts of bottom trawl fishery in selected areas in the North and Baltic Seas.

All WPs will focus on North and Baltic Seas. Selected key regions in West Africa will be addressed by WP1 and WP3.

The WPs will closely collaborate and contribute to the overall aims to develop options for an environmentally safe and sustainable use of marine resources and services, and to maintain a good environmental status. Their results are linked and form the basis for assessments for potential future development as well as recommendations for options of action.

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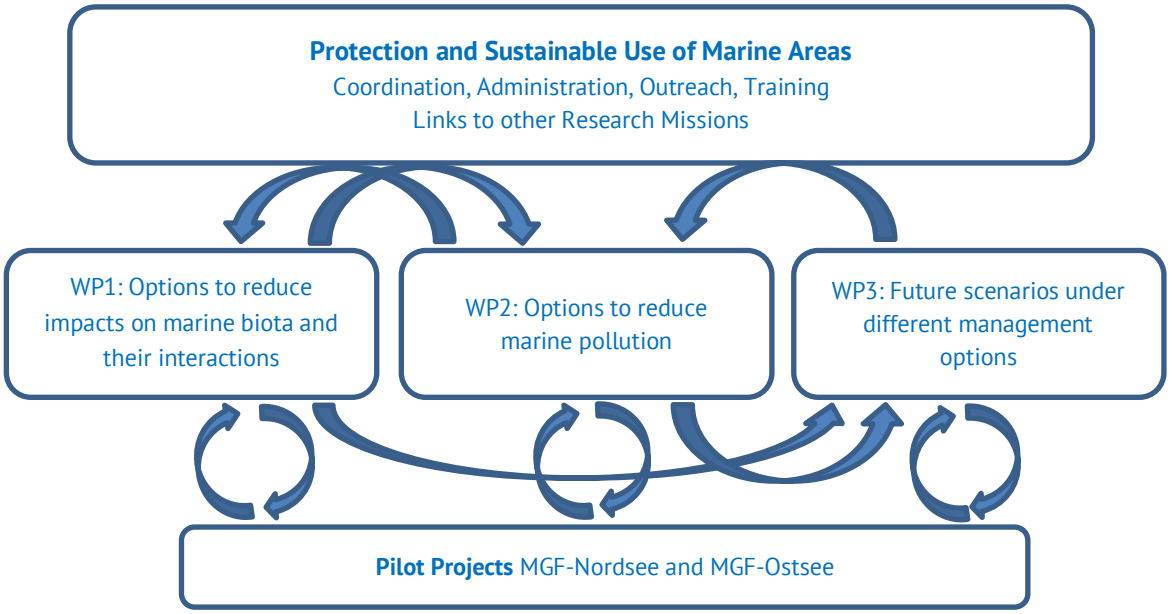

Structure of the proposed DAM Research Mission "Protection and Sustainable Use of Marine Areas"

1.5 Utilization

The major stakeholders are Agencies of the environmental, fisheries, transport and economic Ministries in Germany and West Africa. In Germany these comprise the Federal Ministries for the Environment, Nature Conservation, and Nuclear Safety (BMU; BfN, UBA), of Food and Agriculture (BMEL, vTI), of Transport and Digital Infrastructure (BMVI; BSH, BAW), of Economic Affairs and Energy (BGR), and their counterparts in Federal States (Landesämter). In addition, NGOs are interested in contributing to the discussions. Also trade and industrial associations will be included in order to evaluate potential options for solutions and to consider German economic activities in a global marine context. The outcome of the mission will also improve the prospects for transformative change by providing novel links between science and business, e.g. between wild-capture fisheries and aquaculture, and across geographical space (Österblom et al. 2017). The results of the Research Mission will inform politics on current and potential future human-use and climate stressors also support the development of measures for sustainable use of marine space and resources.

The results of this Research Mission will support the work of the second phase of the EU Marine Strategy Framework Directive after 2020 and provide sound scientific knowledge in order to achieve the demands. Moreover, the results of the mission contribute to achieve the SDGs and help to fulfil the demands of certain goals of the German Sustainable Development Strategy.

The Research Mission “Protection and Sustainable Use of Marine Areas” will also provide a platform in which all stakeholders, from governmental agencies to marine businesses, can engage to find mutually agreeable solutions that resolve use conflicts, help to protect the marine environment and give due consideration to the marine-related economy. The support of the general public for suggested management measures must be sought by broad information and dialogue activities.

1.6 Economic prospects

The Research Mission will help to avoid penalties, which the Federal Republic of Germany will have to pay to the EU if the targets of the Marine Strategy Framework Directive are not met. The mission will further support the implementation of the second phase of the MSFD, provide the knowledge base for the further development of management strategies and will evaluate trade-offs of environmental, societal and economic objectives. Thus, new links to and cooperation with industry need to be established. If necessary and beneficial, companies and businesses can directly be involved in the Research Mission.

