BONUS

SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

STRATEGIC RESEARCH AGENDA 2011-2017

The joint Baltic Sea research and development programme

BONUS PUBLICATION NO. 12

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BONUS vision

Economically and ecologically prosperous Baltic Sea region where resources and goods are used sustainably and where the long-term management of the region is based on sound knowledge derived from multi-disciplinary research.

BONUS brings together the research communities of Earth system research in marine, maritime, terrestrial, economical and societal fields to address the major challenges faced by the Baltic Sea region.

The main aim of BONUS is to generate and disseminate knowledge and provide necessary know-how in order to resolve successfully **major challenges** facing the Baltic Sea region in the coming decade and beyond:

- **Adapting to the climate change and its effects**
- **Restoring good environmental status of the Baltic Sea and its coasts**
- **Achieving sustainable and safe use of the exploited coastal and marine ecosystem goods and services**
- **Creating cost-efficient environmental information system**
- **Evaluating and developing relevant policies and collective governance**
- **Adapting to a sustainable way of living**

The content of this BONUS strategic research agenda 2011-2017 is policy-driven and solution oriented. Its overall framework consists of five **main strategic objectives** that correspond to the major challenges (above):

1. **Understanding the Baltic Sea ecosystem structure and functioning**
2. **Meeting the multifaceted challenges in linking the Baltic Sea with its coast and catchment area**
3. **Enhancing sustainable use of coastal and marine goods and services of the Baltic Sea**
4. **Improving the capabilities of the society to respond to the current and future challenges directed to the Baltic Sea region**
5. **Developing improved and innovative observation and data management systems, tools and methodologies for marine information needs in the Baltic Sea region**

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Preface

Since its inception in June 2010 by the co-decision of the European Council and Parliament, much of the focus of BONUS, the joint Baltic Sea research and development programme 2010-2016, has been in developing the strategic research agenda jointly with the stakeholders across the Baltic Sea region.

Over the past year, the scientific community, policy makers and funders have come together expressing their strong support for the sustainable, knowledge-based governance of the Baltic Sea region and laid the foundation of the future research programme. BONUS has provided a common vehicle for key actors to share and coordinate the most critical research needs and contribute to the common goal of ensuring a better future for the Baltic Sea region.

During the summer months 2010, BONUS ran an open poll for suggestions for research themes and received nearly 200 suggestions through an online consultation, majority from the Baltic Sea region's scientific community.

In late summer 2010, dedicated national representatives, the BONUS advocates, commenced their work in each of the eight EU (and BONUS) member states around the Baltic Sea. Starting from autumn 2010, significant work was carried out in regards of mapping and analysing the key stakeholder landscape. The advocates organised national workshops and defined research priorities involving over 700 policymakers and members of the scientific community.

In October 2010, at the BONUS Forum in Tallinn, representatives of ministries across sectoral borders of the nine Baltic Sea countries – environment, transport, agriculture, forestry and science – convened for the first time to define research needs from different sectors' perspectives.

To complete the process of region-wide programme, 70 country representatives from the nine Baltic Sea coastal countries (eight EU member states + Russia) came together in March 2011 at the Strategic Orientation Workshop held in Latvia. The participants considered the open poll results, the national workshop reports and the BONUS Forum 2010 outcomes, and together confirmed the broad strategic research agenda themes for the years to come.

The BONUS Steering Committee approved the agenda in August 2011. The next review of the agenda will take place in 2013, again through a transparent and flexible process that will involve key stakeholders and take into account future knowledge demands.

The BONUS Steering Committee would like to thank all those who have provided their valuable input and contributed to realising this strategic research agenda: the members of the scientific community, and others who submitted proposals to the open poll in the summer 2010; the BONUS advocates and their respective networks that were consulted through the workshops and other consultations carried out in all eight BONUS member countries; the participants of the BONUS Forum who convened in autumn 2010 in Tallinn; the participants of the Strategic Orientation Workshop held in March 2011 in Latvia; the EU Commission services which supported this work and the national funding institutions who made this all possible.

Also, a big thank you goes to the members of the dedicated drafting team who, together with the Secretariat and based on the knowledge and information obtained throughout this process, prepared the materials for consideration of the March 2011 Strategic Orientation Workshop.

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Executive summary

The Baltic Sea region forms a complex system, both in its biological and physical properties that involve many inter-connected pressures as well as in its complex policy situation. In the coming decades, global change, including climate change, and long-term as well as long-range influences are likely to intensify and thus will put additional external pressures on the Baltic Sea region.

Entangled and complex issues in the Baltic Sea system – as part of the Earth system – require strong cooperation. Despite environmental protection efforts by the countries surrounding the Baltic Sea, stretching today across several decades, society has not found efficient solutions to sustain the health of the Baltic Sea ecosystem. Examples of missing solutions to current and emerging environmental and sustainability issues in the Baltic Sea area are many as are the related knowledge needs. The main aim of BONUS, the joint Baltic Sea research and development programme 2010-2016, is to respond to this unsustainable situation through a strong cooperation across the region and consolidate the joint research effort on a macroregional level. While the macroregional approach is in the core of the BONUS programme, it also draws from and complements the national marine research programmes of the participating countries. BONUS generates and disseminates knowledge and provides necessary know-how in support of knowledge-based governance and long-term solutions beneficial to the Baltic Sea region.

The policy landscape of today, with relevance to the sustainability of the Baltic Sea region, is a combination of Baltic Sea regional, European and global initiatives that provide some key mechanisms to meet the challenges. In addition, the EU framework provides a mechanism to combine national research funding in favour of transnational, cross-sectoral and trans-disciplinary work of BONUS. This work is carried out in support of the implementation of the Baltic Marine Environment Protection Commission's (more widely known as the Helsinki Commission, or HELCOM) Baltic Sea Action Plan and integrated policy approaches adopted by the European Union, such as the Water Framework Directive, the Integrated Maritime Policy (with Marine Strategy Framework Directive as its environmental pillar) and the Roadmap for Maritime Spatial Planning. In this context, the development of a European macroregional policy within the Baltic region, in particular, is viewed as a pioneering activity and of critical importance.

Integrated approaches and integrated research for the Baltic Sea system are required at several levels in order to understand and predict global change in the Baltic Sea region. Also needed is a full understanding of the Baltic Sea system in connection with relevant societal options for planning and remediation. In particular, it is important for BONUS to work together with relevant stakeholders in defining the knowledge needs and provide them with an opportunity to participate in shaping the strategic research agenda and exploiting its outcomes.

The overall framework of the BONUS strategic research agenda 2011-2017 consists of five main strategic objectives that form the backbone for a total of 19 specifically defined themes.

The first strategic objective is to understand the complexity of the Baltic Sea ecosystem structure and functioning

The Marine Strategy Framework Directive calls for implementing an ecosystem-based approach to management of the human activities and pressures affecting the marine environment. This is not achievable without a better understanding of the complex processes that shape the structure of the marine ecosystem and determine its functional characteristics.

New knowledge about the Baltic Sea ecosystem is necessary for implementing the leading environmental policy initiatives aiming to achieve good environmental status of the Baltic Sea, the Marine Strategy Framework Directive and the Baltic Sea Action Plan.

The research will address the principal knowledge gaps related to the implementation of these initiatives, namely ecosystem's resilience and dynamics of biogeochemical processes, changes in biodiversity and food webs, and the impact of hazardous substances.

The second strategic objective aims to meet the multifaceted challenges in linking the Baltic Sea with its coast and catchment area

This strategic objective will be addressed by studies where either the entire catchment-coast-sea continuum is considered or catchment-related topics are in focus. The BONUS research will include research dedicated to the catchment of the sea and beyond where a clear direct or indirect linkage to the ecosystem of the Baltic Sea (including the sea and its coasts) is demonstrated or can be expected with a reasonable level of confidence.

The research will address impacts of natural and man-induced changes in the catchment land-cover patterns and responses of coastal systems to changes in climate and human-induced pressures. Also, new knowledge will be produced on integrated approaches to coastal management, spatial planning and water quality improvement along the catchment-coast-sea continuum. Furthermore, ecoinnovative approaches with strong contribution from small and medium size enterprises of the region to achieve a good environmental status in the Baltic Sea are called for.