Production of renewable ocean energy represents a vital contribution to German and EU CO_2 reduction targets. At the same time, they, as well as other coastal industries, provide economic growth options. Sustainable marine use in general also contributes to broadening and stabilization of local economies in coastal areas. Solutions to maintain and develop the economic base must be found and management strategies need to be developed to handle and balance competing interests and trade-offs. This in many cases concerns small and medium enterprises in fisheries, tourism, sand and gravel extraction etc. located in the coastal federal states, but also in other coastal areas. The Research Mission will contribute to their economic security through the joint development of management options.

1.7 Link to FONA and MARE:N

The research program, MARE:N - Coastal, Marine and Polar Research for Sustainability, was established by the German Federal Government as a component of the "Research Program for Sustainable Development" (FONA) (BMBF 2017). MARE:N addresses topics related to coastal and marine regions and serves as an open, adaptive decision making framework. The Research Mission "Protection and sustainable use of marine areas" directly responds to this as it addresses relevant societal and political topics with the goal of providing decision support for society, government and business. In a transdisciplinary process involving stakeholders from different sectors (society, science, government, and business) this mission will design possible development and action scenarios for sustainable, low-regret use of marine and coastal areas. The Research Mission builds on the Coastal Research Agenda "Küste im Wandel" (KDM, 2018) and is, hence, one way to implement MARE:N in close cooperation with KüNO (Küstenforschung Nordsee-Ostsee) projects. Specifically, the Research Mission contributes to the MARE:N themes

- Ecosystems and biodiversity
- Sustainable use of resources
- Governance and participation

The inter- and transdisciplinary research along the coasts of West Africa will contribute to the Africa Strategy of BMBF 'Creating Prospects! New Impetus for Cooperation with African Partners in Education, Science and Research'. Further it will inform the scientific basis for the implementation of the Ten-point Plan of Action 'Marine Conservation and Sustainable Fisheries' by the Federal Ministry of Economic Cooperation and Development (BMZ) of Germany as well as the Marshall-Plan with Africa of the Federal Government of Germany and support the development of Sustainable Fisheries Partnership Agreements of EU and West African countries.

2 Potential Work Packages

2.1 WP 1: Options to reduce direct impacts on marine biota and their interactions

2.1.1 Summary

WP1 will focus on the cumulative effects, further enhanced by contradictory and competing governance practices, of multiple stressors (including fishing, sand and gravel mining, offshore wind parks, exploration for oil and gas, etc.) on marine ecosystems, functional trait diversity, shifts in biotic and abiotic environment and ecosystem services. The focus on functional trait diversity (which is estimated by the range and values of those species and organismal traits which influence ecosystem functions) is a particularly relevant component of biodiversity here, because it is most directly related to processes that influence ecosystem dynamics, stability, productivity, nutrient and particulate matter balance, and other critical aspects of ecosystem functioning.

Representative locations in the North and Baltic Seas and West African coastal waters will be selected and where possible as a kind of living lab. This includes building explicit stakeholder networks in each region. This represents a first step towards providing options for mitigating impacts in these selected locations, the impacts of the multiple stressors will be mapped. These maps will be temporally dynamic to allow not only the detection of the status, but also the trends

for functional diversity, ecosystem functioning, and the related ecosystem services. Managers, policymakers and other stakeholders require such information to make strategic decisions and monitor progress towards management objectives and options.

WP 1 will quantify, through data analysis and mathematical modelling, how these impacts alter species interactions and the emergent properties of ecosystems based on these interactions. So far, assessments of biodiversity and its associated abiotic and biotic factors often focus on compositional aspects, but the functions of ecosystems and the services derived from them mostly depend on functional traits and the interactions between species. For this, WP 1 will integrate existing information from the systems to determine how functional trait diversity and ecosystem service relationships and shifts in essential abiotic and biotic components change on temporal and spatial scales. This will be used to discern the effects on species interactions. By comparing these aspects with impact maps, WP 1 will provide a spatially explicit knowledge regarding the anthropogenic impact on the functional integrity of biodiversity. These efforts will be complemented by mathematical modelling studies with a solid foundation on trait-based approaches in order to address the impacts of multiple stressors, because the magnitude of cumulative impacts (synergistic or antagonistic) can rarely be assessed from observations alone. These steps require close interactions with stakeholders, which often hold the primary monitoring data in the framework of regional and international agreements.

WP 1 will develop options for mitigating these stressor impacts in close interaction with stakeholders. WP1 will implement the mitigation hierarchy concept (i.e., Arlidge et al. 2018) to guide stakeholders towards limiting the negative impacts on functional trait diversity from non-sustainable resource uses. This concept is designed to facilitate and to achieve net-zero negative or positive impact on functional diversity via strategic decision making about sustainable resource use. WP1 will employ an established sequence of insights via the mitigation hierarchy: 1) Avoidance: measures taken to avoid negative impacts. 2) Minimization: reduce the duration, intensity and/or extent of stressors that cannot be avoided. 3) Rehabilitation/ restoration: improve degraded or removed ecosystems. 4) Offset: compensation for adverse impacts where mitigation fails. In a structured communication concept including scientists and stakeholders, WP 1 will also develop operational goals for these management options as well as criteria of their successful implementation. If feasible within the duration of the mission, the implementation of suitable mitigation solutions can be accompanied by an explicit assessment of their impacts.