The goal of the third strategic objective is to enhance sustainable use of coastal and marine goods and services of the Baltic Sea

Shipping and fisheries (including aquaculture) are the most traditional and yet most intensively exploited marine goods and services. Despite the decades-long effort by governments of the Baltic Sea states, neither shipping nor fisheries can be regarded as being managed in a way that secures safety of operations or sustainability.

In order to fulfill the objectives of the Baltic Sea Action Plan, and the EU Marine Strategy Framework Directive and to implement successfully the revised EU Common Fisheries Policy, fundamental improvement in management of both interlinked sectors and the technologies applied therein are required.

As new ways to utilise coastal and marine goods and services expand dynamically, e.g. harvesting of renewable energy, offshore mining, coastal protection, marine biotechnology etc., also the BONUS strategic research agenda will require further development in regards of the associated research needs.

The fourth strategic objective is to improve the capabilities of the society to respond to the current and future challenges directed to the Baltic Sea region

Societal characteristics and individual attitudes and behaviour are the main drivers that determine the environmental state of the Baltic Sea. Therefore, responses to the main problems in the Baltic Sea need well-performing institutional solutions and governance structures that take into account the various current political and administrative settings in the Baltic Sea region. New institutions are needed that perform better than earlier ones in relation to the environmental state of the Baltic Sea.

With the help of science, models to support management of the most critical natural and human induced threats to the marine environment will be identified and developed. Policy makers need to know the benefits derived from the ecosystem goods and services as well as the costs involved in protecting or improving them. In response to societies' ever intensifying and diversifying interest and capacity to occupy marine space, maritime spatial planning has only recently emerged globally as a cross-sector governance tool. The performance of different planning systems will be analysed and compared in order to set sensible targets and develop optimal tools for the Baltic Sea.

The goal of the fifth strategic objective is to develop improved and innovative observation and data management systems, tools and methodologies for marine information needs in the Baltic Sea region

Data and information on marine ecosystem as well as on catchments and the human activities impacting these ecosystems are needed for a multitude of purposes. In particular, the Marine Strategy Framework Directive requires the development of a regionally coordinated monitoring programme covering a wide range of information to characterise both the ecosystem's state and the magnitude of human-induced pressures.

The Baltic Sea and its catchment area extend over different climatic zones. Observation and data integration issues are strongly influenced by several area-specific factors like high shipping activity, extensive ice cover, brackish and turbid sea waters, physical and ecosystem patchiness with strong and variable stratification of the water column, variety of river influence areas, coastal bays and archipelagos. These features present a unique challenge and development opportunity to the global and European Earth observation initiatives.

Moreover, the next generation of monitoring programmes will be established by combining the progress of traditional and operational monitoring systems with advanced research methods. These innovations could be used as prototypes also in other areas of the global ocean.

Putting the BONUS research programme into practice

The BONUS strategic research agenda 2011-2017 is policy-driven and solution-oriented and hence it sets out to respond to stakeholders' needs and scientific possibilities. It follows a dynamic approach of evolving along with the development of knowledge and scientific thinking. The review of the current agenda will take place again in 2013 through a transparent and flexible process that takes into account future demands. Furthermore, the agenda includes both marine and coastal aspects in order to fully encompass the ecosystem of the Baltic Sea and its coasts; recognises the importance of the influences on and inputs to the Baltic Sea system from the catchment area; and involves the stakeholders as an integral part of development and execution of the agenda. Delivering stakeholder-relevant results that take into account the socio-economic aspects of the Baltic Sea system is critical in the implementation of the BONUS research programme and respective calls for proposals.

The research landscape of today is extraordinarily complex with a wealth of various programmes of different configurations and diverse funding sources being implemented concurrently. The importance of avoiding overlaps and seeking synergies cannot be overestimated. While putting this agenda into practice BONUS will pay close attention to the complementarity and synergies and avoid overlaps with other relevant research initiatives at international, EU, Baltic Sea region and national levels, in particular, the calls announced and activities supported within the EU Research Framework Programme and projects implemented through the Baltic Sea Region Programme.

Moreover, true progress towards an economically and ecologically prosperous, sustainable Baltic Sea region requires also the development of eco-technological approaches and new technological tools and solutions. BONUS collaborates with relevant macroregional networks of companies, research actors and financiers that have emerged within the EU Strategy for the Baltic Sea Region and pioneers the implementation of the EU's emerging strategic framework for research and innovation funding, called 'Horizon 2020'.

Besides outlining its strategic objectives and themes, the overall framework of the BONUS strategic research agenda 2011-2017 provides the basis for developing practical priorities for the years to come in managing calls, projects, stakeholder – and in particular end-user – effective communications and reporting about the progress and results achieved.

BONUS calls

BONUS will launch altogether five calls inviting proposals for projects that address strategic objectives of the research agenda. Research themes of four calls have already been defined (see figure 4, page 34), while the composition of the last one to be launched in late 2013 will be defined only after the revision of the research agenda and identification of most urgent research needs.

The calls to be launched in December 2011 and 2012, referred as 'thematic calls' address the complexity of the Baltic Sea ecosystem, role and management of coastal areas as well as changes in the catchment. Also, research needs related to fisheries management and maritime risk management and pollution from shipping will be included as will be issues related to governance, policy, life styles and maritime spatial planning. Calls to be launched in spring 2012 and 2013 are referred to as 'innovation calls' and implemented in cooperation with innovation funding agencies of the participating countries. These calls will address eco-technological approaches, aquaculture as well as measurement techniques and ICT services. They will give small and medium sized enterprises a chance to participate actively in developing knowledge and products for the benefit of the Baltic Sea.

The maximum funding available is EUR 100 million for the years 2011-2017. Half of the sum, up to EUR 50 million matching national contributions, is provided by the European Community Seventh Framework Programme, and the other half by the participating funding institutions.

When executed well, BONUS and the multidisciplinary science it supports, promises to take a critical role in the coming decade and beyond in finding solutions for some of the major challenges presently facing the Baltic Sea region and in making the region an environmentally, socially and economically attractive and wealthy place to live.

1. Facing the major challenges in the Baltic Sea region

Humans' dependence on the seas is strong and manifold. The goods and services the seas provide range from non-monetary nature experiences and recreation to those with economical value offering profits and jobs, such as commercial fishing, oil drilling and tourism among other. Protection of the health of the marine environment is a widely accepted political goal across the modern society and the establishment of regulatory instruments to protect the seas has been for decades in the core of the international, European and regional policy institutions. These instruments range from the United Nation's environment and science programmes (UNEP, UNESCO) to regulations set by the International Maritime Organisation (IMO), various EU institutions and the Baltic Marine Environment Protection Commission (HELCOM).

Fit-for-purpose policies are required to determine the direction of the future development. Also, experienced and well informed environmental managers are needed to use their skills to set up smart regulations and effective management practices to implement the policy objectives. The success in overcoming the current and future challenges needs to draw from sound scientific knowledge. During the past two decades there has been an unprecedented development in the marine and maritime policy landscape directly impacting to the Baltic Sea and its drainage area (see the following chapter for further details). Nevertheless, the deterioration of the Baltic Sea environment and threats towards its sustainability is today a fact that has been evidenced by a number of studies and assessments (HELCOM 2010(1)).

Despite environment protection efforts by the countries surrounding the Baltic Sea, stretching today across several decades, society has not found efficient solutions to sustain the health of the Baltic Sea ecosystem. Examples of missing solutions to current and emerging environmental and sustainability issues in the Baltic Sea area are many as are the related knowledge needs (see box 1).

Science needs to produce know-how and solutions in order to resolve successfully the challenges that are to be addressed by the Baltic Sea region in the coming decade and beyond (see box 2). The task is not simple. The goal – to achieve a sustainable Baltic Sea region – where the economic and ecological prosperity of the Baltic Sea region is based on sustainable use of resources as well as ecosystem goods and services, and where the long-term management of the region is based on sound and comprehensive scientific knowledge, is still far from being reached. Albeit an ambitious goal, it is also the only thinkable goal for a responsible society of today which strives to leave this part of the planet as a heritage to the future generations.