2.1.2 Goals

WP1 will directly address the objectives of the UN sustainable development goals (SDGs) and will not only contribute towards the achievement of the SDG 14, but will also consider synergies and trade-offs between SDGs pairs to identify and classify the SDG interactions. This approach will facilitate the attainment of the SDG agenda as identified synergies among the SDGs can be leveraged.

WP 1 will achieve the following goals:

- Acquire the scientific understanding of how environmental stressors affect functional trait diversity.
- Determine the links between functional trait diversity of model organisms, abiotic and biotic factors and ecosystem functions and services.

- Develop maps of impacts from various abiotic and biotic environmental and anthropogenic stressors in a "living lab type situation" of the North and Baltic Seas and of the West Africa region (i.e., Kenney et al. 2017)
- Carry out policy- and practice-level analysis of "de jure and de facto" governance regimes and practices in the North Sea, Baltic Sea and selected West African coastal resource regimes
- Quantify the temporal trends of these impacts and their cumulative impacts on functional diversity and biotic interactions
- Model multiple stressor accumulation, detailing potential synergistic and antagonistic interactions across temporal and spatial scales
- Develop criteria for operational goals for mitigation strategies, which integrate environmental, economic and social elements and assess impacts as well as benefits, (i.e. analyzing trade-offs and synergies)
- Map of the relation (potential co-benefits/synergies and trade-offs) to the SDGs and the German Sustainable Development Strategy.
- Development of a mitigation hierarchy for the different stressors and uses in marine systems and provision of roadmap for decision makers;
- Create roadmaps for decision makers including development and application scenarios and recommendations with the aim to assess the feasibility of potential mitigation strategies and provide a suite of mitigation options ready for implementation and integration in existing governmental structures

Upon achieving these goals WP1 will directly contribute to the second phase implementation of the Marine Strategy Framework Directive (MSFD).

2.1.3 State-of-the-art

Marine systems play and will continue to play a fundamental role in the well-being of people by providing numerous fundamental ecosystem services. These services are a direct or indirect consequence of the interplay of organisms, habitats and their environment in marine systems. Multiple stressors act individually and/or in combination upon/with marine systems and biodiversity. Options, however, for reducing their impacts need to be based on different scales of ecosystem management. Some stressors such as climate change warming, changed hydrography and ocean acidification act on global to regional levels, whereas eutrophication, overfishing and species invasion creates regional impacts and habitat change often leads primarily to local impacts. Strategies to mitigate the impact of stressors on biodiversity and ecosystem service consequently must consider this scale-dependence, even more so as the management of coastal areas also arises from a complex governance structure with formal, national and international regulations. Research on the links between anthropogenic impacts and biodiversity often ignore the relevant components of biodiversity (i.e. functional diversity, which is most directly related to critical aspects of ecosystem functioning like, for example, stability, productivity, and nutrient balance), lacks an explicit spatial dimension, overlook the interplay of multiple simultaneous stressors, and fails to extend inference to ecosystem services, biodiversity conservation and sustainable resource use.

Society faces a fundamental problem: How do we manage ecosystems to protect functional diversity and the services they provide? A major societal challenge of the current century is to ensure a sustainable provision of essential ecosystem services. This includes provision (e.g., food provision), regulation (e.g. flood and climate regulation), and cultural (recreational and spiritual wellbeing) services, all of which are compromised by a growing population and unprecedented rates of environmental change and biodiversity loss.

Analysis and mapping of environmental changes and human impacts in the marine environment is developing rapidly since the past 15 years and can provide information relevant to biodiversity and ecosystem management and conservation efforts (i.e., Halpern et al. 2008, Andersen et al. 2015, Halpern et al. 2015).

The living labs identified in the North Sea and Baltic Sea as well as in African Waters are well characterized by past, ongoing and future monitoring activities (BFN 2017, 2018; DAM Pilot Projects). Providing a catalogue of multiple stressors, their interactions and mitigation options will identify factors and actions that support enhanced adaptive capacity and a sustainable development of a blue economy and support national and international biodiversity action plans, aiming to integrate biodiversity thinking into the areas of e.g. conservation and sustainable use of natural resources, fisheries and aquaculture.

We lack sufficient, mechanistic and reliable knowledge about the link between functional diversity, fragmented coastal resources management regimes, ecosystem services and the different stressors. We must understand how ecosystem services emerging from functional diversity drive the total service provision and how this is challenged by different stressors and their respective impacts. WP1 will employ a transdisciplinary and cross-ecosystem approach to develop the mechanistic knowledge of how different stressors constrain the success and failure of efforts to conserve the relationships between biodiversity and ecosystem services (BD-ES).

Large Projects: **Coastal Ocean Darkening** (MWK, Lower Saxony), **DynaCOm** (DFG Research Unit), **HARMONY** Project (EU MSP Platform), BONUS **INSPIRE, BLUEWEBS, TRIATLAS, MISSION ATLANTIC (EU HORIZON 2020**)

2.1.4 Milestones and Deliverables

The milestones and deliverables of WP1 are:

Milestone	**Deliverable**	**Timing** (in Month)
Selecting “Living Labs” in each of the three regions (North Sea, Baltic Sea, West Africa)		M6
“de jure and de facto” assessment of prevalent management regimes for key coastal resources		M12

Developing stakeholder integration concept	Stakeholder workshops Reports on stakeholder demands and expectations Roadmap for continuous exchange with stakeholders	M3, 6 &9
Data and observatory accessibility provided	Knowledge network on existing data and observatory output on stressors and their impacts	M12
Mapping stressors and their respective cumulative impacts on biotic and abiotic structures in the selected living labs	Impact maps with explicit spatial and temporal scales	M12
Impact analysis of multiple stressor impacts on biodiversity, ecosystem functioning and ecosystem services	Data dissemination and synthesis Publications of data (open access) and outcome of analyses	M24
Modelling cumulative impacts	Open access model on synergistic and antagonistic impacts of multiple stressors	M24
Development and analysis of mitigation strategies and options with stakeholders	List of mitigation options and strategies Reports from stakeholder workshops & engagement activities	M12,24,36
Selection/proposal of mitigation options ready for implementation and integration in existing governmental structures	Publication of Mitigation Strategy and Options Catalogue; Roadmap for decision makers for options of actions and strategies	M36
Outreach activities as input to the central task *Knowledge Transfer (see section 3.3)*	Various activities in coordination with the central task *Knowledge Transfe*r, e.g. Science Policy Forum and Policy Brief; Contribution to the second phase of the implementation of the Marine Strategy Framework Directive	every 6 months

2.2 WP 2: Options to reduce marine pollutants

2.2.1 Summary

A key goal of the UN 2030 Agenda for Sustainable Development is to take actions for improving ocean health (SDG 14). As prime measures to avoid significant adverse impacts, SDG14 calls for the reduction and prevention of marine pollution and the conservation of coastal and marine areas. Achieving this goal requires an improved understanding of the interactions between the pollutants,

also in concert with other stressors, of the contamination pathways from the terrestrial source via rivers and air into the coastal seas, and of the consequences on downstream marine ecosystems.

In this context WP2 will create the basis to prevent and significantly reduce marine pollution from different sources, but in particular from land-based activities. It will address emerging "new pollutants", such as plastic litter (including chemical additives) and other debris, pharmaceuticals (e.g. antibiotics, endocrine disruptors, etc.), UV-filters, ammunition residuals as well as other pollutants of ongoing concern (nutrients, heavy metals, POPs). Aims of WP2 are to prioritize pollutants according to their toxicological potential and develop pollution reduction scenarios for selected relevant substances. Distribution pathways of these substances from sources to sinks and their impacts on marine ecosystems will be assessed. This should include risk assessments and also take possible transformation products and combinatory effects into consideration. The research will be carried out in selected regions, but especially considering the coastal transition zones. Options to avoid the release of the prioritized pollutants into the coastal seas will be developed and tested for feasibility and effectiveness.

WP2 will deliver an assessment of the regional distribution and concentration of the selected pollutants and its effects on marine life. Concepts for reduction or avoidance of harmful substances in the sea will be developed. Consultations with stakeholders (including involvement of citizens) are an important aspect of this work package to provide politics with tools and facts for appropriate decision-making. Overall, WP2 will work towards delivering for the key goal of SDG 14, i.e. the reduction and prevention of marine pollution and the conservation of coastal and marine areas, and the German Sustainability Development Strategy.

WP2 will closely collaborate with the pilot-projects MGF-Nordsee and MGF-Ostsee.

2.2.2 Goals

WP2 will achieve the following goals:

- Provide baseline information for different pollutant classes for the evaluation of existing and future regulations.
- Assess the distribution and concentration of a specific pollutants or pollutant classes in a selected coastal region and investigate their origin, transport pathways, natural attenuation or amplification processes.
- Establish publicly accessible data and sample archives for future retrospective assessments.
- Identify which organisms and ecosystem functions are affected by the selected pollutant or pollutant class
- Prioritize pollutants or pollutant classes concerning toxicological potential
- Develop and prioritize concepts for the reduction or avoidance of release of pollutants into the marine environment
- Analyze reduction concepts with respect to environmental, social and economic aspects

By achieving these goals, the project will directly contribute to the second phase of the implementation of the Marine Strategy Framework Directive (MSFD) of the EU and support the UN SDG 14 and the national German Sustainability Development Strategy.

2.2.3 State-of-the-art

The *Chemical Anthropocene* (the time period wherein man-made pollution reached a global dimension) is characterized by the invention, production and release into the environment of a plethora of synthetic substances. Coastal systems receiving river discharges and pollutants transported through the atmosphere can be seen as hotspots for the release of pollutants into the greater marine system. Among the many substances giving rise to public concern and having adverse effects on organisms, ecosystems, and living resources are plastic litter, novel and emerging pollutants currently not monitored in standard environmental monitoring programs, and ammunition - a historical legacy. They are the first substances to be addressed by the Mission.