In order to move towards a sustainable Baltic Sea region, the most cost-efficient solutions need to be known as do the political and social conditions that allow distribution of management and remedial costs in a feasible and balanced way in relation to other living costs. Also, tools and mechanisms are required to support the change of modern lifestyles towards a more sustainable way of living. To be able to do so, adequate understanding is needed of the structure and functioning of the Baltic Sea ecosystem and how the various human activities in its drainage area and the coast are interlinked. And, the advantage of the newest technologies for future marine and maritime information needs in the region must be realised.

The multifaceted research challenges of today can be approached only from the multi- , inter- and transdisciplinary perspectives. Also, when facing the immenseness and complexity of the problems needing solutions, the limited research resources must be used efficiently and scientists need to work together across the region.

It is fortunate that in parallel to the development of the marine and maritime policies, the so called European Research Area, also known as ERA(2)- process has been in place for the past decade. It supports the harmonisation of national research and development policies in the European countries, together with the possibility of pooling national and European Union research funds. The initial steps towards close cooperation among the relevant research funding agencies were taken during the BONUS ERA-NET project (2004-2008). By building up a novel research governance structure for the Baltic Sea system research, and launching a policy-driven BONUS programme, the Baltic Sea region is paving the way for a better future of the region while also acting as a model for other regional seas in Europe and elsewhere. As a proof of commitment and a test case of mechanisms necessary for a joint research programming at macroregional level, the funding agencies came together with the European Commission and invested EUR 21 million in a joint BONUS+ call for proposals. Sixteen cross-disciplinary and cross-national projects funded for 2009-2011 research various aspects of implementation of the ecosystem approach to management of human activities related to the Baltic Sea.

Box 1: Examples of current and emerging environmental issues in the Baltic Sea and related knowledge needs

Increasingly diversified use of chemicals and new materials poses hazards to the environment
The Baltic Sea is a recipient of an increasing number of chemicals from local and regional sources, introduced through rivers, the atmosphere and by direct discharges. These include for example organic contaminants, heavy metals, chemical weapons and new kinds of chemicals such as pharmaceuticals. More information is needed regarding their forthcoming effects on biodiversity and ecosystems.

Eutrophication affects today nearly the entire Baltic Sea
Increasing population, intensifying agricultural production and atmospheric transport of nutrients have resulted in an increasing eutrophication which is manifested by algal blooms, turbid water, loss of submerged vegetation and anoxic zones on the sea floor. Research seeks answers to what kind of impacts changes in land use in the drainage area and eutrophication have on biodiversity, ecosystems and food webs and what would be the practicable and cost-efficient options to reduce eutrophication.

Increasing maritime traffic is imposing risks to the environment
The potential risks associated with increasing maritime traffic include threats to the environment (ship generated waste, oil spills, noise, air pollution, and transportation of non-indigenous organisms). Environmental safety and clean shipping will be enhanced by the development of sophisticated communication and logistic methods, as well as by studies of risk management and better prevention of accidents.

Fisheries regulation is not effective enough to secure the stability of the ecosystem and reproduction capacity of the Baltic Sea fish stocks
Catch quotas for Baltic fish stocks have been set often above the scientific advice or fishing industry has not complied with the quotas set, resulting in overfishing and stock decline. These in turn affect ecosystem structure and functioning and lead to low profitability of fishing as a livelihood in the long run. There is a need to adopt the maximum sustainable yield approach as well as implementing the ecosystem approach to the fisheries management.

Marine space is not used safely and systematically to fulfil the intensifying needs from society
The countries surrounding the Baltic Sea have to address the common welfare and goods of the wider region, not issues within their own national borders alone. The enormous potential for economic and social development in the Baltic Sea region may increase pressures on the environment and accelerate competition for the use of space between national and sectoral interests. Efficient maritime spatial planning requires harmonisation of the activities related, considering the compilation of data of natural processes and examination of the economics and societal impacts.

Climate change causes changes in the Baltic Sea region that need to be understood and adapted
Climate change is expected to increase the likelihood of extreme weather events occurring at shorter intervals in the future. In fact, the Baltic Sea region is one of the areas where climate change effects are most unclear. The anticipated changes include increased precipitation, which consequently increases the land-based leaching and loading. Lengthening of the growing season may have its impact on the relative shares of economic sectors. There is also a need to be prepared for extreme events, flooding and intensified erosion.

Protection measures are neither cost-efficient nor optimally shared
The impacts of national and international steering mechanisms and EU policies on the environment and biodiversity can be contradictory. It is important to evaluate what are the impacts of existing policies and agreements to the environment, and map their contradictions, in order to find ways for their improvement and harmonisation. It is also important to evaluate their cost-effectiveness and societal impacts. There are a lot of different political structures, legal entities, secretariats and institutions handling issues around the Baltic Sea that have an impact on the Sea area. Evaluation of the function and importance of these actors is essential.

Existing data are insufficient and not efficiently used to support research and decision making
Today, information related to marine issues is scattered in different databases or is not necessarily generally accessible. In addition, data gathering and analysing systems vary from country to country. There is still too little joint use and open access to data gathered by different disciplines, for example, this is the case with methods for obtaining data from social studies and combining them with the relevant data from natural sciences. Overall, there is a need for a better evaluation of cost effectiveness of different monitoring and mapping methods.

Box 2: Major challenges facing the Baltic Sea region in the coming decade and beyond. Although these six challenges are critically important to be addressed in order to ensure a sustainable, knowledge-based management of human activities related to the Baltic Sea ecosystem in the future, this is not a comprehensive reflection of all the challenges facing the entire region.

Adapting to the climate change and its effects

While the effects of climate change in the Baltic Sea area are less certain as compared to other regions of the world, our ability to adapt to these changes without compromising the life quality and targets of environmental status depends crucially on our predictive capacity. Adapting to climate change calls for urgent reformulation of the governance models on macro-region, European and global scale.

Restoring good environmental status of the Baltic Sea and its coasts

Restoring and sustaining a good environmental status and viable marine nature to safeguard ecosystem resilience and support its well-functioning is a central task to secure life quality of the nations living on the coasts and beyond. Given the magnitude of pressures and the scale and complexity of marine systems, implementing the EU Marine Strategy Framework Directive and the Baltic Marine Environment Protection Commission's Baltic Sea Action Plan are among the most ambitious commitments revealing a wealth of knowledge needs for natural and societal science.

Achieving sustainable and safe use of the exploited coastal and marine ecosystem goods and services

Supporting long-term economic competitiveness of the Baltic Sea region and the quality of life of its inhabitants depends on our ability to sustainably use the marine goods and services, both the classic ones, such as shipping and fishing, as well the dynamically evolving new ones as harvesting renewable energy, marine biotechnologies, CO_2 sequestering etc. This is the pivotal issue of the integrated maritime policy of the EU and the EU Strategy for the Baltic Sea Region. Cross-sector cooperation and knowledge-based management are the keys in resolving this challenge.

Creating cost-efficient environmental information systems

While this is a challenge mostly for scientific and technical professionals, creating a new generation of integrated marine and maritime observation and information handling systems, it is crucial, however, in order to fully utilise today's achievements in data acquisition and information and communications technologies and support the broader societal challenges. We need to respond to today's demands in regard to the accessibility, operativeness, cost-efficiency and versatility of data and their interpretation. This urgency is clearly emphasised by the EU Integrated Maritime Policy, the European Strategy for Marine and Maritime Research(3), the Global Earth Observation System of Systems(4) and the Global Monitoring for Environment and Security(5).

Evaluating and developing relevant policies and collective governance

A governance framework "that applies the integrated approach at every level, as well as horizontal and cross-cutting policy tools"(6) is strongly required for achieving the goals of the EU Integrated Maritime Policy and the EU Strategy for the Baltic Sea Region. Concrete cross-national and cross-sector governance tools and mechanisms, including maritime spatial planning, will have to be urgently elaborated and adopted based on sound natural science and socio-economic analyses.