A large body of research is presently available for information on plastic litter (e.g., Andrady, 2015; Van Sebille et al., 2015). Studies of effects of plastic litter on marine life and human health are also available from national and international research (e.g., Burns et al., 2018; Nauendorf et al., 2016; Werner et al., 2016). However, knowledge gaps continue to exist on several aspects, such as accumulation in the food web and trophic transfer, quantitative material fluxes and involved time scales from the various terrestrial sources into the sea, as well as secondary effects in the marine environment (e.g. colonization of pathogens on biofilms). Currently, these prevent the development of effective pollution reduction scenarios. Analytical expertise for plastic litter, such as quantitative extraction protocols from different matrices and spectroscopic analysis for microplastic as well as photographic analysis for macroplastic is available at several marine institutes in Germany.

Large Projects: **BASEMAN, WEATHERMIC, EPHEMARE, PLASTOX, HOTMIC, FACTS** (all funded through JPI Oceans/BMBF)

Assessments of release and impacts of novel pollutants, among them pharmaceuticals, antibiotics etc, in aquatic systems are available (e.g., Emeis et al., 2015; Kötke et al., 2019). Due to continuously changing production patterns of industry in response to scientific development or regulatory action (Council of the European Union, 2019; European Chemicals Agency, 2019) these pollution patterns evolve and diversify and new man-made substances such as nano materials, personal care products and other “exotic” new chemical molecules enter the environment via different pathways (e.g., Kümmerer et al., 2019). Only limited data on such new pollutants is available at present, in particular due to a lack of suitable, sensitive analytical techniques.

Large Projects: **BONUS Balthealth** (BMBF, UBA); **NOAH** (BMBF); **Toxische Wirkung von Schadstoffen im Modellsystem Fischembryo** (BMEL)

Records of ordnance disposal provide accurate information on locations of ammunition in the North Sea and Baltic Sea and are monitored by governmental authorities. High-resolution side scan sonar images to assess ammunition dump sites as well as first attempts to determine the impact of deteriorating ammunition housings on the marine environment and human health were carried out by German institutes (project **Munition im Meer**; Beck et al., 2018). Relevant data are available from a variety of sources and can be compiled as a basis for developing options for the protection of the marine environment and human health.

2.2.4 Milestones and Deliverables

The milestones and deliverables of WP2 are:

Milestone	**Deliverable**	**Timing** (in Months)
Compilation of pollutant monitoring data from past and present studies	Map of distribution patterns and distribution history	M 6
Distribution patterns of harmful substances in selected regions	Map of distribution patterns	M 12
Assessment of impacts on the marine ecosystem or on organisms from literature or new studies	Compilation of environmental impacts (including related social and economic aspects)	M 18,24
Consultation with stakeholders regarding real or perceived impacts	Reports from stakeholder workshop; Overview on real or perceived impacts	M 24
Development of different options of actions and strategies to reduce harmful substances	Concept of options of actions and strategies	M 30
Discussion of feasibility of different options of actions and strategies with stakeholders	Reports from stakeholder workshops; Ranking of options regarding their feasibility	M 33
Testing of options of actions and strategies in selected regions in consultation with stakeholders	Reports from stakeholder workshops and test result	M 36
Outreach activities for the general public as input to central task *Knowledge Transfer* (section 3.3)	Various activities in cooperation with the central task *Knowledge Transfer*; Contribution to the second phase of the implementation of the EU Marine Strategy Framework Directive	every 6 months
	Roadmap for decision makers for options of actions and strategies for reduction of marine pollutants (Concept paper)	M 36

2.3 WP 3: Future scenarios of human use and options for management

2.3.1 Summary

In WP3 local and remotely acting man-made pressures will be assessed and upscaled using advanced cross-scale modelling. Upscaling and assessment will consider the full physical, chemical and biological chain of effects and consider as well far field and remote effects. Climate and man-made pressures will be disentangled, and the effect of protection measures will be assessed for entire populations and ecosystems through application of a combination of coupled regional model systems and novel end-to-end ecosystem models including all trophic levels up to top predators such as marine mammals. Cumulative risks to the diversity and functioning of benthic and pelagic communities will be tracked through the marine food web, biogeochemical cycling and the hydrodynamic environment. System feedbacks within the pelagic and benthic system, the benthic-pelagic coupling as well as remote effects will be resolved through coupled model simulations. WP3 will moreover resolve the sensitivity of ecosystem components to projected physico-chemical alterations (e.g., replacement of species due to pollution and warming), and the related possible amplification of stressors, and will track changing biodiversity and its effect on ecosystem functioning.

Moreover, future scenarios for human use will be developed for the North and Baltic Seas and for selected marine regions off the coasts of West Africa. The scenario development for future human-use will be based on national and international policy goals and will consider different economic growth scenarios. Future human-use scenarios will be combined with future climate change predictions and projections for the near future (next 30-50 years) and downscaled to the regional ecosystems to assess the future challenges management has to deal with. Different management pathways will be tested for these future scenarios to increase the knowledge base for sustainable management. The final goal of WP3 is the identification of management strategies, which minimize impacts and trade-offs under increasing human use while developing and maintaining economic prospects. Future ecosystem status and health will be explored under different management pathways and strategies for improved management will be identified. Intense and continual communication with relevant institutional, industrial and societal stakeholders as well as national and international expert groups will ensure seamless transfer of results to marine spatial planning.