Adapting to a more sustainable way of living

With the increasing realisation of the unsustainable consumerist lifestyle that prevails in the modern society, a need for a clear shift towards more sustainable living is apparent. The role of science here is to provide and promote credible scenarios, justifying the measures required, combating misconceptions and substantiating revised value systems involving externalities of environmental goods and services.

2. Policies shaping the future direction

Development of the key policies which have relevance to the sustainability of the Baltic Sea region has taken place historically under the influence of changing geopolitical phases. Therefore, the policy landscape of today is a combination of Baltic Sea regional, European and global initiatives.

Baltic Sea regional collaborations with relevance to sustainability

Already in 1974 coastal states signed the Convention on the Protection of the Environment of the Baltic Sea Area (Helsinki Convention), the first ever single convention embracing the whole sea and addressing all kinds of pollution threatening it. The scope of the Helsinki Convention was extended greatly in 1992 when political development in the region made it feasible to address the whole Baltic Sea drainage area.

Fifteen years later the governments of the contracting states under the Helsinki Convention assumed an even more ambitious task – a collective action plan with firmly set measurable objectives to restore a good environmental status in the Baltic Sea by 2021 (Baltic Sea Action Plan, see box 3).

Development of the technical capability and new economic opportunities and necessities brought about a whole range of new ways of using the sea space and its goods and services. For example, Visions and Strategies around the Baltic Sea (VASAB) underlines the increasing importance of maritime spatial planning, and the urgency of elaborating and applying common principles in the use of marine space in the Baltic Sea region (see box 3).

In parallel with the key regional policy institutions a considerable number of networks are established which aim at facilitating the implementation of the environmental and sustainability objectives.

European Union policy instruments with relevance to the Baltic Sea

With eight out of the nine coastal countries being now member states of the European Union (EU), also the common EU policies have become legitimate and important for the Baltic Sea region (see box 4). The countries are legally bound to a number of sector specific directives originating from the 1970s and thereon. More recently, the broader European frameworks of integrated, cross-sectoral maritime and macroregional policies (Integrated Maritime Policy and Common Fisheries Policy) and directives (Water Framework Directive and Marine Strategy Framework Directive) introduced the common principle of 'ecosystem approach to management' into the Baltic Sea management plans. The Russian Federation, being the only non-EU Baltic coastal state, has its own national marine, maritime and environmental legislation. However, through the implementation of the Baltic Sea Action Plan, also Russia is linked to the EU's Marine Strategy Framework Directive.

Box 3: Regional collaborations with relevance to sustainability

The **Baltic Sea Action Plan (BSAP)**(7) was adopted in 2007 by nine Baltic Sea coastal states as an ambitious cooperative action programme – under the auspices of the Baltic Marine Environment Protection Commission (HELCOM). HELCOM BSAP aims at establishing good environmental status in the Baltic Sea by 2021 thus serving as a pilot project under the EU Marine Strategy Framework Directive.

Visions and Strategies around the Baltic Sea (VASAB) established in 1992, is an intergovernmental forum for co-operation of ministers responsible for spatial planning and development around the Baltic Sea. In 2009, VASAB ministers adopted the Long Term Perspective for the Territorial Development of the Baltic Sea Region. VASAB cooperates closely with HELCOM, for example, through the joint HELCOM-VASAB Working Group on Maritime Spatial Planning that was created in 2010(8).

Baltic Sea drainage basin and the countries in the region. The drainage basin represents all water that drains into the sea, through rivers and ground water. http://maps.grida.no/go/graphic/baltic_sea_drainage_basin

Box 4: European Union policy instruments with relevance to the Baltic Sea

EU Framework Directives

The **Water Framework Directive** (WFD, 2000)(9) commits EU's member states to achieve good qualitative and quantitative ecological status of all water bodies (including marine waters up to one nautical mile from the baseline of territorial waters) by 2015. To achieve 'good surface water status' both the ecological status and the chemical status of a surface water body need to be at least 'good'. Ecological status refers to the quality of the structure and functioning of aquatic ecosystems of the surface waters. The Directive is implemented through drafting local river basin management plans which include objectives for each water body and the programme of actions required to meet the objectives. Plans are published in 2009, 2015 and 2021.

EU Marine Strategy Framework Directive (MSFD, 2008)(10) is the environmental component of the EU Integrated Maritime Policy. It establishes a framework within which the EU member states shall take the necessary measures to achieve or maintain good environmental status (GES) in the marine environment by 2020 (see box 5 for a complete list of qualitative descriptors for determining GES). The Directive stresses that the programmes of measures will be effective only if they are devised on the basis of a sound knowledge of the state of the marine environment in a particular area. By setting a coherent framework for environmental protection across the European regional seas, the directive also embraces and strengthens the principles and requirements of the EU Water Framework Directive (2000).

Both the Water Framework Directive and Marine Strategy Framework Directive integrate a number of other, more specific EU directives issued earlier.

EU Waste Framework Directive (2006, revised in 2008)(11) presents a comprehensive framework of requirements of waste management for the EU member states. I.e. it calls member states for prevention or reduction of waste production and reducing harmful wastes by developing clean technologies, developing products making smallest possible contribution of waste in their manufacture, use and disposal, developing appropriate techniques for final disposal of dangerous substances contained in waste, and to recover and recycle waste, and foster its use as energy source. This directive gives certain impetus for the development of the related eco-innovation.

Other EU policy instruments

EU Integrated Maritime Policy (IMP)(6) was launched by the EU in 2007 and focuses on five main action areas:
1. Maximising sustainable use of the oceans and seas
2. Building a knowledge and innovation base for the maritime policy
3. Delivering the highest quality of life in coastal regions
4. Promoting Europe's leadership in international maritime affairs
5. Raising the visibility of maritime Europe

In its action plan, IMP sets the following tasks, among other, implementing and further developing maritime policies, strategies and cross-cutting policymaking tools; enhancing integrated maritime spatial planning and coastal zone management and further developing and integrating maritime surveillance and monitoring methodologies(12).

EU Common Fisheries Policy (CFP)(13) is currently under reform(14). The green paper issued by the Commission in 2009 draws a vision of European fisheries towards the year 2020, among other, by restoring Europe's fish stocks to maximum sustainable yields (MSY), and promoting sustainable and more prosperous fishing and aquaculture(15) industries. The CFP reform recognises the importance of integrating the CFP into the overall maritime policy context. The CFP is supported by the Community framework for the collection, management and use of data in the fisheries sector(16), (17), (18).

EU Common Agricultural Policy (CAP) is due to be reformed by 2013. The Commission presented in November 2010 a communication on "The CAP towards 2020"(19), which outlines options for the future CAP. Through its response to the new economic, social, environmental, climate-related and technological challenges facing our society, the CAP aims to contribute more to developing intelligent, sustainable and inclusive growth.

One of the main objectives for the future CAP is sustainable management of natural resources in order to enable agriculture to respond to climate change. It calls for sustainable production practices and an enhanced provision of environmental public goods, green growth through innovation, and climate change mitigation and adaptation actions.

Box 4 continued

The **EU Strategy for the Baltic Sea Region** (EUSBSR)(20) was launched in 2009, following a request from the EU Parliament(21). The aims of this strategy are to make the Baltic Sea region an environmentally sustainable, prosperous, accessible, attractive, and secure and safe region. EUSBSR is subdivided into 15 priority areas, each implemented through flagship projects and several cross-cutting horizontal actions, e.g. the development of integrated maritime governance structures and maritime and land-based spatial planning.

European Marine Observation and Data Network (EMODNET)(22)·(23) is an important tool for the implementation of the EU Integrated Marine Policy. There is a need to define the boundaries of sustainability of human activities that have an impact on the marine environment, paying due attention to their cumulative impacts on the basis of the ecosystem approach.

Roadmap for Maritime Spatial Planning(24) helps authorities and stakeholders to coordinate their actions and to optimise the use of marine space for the benefit of economic development and of the marine environment.

Box 5: Qualitative descriptors for determining good environmental status referred to in the EU Marine Strategy Framework Directive

In 2009, the EU Commission published a white paper on "**Adapting to climate change: Towards a European framework for action**"(25) calling for a strategic approach to ensure that the adaptation measures take place timely, efficiently and coherently across different sectors of economy and levels of governance.

1. Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions.
2. Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystems.
3. Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock.
4. All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity.
5. Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algae blooms and oxygen deficiency in bottom waters.
6. Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected.
7. Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems.
8. Concentrations of contaminants are at levels not giving rise to pollution effects.
9. Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards.
10. Properties and quantities of marine litter do not cause harm to the coastal and marine environment.
11. Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

International conventions with relevance to the Baltic Sea

Baltic Sea countries are involved in several global-level political agreements of key importance, in particular dealing with the biological diversity(26), prevention of pollution from ships(27) and climate change(28) (see box 6). The environmental impact assessment in a transboundary context(29) has an increasing importance for the region of growing economic activities. These pose potentially trans-boundary threats, such as sub-sea pipelines and cables, and off-shore wind parks among other.

Box 6: International conventions with relevance to the Baltic Sea

Convention on the Protection of the Marine Environment of the Baltic Sea Area(30) (Helsinki Convention) was signed in 1974 by the then seven Baltic coastal states. For the first time ever, all the sources of pollution around an entire sea were made subject to a single convention. In the light of political changes, and developments in international environmental and maritime law, a new convention was signed in 1992 by all the states bordering the Baltic Sea, and the European Community. The Convention covers the entire Baltic Sea area, including inland waters as well as the water of the Sea itself and the sea-bed. Measures are also taken in the entire catchment area of the Baltic Sea to reduce land-based pollution.

Convention of Biological Diversity(26) (CBD) relates to the conservation of biological diversity and sustainable use, including the Baltic Sea. One of the CBD programmes addresses in particular marine and coastal biodiversity. Elements of this programme include: Integrated marine and coastal management, marine and coastal living resources, marine and coastal protected areas, mariculture and invasive alien species. In its decision X/29, the 10th Conference of the Parties decided to take into account the special characteristics of enclosed and semi-enclosed seas that are affected by multiple direct and indirect human induced influences originating from the watershed area, and where the biodiversity issues require an integrated holistic approach and co-operation.

International Convention for the Control and Management of Ships' Ballast Water & Sediments(31) was adopted in 2004. Its aim is to prevent, minimise and ultimately eliminate the transfer of harmful aquatic organisms and pathogens through the control and management of ships' ballast water and sediments.

International Convention for the Prevention of Pollution from Ships(27) (MARPOL 73/78) is the central convention addressing safe and clean shipping. MARPOL contains six annexes that deal with the prevention of different forms of marine pollution from ships: oil, noxious liquid substances carried in bulk, harmful substances carried in packaged form, sewage, garbage and air pollution.

United Nations Framework Convention on Climate Change (UNFCCC)(28) sets an overall framework for intergovernmental efforts to tackle the climate change challenge. Under the UNFCCC, the member governments gather and share information on greenhouse gas emissions, national policies and best practices. In addition, national strategies for addressing greenhouse gas emissions and adapting to expected impacts are developed, including a provision of financial and technological support to developing countries and cooperation in preparation for adapting to the impacts of climate change.

Convention on Environmental Impact Assessment in a Transboundary Context (Espoo, 1991)(29) - the 'Espoo Convention' was signed in 1991 and entered into force in 1997. The Espoo convention sets out the obligations of Parties to assess the environmental impact of certain activities at an early stage of planning. It also lays down the general obligation of states to notify and consult each other on all major projects under consideration that are likely to have a significant adverse environmental impact across boundaries.

Convention on Long-Range Transboundary Air Pollution (Geneva, 1979)(32). The Geneva convention obliges its contracting parties (51 states) to mitigate the emissions and exchange information in regard to air pollution having adverse effects at such long distances that it is not possible to distinguish the source. It calls i.a. to initiate and co-operate in research to (a) develop technologies for reducing emissions of sulphur compounds and other major air pollutants, (b) develop instrumentation and other techniques for monitoring and measuring emission rates and concentrations of air pollutants, (c) develop models for a better understanding of the transmission of long-range transboundary air pollutants, (d) investigate the effects of sulphur compounds and other major air pollutants on human health and the environment, including agriculture, forestry, materials, aquatic and other natural ecosystems, (e) undertake economic, social and environmental assessments of alternative measures for the reduction of long-range transboundary air pollution, (f) perform education and training programmes related to the environmental aspects of pollution by sulphur compounds and other major air pollutants. This convention serves as a certain promoter of technological innovation in its specific field.

UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters(33) was adopted in 1998. This so-called 'Aarhus Convention' is a new kind of environmental agreement. It links environmental and human rights. It states that sustainable development can be achieved only through the involvement of all stakeholders, links government accountability and environmental protection and focuses on interactions between the public and public authorities in a democratic context. The Aarhus Convention grants the public rights and imposes on Parties and public authorities' obligations regarding access to information and public participation as well as access to justice.

Marine research programmes and policies

Throughout the last century, the Baltic Sea scientific community has been actively involved in international research networks and has also established its own research associations. Collaboration with the International Council for the Exploration of the Seas (science organisation) and the International Baltic Sea Fisheries Committee (policy organisation with action plan effective until 2006) in setting fishing quotas was pioneering the use of scientific advice in fisheries policy. This function still continues and has broadened to cover ecosystem health while the policy side is managed now by the EU.

In earlier times the landscape of national marine research policies and programmes in the Baltic Sea region used to be variable. During the past decade, however, it has become more homogenous due the development of the European marine related policies. Many countries of the region are currently in a process of designing their own national marine research policies/ strategies in line with the EU Integrated Maritime Policy and with consideration of the development of the joint BONUS programme.

In general, the marine research issues have been embedded into broader national research programmes such as sustainability or environmental research. During the 2000s, there were several national dedicated Baltic Sea research programmes (e.g. Finland, Latvia, Poland, Sweden) with duration of 3-5 years. Along the development of BONUS, most of these national programmes have been finished and merged into the joint programme. Germany has an ongoing broader marine research programme that is based on the national strategy for sustainable use and protection of the seas and the emerging German integrated maritime policy.

On the European level, a communication on Strategy for Marine and Maritime Research(3) was published in 2008. In order to address the complexity of the marine system, the strategy promotes bridging of the traditional boundaries between science and policy-making, science and technology, scientific disciplines and industrial sectors. Also, it calls for bringing about new forms of research governance to seek consensus among all parties concerned and to establish a continuous dialogue between scientists, policymakers, industries and representatives from society. The strategy emphasises that international scientific cooperation is a powerful vehicle for coordinated and integrated management of maritime activities in the seas shared by the EU member states and other countries.

Not only policies dealing with environment and sustainability but also those horizontal policies dealing with research and development are relevant in the context of the Baltic Sea. Rooted in the EU's integration and competiveness objectives, the European Research Area 'ERA'-process(2), which was initiated in 2000, aims at removing national borders in regards of free movement of researchers, research funding and knowledge. The BONUS programme has been developed within this framework.

An important process was launched in 2011, when the European Commission presented a green paper(34) on common strategic framework for the future European Union research and innovation funding. It proposes major changes to EU research and innovation funding to make participation easier, increase scientific and economic impact and provide better value for money. The changes would bring together the current framework programme for research and the competitiveness and innovation programme.

Significant milestones of the key policies

Matching sound knowledge with the correct timing in regard to the policy development requirements is important in order to ensure better development, implementation, assessment and reforms of the policies. Therefore, an appropriate timing of addressing various research themes is critical when developing a policy-driven research agenda. The timeline of significant milestones of key international, European and Baltic Sea region specific policies is provided in box 7.

By addressing policy driven research issues and carefully designing themes and timings of the forthcoming calls for research proposals, BONUS can offer a foundation and support for achieving the objectives of several relevant policies and strategies outlined on the the following page. This way BONUS can help in reaching the good environmental status of the Baltic Sea.