WP3 will closely collaborate with the pre-projects MGF-Nordsee and MGF-Ostsee and builds upon and synthesize results of relevant ongoing and funded projects funded under FONA, Mare:N and KüNO (call 2019, under evaluation) and projects funded by BMU and BMVI and on institutional funded programs.

2.3.2 Goals

WP3 will achieve the following interlinked goals for the marine and coastal ecosystems of North Sea, Baltic Sea, and selected key regions of the coast of West Africa.

- Develop ecosystem models to enable assessment of basin scale ecosystem impacts and protection measures from physics throughout the entire food web.
- Assess impacts of human-use on ecosystems and populations on basin and multi-national scale. Identify long-range effects and feedbacks of human use and protection

measures such as marine protected areas and investigate suggested additional protection measures on basin scale.

- Disentangle effects of climate, man-made pressures and protection measures on the ecosystem services and key selected species.
- Develop future human- use scenarios management may have to deal with and assess how these will impact marine and coastal ecosystems under current regulations and management systems.
- Identify combined human use and future climate change impact scenarios on management relevant time scales from decades to multi-decades and estimate uncertainties of these projections.
- Consider different management strategies within MPAs (in close cooperation with WP1 above) and assess the trade-offs and multiple risks of human-use.
- In collaboration with WP1 above, explore how current spatial management approaches such as MPAs and MSP (Marine Spatial Planning) can be further developed to consider multiple-use and to minimize multiple stressor impacts in spatially and temporally changing marine and coastal environments.
- Provide knowledge based on modelling to decision makers to accompany and support the implementation of the second phase of the Marine Strategy Framework Directive in European Waters and the exploration of management options for West African waters.

By achieving these goals, WP3 will directly contribute to the second phase implementation of the Marine Strategy Framework Directive (MFSD). Through the timely identification of future multiple use management strategies, which minimize the impacts and trade-offs, WP3 will directly support the EU Blue Growth strategy and EU climate action targets and the UN sustainable development goals (SDGs) 13 and 14.

2.3.3 State-of-the-art

The EU Blue Growth strategy and EU climate action targets are significant drivers of offshore industrialization, which will considerably increase man-made pressures in the coastal ocean. In combination with future climate change, which will impact coastal ecosystems significantly (e.g. Chust et al., 2014), blue growth poses yet unknown challenges for marine management. Today no comprehensive modelling tools exist, that are suitable for the assessment of human use ecosystem impacts on basin scales, which resolve the entire chain of impacts from physics to the food web, resolving feedbacks between physical, chemical and biological processes. So far modelling has only covered parts of the impact chain and comprehensive scenario assessments combining future human use and climate impacts on management relevant time scales are lacking.

Specific challenges in managing the marine ecosystem are related to the dynamics of the marine environment (Bode 2018), which challenges sustainable resource management under human use and climate impacts. Marine ecosystems and populations are spatially connected, and individuals migrate into and out of MPAs. Water mass transport connects MPAs with unprotected areas outside. Moreover, ecosystems and populations are substantially influenced by weather and climate, which challenges the assessment of management measures.

Marine ecosystem models coupling physics, biogeochemistry and the marine food web are powerful tools to integrate knowledge and data and offer the potential to predict how marine ecosystem will respond to future scenarios thereby supporting the implementation of ecosystem-based management. However, they often treat trophic levels separately and seldom link 3-d high resolution hydrodynamics with end-to-end food web models, which cover the entire food web from microbes to apex predators (Heymans et al., 2018; Piroddi et al., 2015) which limits the potential of one-way coupled food-web models compared to full end-to-end models measure (Daewel et al., 2019) thereby constraining proper assessment of risk and trade-offs related to the increasing amount of human activities in the sea.

Comprehensive assessments of man-made pressures are still scarce (Andersen and Stock, 2013) and basin-wide effects and spatial connectivity remain largely unconsidered. Human-use develops rapidly and basin wide assessments of current man-made pressures are intermittent and do not keep pace with actual developments (e.g. Andersen and Stock, 2013). Information on human-use is e.g. available through EMODNET (http://www.emodnet.eu/) but has to our knowledge not used for comprehensive pressure assessment on ecosystems and populations, nor have consistent human-use scenarios been compiled as a base for future challenges in management.

In addition to human-use, future management has also to deal with impacts of climate change. Although, first climate change scenarios became available in the past years, downscaling future climate impacts to regional marine and coastal ecosystems is still in its infancy and fundamental challenges, such as the land-ocean coupling or the regional atmosphere-ocean coupling still limit the validity and robustness of currently available climate change downscaling (Schrum et al., 2016; Meier et al., 2019a). The effects of future climate have been studied at the organismal or species levels (Catalán et al., 2019), but we are still lacking holistic assessments of its potential impacts on complex coastal ecosystems. Combined climate and human use scenarios considering fisheries and river load scenarios have been investigated for the Baltic using a one-way ecosystem modelling approach (Bauer et al., 2019), thereby neglecting top-down control on lower trophic level dynamics and biogeochemical cycling. Potential impacts from offshore industrialisation so far remain unconsidered. Climate change and man-made pressures affect the abiotic as well as biotic ecosystem compartments and impacts are often indirect and remote and positive and negative feedback may occur (eg. Meier et al., 2019b, Floeter et al., 2017; Rennau et al., 2012; Daewel and Schrum, 2017; Andersen and Stock, 2013). Furthermore, multiple stressors can interact at various spatial and temporal scales.