Box 7: Significant milestones of key policies

2011	Reform proposals on EU Common Fisheries Policy (CFP reform process)
2011	Legal proposals for the future EU Common Agricultural Policy (CAP) presented
2012	Initial assessment of the current environmental status and the environmental impact of human activities complete; criteria for determining good environmental status as well as environmental targets and associated indicators established (MSFD)
2012	EC first report to the Council and European Parliament on the implementation of the European Strategy for Marine and Maritime Research (ESMMR)
2013	Effectiveness of the Baltic Sea Action Plan national programmes evaluated and the progress towards the ecological objectives reviewed. Based on this review the Action Plan adjusted and the set of indicators with associated targets updated (HELCOM BSAP)
2013	HELCOM Red Lists of Baltic habitats and biotope complexes updated; HELCOM Red List of Baltic Sea species produced, potential and actual extent of some valuable habitats identified and mapped (HELCOM BSAP)
2013	Ultimate deadline for ratification of the International Convention for Control and Management of Ships' Ballast Water and Sediments (BWM Convention) by the HELCOM Contracting States (HELCOM BSAP)
2013	Member States to make publicly available relevant information on the special areas of conservation pursuant to the Habitats Directive and special protection areas pursuant to the Birds Directive (MSFD)
2013	EU Common Agricultural Policy (CAP) due to be reformed
2014	Commission to report on progress in the establishment of marine protected areas
2014	Establishment and implementation of a monitoring programme for ongoing assessment and regular updating of targets (MSFD)
2015	Development of a programme of measures designed to achieve or maintain good environmental status (MSFD)
2015	European fish stocks managed at Maximum Sustainable Yields (CFP reform ,Green Paper, commitment by the member states from the World Summit of Sustainable Development, 2002)
2015	Continuous decline of catches by the European fleet come to end (CFP reform Green Paper, vision)
2015	Next generation of River Basin Management Plans under EU WFD should be fully climate-proofed (Climate Change Adaptation White Paper)
2015	A BSR conference to develop a common approach for the Baltic Sea maritime spatial planning arranged together with relevant stakeholders (VASAB Long Term Perspective, Action Agenda 20, short term perspective)
2015	Each Party of Convention of Biological Diversity has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan ((CBD, Aichi Biodiversity Target)
2015-2025	Creation of intelligent sea transport corridors in the Baltic Sea initiated by activating at least one pilot project for a corridor with high traffic volumes in an environmentally sensitive area (VASAB Long Term Perspective, Action Agenda 15, short/medium perspective)
2015-2025	Maritime spatial planning demonstration projects for some Baltic Sea areas of severe use conflicts (e.g. Gulf of Finland, Gulf and Sea of Bothnia including archipelagos, Gulf of Riga, Norra Kvarken, Danish straits) prepared and implemented (VASAB Long Term Perspective, Action Agenda 21, short/medium perspective)
2016	Entry into operation of the programme of measures designed to achieve or maintain good environmental status (MSFD)
2019	The Commission to publish a first evaluation report on the implementation of MSFD
2020	Achieve or maintain good environmental status in the marine environment (MFSD)
2020	Full-scale return to sustainable and profitable European fisheries (CFP reform Green Paper, vision)
2020	Share of renewable energy sources in EU energy budget shall reach 20%, with significant contribution of offshore wind farms (Directive 2009/28/EC on renewable energy)
2020	All fish and invertebrate stocks and aquatic plants are managed and harvested sustainably, legally and applying ecosystem based approaches [by the CBD Parties], so that overfishing is avoided, recovery plans and measures are in place for all depleted species, fisheries have no significant adverse impacts on threatened species and vulnerable ecosystems and the impacts of fisheries on stocks, species and ecosystems are within safe ecological limits (CBD, Aichi Biodiversity Target)
2021	Good environmental status in the Baltic Sea achieved (HELCOM BSAP)
2023	The Commission to review Marine Strategy Framework Directive and propose any necessary amendments (MSFD)

3. BONUS research programme responding to challenges

The overarching aim of the BONUS research and development programme is to generate and facilitate dissemination of the necessary knowledge and know-how in order to resolve successfully the major challenges of the coming decade and beyond. For this purpose BONUS aims at improving the efficiency and effectiveness of the Baltic Sea region's environmental research programming by integrating the research activities into a durable, cooperative, interdisciplinary well-integrated and focused multi-national programme.

The content of the BONUS strategic research agenda 2011-2017 is policy-driven and serves as the basis for a multidisciplinary and transnational research programme in support of knowledge-based decision-making and management action in the Baltic Sea region. Themes of the BONUS strategic research agenda arise from five mutually interlinked strategic objectives:

1. **Understanding the Baltic Sea ecosystem structure and functioning**

2. **Meeting the multifaceted challenges in linking the Baltic Sea with its coast and catchment area**

3. **Enhancing sustainable use of coastal and marine goods and services**

4. **Improving the capabilities of the society to respond to the current and future challenges directed to the Baltic Sea region**

5. **Developing improved and innovative observation and data management systems, tools and methodologies for marine information needs in the Baltic Sea region**

Many horizontal links exist among the research themes formulated under the five strategic objectives. While understanding the complexity of the Baltic Sea ecosystem structure and functioning is the core objective of this agenda *(1)*, pressures on the ecosystem originate from its catchment area and coasts *(2)* or from the unsustainable use of marine goods and services *(3)*. Similarly, the knowledge-based ecosystem approach to management of these human activities as a response to the impact of unsatisfactory state of environment has to be implemented throughout the Baltic Sea catchment area and coasts and involve all kinds of usage of marine goods and services. Improving society's capability and motivation to respond to these impacts *(4)*, which depend greatly on the ability to understand the rules of governance and socio-economy, constitutes a key cross-cutting strategic objective. Finally, the need to develop innovative data acquisition and information management tools and systems *(5)* underpins the whole programme methodologically. Hence, in which form and when to include the themes into the BONUS calls for proposals will require careful consideration. For example, synchronisation or arrangement of the themes into an optimal sequence is required and particular policy-driven research needs are best when addressed following a concrete time schedule (see box 7 on previous page).

Figure 1 demonstrates how each of the BONUS research themes addresses the core knowledge needs arising from the necessity to take on at least one of the major challenges facing the Baltic Sea region. These major challenges have emerged from the extensive, joint process of strategic research agenda development with the key stakeholders. Although these six challenges are critically important to be addressed in order to ensure a sustainable, knowledge-based management of human activities related to the Baltic Sea ecosystem in the future, this is not a comprehensive reflection of all the challenges facing the region.

Figure 2 demonstrates how five out of seven major research topics defined by the European Strategy for Marine and Maritime Research(3), that require cross-thematic approach, are in the centre of attention of BONUS: *(1)* impacts of climate change, *(2)* impact of human activities on coastal ecosystems and their management, *(3)* ecosystem approach to resource management and spatial planning, *(4)* marine biodiversity and biotechnology and *(5)* operational oceanography and marine technology.(35)

In the description of the research needs in the following chapters, the logical framework of Driving forces – Pressures – State of the environment – Impacts – Responses (the DPSIR framework) is used as a tool to describe the interlinkages of research needs related to the management of human activities(36). Moreover, the DPSIR framework emphasises clearly the need for interdisciplinary research.

Major challenges of the Baltic Sea region	BONUS strategic objectives																		
	1. Understanding the Baltic Sea ecosystem structure and functioning				2. Meeting the multifaceted challenges in linking the Baltic Sea with its coast and catchment area				3. Enhancing sustainable use of coastal and marine goods and services of the Baltic Sea					4. Improving the capabilities of the society to respond to the current and future challenges directed to the Baltic Sea region			5. Developing improved and innovative observation and data management systems, tools and methodologies for marine information needs in the Baltic Sea region		
	BONUS research themes																		
	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	3.5	4.1	4.2	4.3	5.1	5.2	5.3
Adapting to the climate change and its effects	●	●	●	○	○	●	○		○						○		○		
Restoring good environmental status of the Baltic Sea and its coasts	●	●	●	●	●	●	●	●				○		●	○		○	○	
Achieving sustainable and safe use of the exploited coastal and marine ecosystem goods and services		○						○	●	●	●	●	●						○
Creating cost-efficient environmental information system	○	○	○		○	○											●	●	●
Evaluating and developing relevant policies and collective governance							○		○			○		●	●	●			
Adapting to a more sustainable way of living					○		○	●						●	●	○	○		

Figure 1: The BONUS strategic objectives' and research themes' links to the major challenges.
Key: Core links are marked as black circles, supplementary links as white circles.

Cross-disciplinary research topics of European Strategy for Marine and Maritime Research	BONUS strategic objectives																		
	1. Understanding the Baltic Sea ecosystem structure and functioning				2. Meeting the multifaceted challenges in linking the Baltic Sea with its coast and catchment area				3. Enhancing sustainable use of coastal and marine goods and services of the Baltic Sea					4. Improving the capabilities of the society to respond to the current and future challenges directed to the Baltic Sea region			5. Developing improved and innovative observation and data management systems, tools and methodologies for marine information needs in the Baltic Sea region		
	BONUS research themes																		
	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	3.5	4.1	4.2	4.3	5.1	5.2	5.3
Climate change and the oceans	●	●	●	○	○	●	○	○	○						○		○		
Impact of human activities on coastal and marine ecosystems and their management	●	●	●	●	●	○	●	○	●	○	●	●	○	●	●	○	●	○	
Ecosystem approach to resource management and spatial planning	●	●	●				○	○	○		●	●	○	●	○	●	○	○	○
Marine biodiversity and biotechnology	○	●	○		○	●	○		○	○	●	●	●	●	○	○	○	○	
Operational oceanography and marine technology	○	○	○						○	○					○		●	●	●

Figure 2: The BONUS strategic objectives' and research themes' links to five cross-disciplinary research topics highlighted in the European Strategy for Marine and Maritime Research (ESMMR).
Key: Core links are marked as black circles, supplementary links as white circles.

Strategic objective 1:
Understanding the Baltic Sea ecosystem structure and functioning

Rationale

Understanding of the complex processes occurring in the Baltic Sea ecosystem, causes and consequences of its biological diversity, dynamics of food webs and impact of various human-induced pressures is critically important in order to be capable to restore good environmental status of the Sea. Improved predictive capacity through advanced modelling is needed to determine the controls and limits of the ecosystem dynamics and resilience and suggest the most efficient societal responses. Policy initiatives such as the Marine Strategy Framework Directive, the Baltic Marine Environment Protection Commission's Baltic Sea Action Plan (HELCOM BSAP) and the European Union's Water Framework Directive, all follow the concept of adaptive management. These initiatives depend critically on robust assessments of the environmental status. Comprehensive criteria for this must be based on solid knowledge about marine ecosystem structure and functioning. Consequently, this strategic objective occupies the central position in the BONUS strategic research agenda.

State of the art

Although many of the key pressures influencing the Baltic Sea environment have been recognised, their relative impact is far from being understood. It is known that the Baltic marine system is highly dynamic and strongly impacted by large-scale atmospheric circulation, river runoff and restricted water exchange. Nevertheless, the fluxes and fate of nutrients, hazardous substances and dynamics of food webs can only be described in approximate terms. A preliminary model-based estimate of the necessary reductions of nutrient loads into the sub-basins underpins the current policy effort. However, the level of uncertainty with regard to system's responses to pressures and mitigation measures is too high for decisive actions at policy-making levels. In particular, the interaction between climatic driving forces and human induced pressures on various ecosystem levels is not understood sufficiently.

Although considerable knowledge about the properties of the Baltic Sea biodiversity has been accumulated, an integrated overview of ecosystem structure and its functional dynamics is still to be generated. This overview needs to include evolutionary processes, occurrence and role of specific brackish habitats and impact of non-indigenous species. While decreasing trends in contamination have been observed in some hazardous substances, contamination levels remain high for many other compounds. As contaminated aquatic environments contain several hazardous chemicals at the same time, the effects of mixtures have to be studied more intensively. Similarly, occurrence and effect of new potentially hazardous contaminants need much closer scientific examination.

How BONUS will address the strategic objective 1

The research will address the principal knowledge gaps in regards of the Baltic Sea ecosystem. It will provide improved knowledge of the physical drivers and their future alternations, reliable quantification of impacts of combined human pressures on ecosystem structure and functioning including its level of stability and resilience. Detailed information on properties of biogeochemical cycles and food webs in various conditions will be gathered. Improved models incorporating complex food web effects and biogeochemical mechanisms will be created. New qualitative and quantitative information will be acquired on effects of human-induced environmental pressures, including agriculture and fisheries, and on effects of climate on species and on functional diversity of populations and communities; also, including information on ecosystem and economic effects of aquatic bio-invasions. New tools will be created for assessment and description of the spatial distribution of species, populations and communities, as well as marine habitats and landscapes in support of protection of biological diversity and maritime spatial planning. BONUS research on the Baltic Sea ecosystem will generate new knowledge on contaminants' impact at organism, population and community levels including the cumulative effects. Novel information on sources, fate and risks of new chemicals and interactions between hazardous substances and other pressures will significantly enhance the ability to design optimal protective measures and ultimately mitigate the effect of hazardous substances on the ecosystem and humans.

In particular, BONUS research will address the issue of quantification of the criteria of good environmental status identified by Marine Strategy Framework Directive and the deriving updates in the international monitoring programme, in particular, the qualitative descriptors (see box 5 for the full list) relevant to biological diversity

Research themes under strategic objective 1	
1.1	Ecosystem resilience and dynamics of biogeochemical processes, including cumulative impacts of human pressures
1.2	Causes and consequences of changing biodiversity
1.3	Food web structure and dynamics
1.4	Multilevel impacts of hazardous substances

and non-indigenous species *(1,2)*, status of exploited populations *(3)*, integrity of marine food webs *(4)*, eutrophication *(5)*, sea-floor integrity (6), hydrographical conditions *(7)*, levels of contaminants in environment and seafood *(8, 9)*.

Theme 1.1
Ecosystem resilience and dynamics of biogeochemical processes, including cumulative impacts of human pressures

The ecosystem of the Baltic Sea is highly dependent on its physics and biogeochemistry which in turn are affected by the interaction of the Sea with atmospheric processes. Despite the long tradition of physical and biogeochemical studies, there are still major gaps in knowledge e.g. in effects of climatic variations on fundamental processes, such as stratification and vertical and horizontal transport of nutrients in different basins, as well as consequences of these variations to physical-biological interactions. Consequently we are not able to make reliable predictions of the development of the biogeochemical processes of the Baltic Sea at policy-relevant time and space scales.

Baltic Sea-wide research on ecosystem resilience and dynamics of biogeochemical processes needs to include all ecologically relevant components and processes, in order to increase the scientific understanding of what controls resilience and dynamics. In particular, there are significant knowledge gaps in relation to e.g. oxygen dynamics, the biological carbon pump, internal loading of nutrients and greenhouse gas fluxes etc. This knowledge is vital in putting into practice the ecosystem approach to management of human activities. Studies need to be multi- and interdisciplinary, and they also need to take into account various natural and human-induced processes in the watershed, and beyond.

Expected outcome: Improved understanding of the hydrographic-physical drivers of the Baltic Sea and their future alterations by climatic impacts. Improved knowledge on ecosystem stability and resilience with regard to different natural processes, human pressures and climate. Reliable quantification of additive, synergistic and/or cumulative effects of human pressures on ecosystem structure and functioning. Estimates on qualitative and quantitative effects of climate on external and internal loading of nutrients and their availability to primary producers in different Baltic Sea basins. Improved models of biogeochemical cycles (N, P, C, O, and other redox-sensitive elements), including bioavailability of nutrients, and identification of key factors controlling eutrophication in different parts of the Baltic Sea. New detailed information on differences of the effects of oxygenated, hypoxic and anoxic waters and sediments on biogeochemical cycles and food webs. New scientific background of the role of microbes, in the Baltic Sea ecosystem. Combining biogeochemical and food-web models to describe effects on ecosystem functioning and resilience. Science-based knowledge on development of the descriptors and indicators, and their interpretation, in implementing the Marine Strategy Framework Directive, in particular the good environmental status descriptors of eutrophication, sea floor integrity and alteration of hydrographical conditions *(5, 6, 7)*.