Relevant current projects: BMBF- **SeaUseTip**; BMBF - **marEEshift**; BMBF- **MiMeMo, BMBF-ClimXtreme, DFG-Excellence Cluster an der Universität Hamburg, CLICCS;** SeasERA-**SEAMAN,** EU-**CERES, EU-H2020-WAVEFLOW,** EU-H2020-**TRIATLAS**, Bonus-**INSPIRE,** BONUS-**BALTICAPP,** Copernicus- **ZOOMBI,** UBA- **MOBENSEUT,** BSH-**MarEns,** BMWi-**WIPAFF**

2.3.4 Milestones and Deliverables

The milestones and deliverables of WP3 are:

Milestone	**Deliverable**	**Timing** (in Month)
Develop scenarios and modelling strategy	Road Map for climate, human use and management scenario development and a seamless modelling strategy to consider global-regional and local scales as well as end-to-end ecosystem impacts within an interlinked modelling strategy	M12
Map current human use and management on basin scale	Report and data compilation of current management, regulations and human use on basin scale to inform policy and provide input data for modelling	M18,24
Quantify current human use and management impact/success on basin scale	Overview on estimated physical, chemical and biological impacts of human-use on ecosystem services on basin scale for national and international waters	M30
Identify novel future management concepts	Novel future management concepts considering multiple use and multiple stressors as well as trade offs	M30
Establish future scenarios for climate and human use and assess consequences of different management strategies	Scenarios for combined climate and human-use future management has to deal with and assess consequences of different management strategies within the scenario approach	M36
Outreach activities for the general public as input to the central task *Knowledge Transfer* (see section 3.3)	Various activities in coordination with the central task *Knowledge Transfer*; Contribution to the second phase of the implementation of the Marine Strategy Framework Directive	every 6 months
Synthesis and identification of options for actions	Roadmap for decision makers with options for action and recommendations for future management	M36

2.4 The Pilot Projects MGF-Nordsee and MGF-Ostsee

Two pilot projects are already installed to provide a comprehensive baseline analysis of the environmental conditions in and outside of protected areas (MPA) and its development after the exclusion of bottom trawling fisheries. The pilot projects investigate in selected areas (as kind of real labs) of the North Sea and Baltic Sea:

- physical, chemical and biotic effects,
- food web analysis,
- impact on microbiota,
- fluxes of energy and substances.

They provide high quality descriptions of the present status and of the impacts of bottom trawl fishery in the selected areas. In cooperation with WP1 and WP2 of this Research Mission further analysis of other external impacts on the MPAs and the resulting effectivity of the protection measures can be made. On that basis, further suggestions for protective measures will be made. In the future, the long-term development and potential recovery of the environmental status within MPAs and effects to neighboring habitats will be a task of this Research Mission after termination of the pilot projects.

3 Central tasks

Central tasks of the Research Mission comprise research infrastructure, data management, knowledge transfer as well as general management. These central tasks serve all work packages of the Research Mission and are carried out in close cooperation with the DAM head office, which fulfils a coordinating role across all Research Missions.

3.1 Research Infrastructure

The basis for past and future success of research in the mission theme has been and remains to be, access to modern sea-going vessels, observatories, data sets and other large infrastructure designed for specific areas and types of operation. Sophisticated ship-based and autonomous sampling and in-situ analytical tools will be required for analyzing important physico-chemical and biological parameters. Furthermore, high-performance computer resources are required for data analyses and modelling at increasingly complex and high-resolution levels. The following infrastructures are likely to be required:

- ship-time primarily for coastal or shelf sea investigations
- underwater camera systems, side scan sonars, in situ measurement modules, diverse biotic and abiotic sampling systems
- large analytical instrumentation (e.g., FT-IR and Raman microscopes, chemical analytics, genomic analytics)
- large scale data dissemination Systems and Products
- high-performance computing facilities

The infrastructural needs will be determined by the project proposals for WP 1-3 and will be applied in the context of the specific research demands of the WPs.

3.2 Data Management

Data acquired within the WPs will be managed in agreement with the General Data Protection Regulation (GDPR) (EU) 2016/679, the latest EU law on data protection and privacy for all individuals within the European Union (EU) and the European Economic Area (EEA). Data collected and model data produced in the course of the mission will be made available adhering to the FAIR (Findable Accessible Interoperable Reusable) principles. Each WP has to provide a data management plan in agreement with the above regulations and in close collaboration with the data management central task. Within the WPs, quality control of data and a workflow for delivery of data from observation to archive and to product will be defined.

The central data management of the Research Mission will deal with compatibility of data from the different WPs of the Research Mission, will develop overarching data products and provide input for transfer activities. Mission specific data products and services, or advanced tools for data visualization will be developed in collaboration with the proponent scientists and with respect to their needs.

The DAM-data management team will provide support and advice to the research missions regarding acquisition, harmonization, assimilation, formatting, processing, archival, integration, quality control and documentation. The team will also provide for the Research Mission the processes for findability and access to data as well as interfaces to international data portals and link to the “Nationale Forschungsdateninfrastruktur”. Mission-guidelines for immediate sharing, for online access, long-term preservation and dissemination will be developed.

3.3 Knowledge Transfer

The main objectives of the Research Mission were developed in cooperation with stakeholders. As part of the transdisciplinary approach of the mission, the exchange of knowledge with stakeholders, in particular with authorities from the fields of the environment, fisheries and industry as well as NGOs and trade associations will be intensified. The aim of the knowledge exchange is to ensure that practical expertise is integrated into the research projects, that science-based options for action are developed in a targeted manner and that they find their way into relevant user groups, institutions and political processes.

As a central activity of the Research Mission, the results of the WPs will be compiled and used for transfer to different user groups. In order to arrive at these overarching results for the protection and sustainable use of the marine areas, a summary retreat of all participating groups will be held. This will have the task to develop the major concluding statements and summaries for stakeholders and public employing the formats indicated below.

Stakeholders:

- Establishment of **Stakeholder Reference Groups (SRG)** to co-develop and assess region-specific options for sustainable use of marine services and resources. Such a group brings together relevant stakeholders from government institutions as well as representatives from business, NGOs and other civil society groups for goal-oriented dialogues.

- Development of **synthesis formats** to "translate" the necessary knowledge base for the stakeholder dialogues and to present the results in a target-group-specific manner and integrate them into the politically relevant processes.
- Development of appropriate **visualizations** to illustrate complex relationships and possible scenarios (e.g. info-graphics, animations, virtual reality and augmented reality formats).

General public:

- An **online information portal** integrated into DAM will present topics and results of the mission as easily understandable information. Social media channels draw attention and offer opportunities for communication.
- Clear and user-friendly **model and data products** aimed at dissemination of information will be produced for managers and other stakeholders.
- **Participation formats** are of particular importance and will be developed together with regional partners. It will include dialogue events to include citizens of the regions where the Research Mission is active, active citizen involvement in observations or one's own sustainability action, exhibitions in cooperation with the associated partner museums.

Capacity Development:

- Development of **digital materials and products** for pupils and teachers including modern visualization techniques.
- The expertise and dissemination opportunities of the **established student laboratories, centers of excellence** and other educational programs of the DAM members will be incorporated.
- Comparative studies in developing countries, for example along **African** coasts should include also capacity development in cooperation with partners in the region.

3.4 Management

The Research Mission requires coordination and close linkages between the work packages of the Mission. This is also the case with regard to the parallel Research Mission "Marine Carbon Sinks in Decarbonization Pathways" and with the activities of the DAM office. For these tasks a small central management unit will be installed. The affiliation of the Mission management will be negotiated among the funded projects and DAM. The responsibility of the Mission management includes the organization of coordination among the projects including the arrangement of cross project workshops, the organization of joint reporting of the Mission, support for individual project reporting, developing and keeping contacts with stakeholders, organization of Mission and stakeholder workshops for the projects and mission. Moreover, the coordination should develop measures for the fast exchange of information between the projects and provide regular science updates through the DAM website.

4 Budget Plan

The budget plan for the Research Mission is shown below (all costs are given in kEuro).

	2020	2021	2022	2023	*Sum*
Work packages					
Work Package 1	0	1,440	1440	1,970	4,860
Work Package 2	0	1,440	1440	1,970	4,860
Work Package 3	0	1,440	1440	1,970	4,860
Pilot Projects	1,600	2,000	2,000	400	6,000
Central tasks					
Research Infrastructure	0	0	0	0	0
Data Management and Digitalization	0	180	180	180	540
Knowledge Transfer	0	300	300	300	900
Management	0	200	200	210	580
Sum	**1,600**	**7,000**	**7,000**	**7,000**	**22,600**

The budget plan considers the three work packages equally and includes the two already active pilot projects. The budgets for the central tasks are required for the objectives described in section 3. They are applied for separately to support the management of the Research Mission and have to be further specified in the proposal for the coordination and management team of the Research Mission. A budget for infrastructure is not shown as a central task as infrastructure needs have to be applied for within the WPs.

The budget for data management and digitalization comprises funds for data personnel, programming and software, and several workshops per year. The central Research Mission's data management works in close collaboration with the WPs and their data management plans.

The budget for transfer comprises funds for developing synthesis formats, providing input for an online information portal and developing digital materials. Further personnel costs are planned for developing stakeholder contacts and participation formats, potentially with a focus on Africa.

The budget for the central management of the Research Mission comprises the position for one coordinating scientist as well as funds for annual joint meetings, specific workshops, synthesis retreat, travel costs, reporting, organization of stakeholder reference groups.

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