Theme 1.2
Causes and consequences of changing biodiversity

Biodiversity of the Baltic Sea is affected by a multitude of natural and human-induced pressures, such as eutrophication, harmful substances, littering, spreading of non-indigenous species, climate change, as well as maritime traffic, hydro-technical construction, fishing, aquaculture, leisure activities, activities in the watershed and other uses of the Sea. Because of this complex web of natural and human-induced pressures, biodiversity cannot be studied by addressing one pressure at a time. Instead, biodiversity must be studied and assessed by using an integrated holistic and multi-disciplinary approach at several ecological levels: species, habitats including their associated communities and ecological landscapes, and with both species and functional diversity being accounted for.

On species level, research on distributional patterns, and population genetic structures and demographic characteristics is needed for various taxa from viruses to marine mammals, including non-indigenous species.

On habitat level, a coherent classification of marine habitats, supported by adequate mapping, is essential for assessments, taking into account also variations over time and related drivers. Besides habitat distribution, description of habitat condition requires an integrated understanding of the status of associated communities and species, including an assessment of their functional traits.

New knowledge is needed, not only on diversity *per se*, but on the socio-economic drivers and environmental pressures affecting marine biodiversity, and on linkages between biodiversity and state and functioning of the ecosystem.

Expected outcome: New knowledge to underline the measures and policy instruments that support maintenance of the diversity and health of the Baltic Sea ecosystem. Knowledge on sensitivity and resilience of marine biodiversity under different environmental scenarios including new qualitative and quantitative information on i) species, habitat and functional diversity in different Baltic Sea ecosystems, ii) the effect of human-induced environmental pressures as well as climate on spatial and temporal dynamics of species and habitats and associated effects on marine ecosystem structure and dynamics and iii) the ecology of bio-invasions and effects of aquatic invasive species that helps to prevent unintentional introductions, e.g. with ballast water. New knowledge and quantitative analyses on the efficacy and management of the network of marine protected areas, their spatial distribution, connectivity, and their properties and characteristics. New knowledge on the response of biodiversity indicators to management measures intended to restore good environmental status of the Baltic Sea and establishment of an evaluation framework for assessing and testing different indicators, in particular Marine Strategy Framework Directive's good environmental status descriptors characterising biodiversity, presence of non-indigenous species and seafloor integrity *(1, 2, 6)*.

Theme 1.3
Food web structure and dynamics

Individuals and populations of plants and animals are directly and indirectly affected by 'bottom-up' forces (i.e. availability of resources) and by 'top-down' forces in the food web (i.e. grazing, predation, harvesting). The strength and consequences of ecosystem functional aspects such as energy flows and the structure of food webs vary in time and space, and are often nonlinear. Trophic cascading, whether initiated by fisheries, climate change or non-indigenous species may contribute to ecosystem regime shifts and newly established species interactions that prevent recovery of desired food web configurations. Therefore it is complicated to find simple solutions for protecting biodiversity and ensuring the long-term abundance of species and maintenance of their full reproduction capacity.

Despite an increasing number of studies demonstrating trophic cascading in the Baltic ecosystem, the food-web consequences of the top-down influence of fisheries relative to bottom-up effects e.g. eutrophication are not fully understood. Adding complexity, the structuring effects of climate change, introduction of non-indigenous species and impacts of contaminants in food webs have to be considered in food web studies.

Food webs cycle and transform nutrients and harmful substances, both being an important service of the Baltic Sea and knowledge on processes acting are key to understanding human impact on Baltic Sea ecosystems. Integration of these food web processes in ecosystem models is a prerequisite for projecting interacting ecosystem effects of changes in nutrient and contaminant loading, climate forcing, introduction of non-indigenous species and fisheries.

Expected outcome: Improved data and knowledge base for Baltic Sea food web models, satisfactory handling of the impact of eutrophication, climate forcing, non-indigenous species, hazardous substances and fisheries on ecosystems' trophic structure and functioning. In particular, this new knowledge on the bottom-up effects, temporal and spatial dynamics of predators, prey and competitors, and estimation of consumption, mortality and other population dynamic rates being dependent on food web processes.

Food-web models enabling evaluation of trophic effects of various ecosystem drivers and identifying thresholds between different ecosystem states, in particular in relation to Marine Strategy Framework Directive's good environmental status descriptors of the status of exploited populations and marine food webs *(3, 4)*. The ultimate goal would be to produce different scenarios to understand and predict ecosystem functioning, resilience and dynamics. Models should be used to evaluate the effect of various management measures and to test and define indicators of good environmental status suitable to inform on changes in ecosystem structure and functioning in response to these management measures or other ecosystem drivers.

Improved knowledge on the capability of Baltic Sea food webs to i) cycle and transform nutrients helping to improve the performance of ecosystem-based water quality management strategies and ii) accumulate and transform hazardous substances including effects on seafood as needed to achieve good environmental status in accordance with Marine Strategy Framework Directive's descriptors of concentrations of contaminants in environment and seafood *(8, 9)*.

Theme 1.4
Multilevel impacts of hazardous substances

The reliable estimation of ecotoxicological risks of mixtures of hazardous chemicals still needs improvement. As both underestimating and overestimating the risk may have significant undesirable economic consequences, progress in basic research and development of new methods to reduce the uncertainties in risk assessments related to chemical mixtures, including a full effluent assessment, is of critical importance. It is necessary to understand better the additive, antagonistic, synergistic or cumulative effects to be able to determine appropriate threshold values for the Baltic Sea. Traditionally eutrophication processes are studied separately from contaminant dynamics. Nowadays the research shall shift towards a multi-stressor approach, taking into account interactions between eutrophication and contaminant effects as well as climate. Investigations of sediment processes, such as in situ detoxification and burial, and their susceptibility to changed external forcing need a particular attention. New chemicals are introduced for human use, and subsequently to the environment, daily. Thus there is an increasing need for early detection of these new classes of pollutants, given their potential relevance to food webs, in particular, in the context of implementing of the EU regulation concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH)(37). While a number of the emerging chemicals of concern have been already identified, the evaluation of their occurrence, toxicity, ecological risk and impact on biogeochemical processes is still urgently needed. In particular, the development of regulatory framework in regard to the endocrine disruptors, combination effects and nano-materials has to be supported by new knowledge.

Expected outcome: New knowledge on contaminants' impact on organism, population and community level for management purposes. Improved assessment of risks to the Baltic marine environment and human health, including assessment of the cumulative impacts of pressures and a full effluent assessment. New information related to sources, fate and risks of new emerging chemicals in the Baltic ecosystems. Improved capacity to assess and predict interactions between hazardous substances and other stressors (e.g. eutrophication and climate) in order to advise protection and remediation measures at the appropriate temporal and spatial scales.

Detailed understanding of the environmental variables that influence toxicity in order to design cost-effective methods for site-specific sediment quality and risk assessment, monitoring, and

remediation. New know-how for cost-effective reduction of hazardous substances loads to support the Baltic Sea Action Plan goals. New scientific knowledge for implementing the effect monitoring, in particular, development of appropriate indicators and parametrising the Marine Strategy Framework Directive's good environmental status descriptors of contaminant concentrations, contaminants in fish and seafood, and marine litter *(8, 9, 10)*.

Strategic objective 2: Meeting the multifaceted challenges in linking the Baltic Sea with its coast and catchment

Rationale

A specific feature of the Baltic Sea is its large catchment in relation to the Sea area and volume. Therefore, the impact of environmental pressures on the Baltic Sea system originating in the Baltic Sea catchment is considerably large. In particular, the changing climate has not only a direct impact but is also expected to have major indirect effects, through the changing conditions in the catchment, on the state and future development of the environmental conditions of the Baltic Sea including its coastal areas.

State of the art

In order to understand the impact of the changing climate, there is a need for an integrated modelling approach taking into account a hierarchy of scales which range from local catchments to the continental scale. Such comprehensive analyses have started to emerge only recently. Even less developed are studies on nutrient and organic matter transformations in the transitory basins under climate change. There is a considerable amount of information about many aspects of human impact on the coast and the open sea. However, due to the increasing man-made impact on the highly dynamic coastal ecosystems, there is a need for interdisciplinary studies on the jointly developing and interacting socio-economic and ecological systems. Furthermore, there is a gap between the scientific research and integrated management, including, for example, spatial planning, impact analyses and changes in land cover.

How BONUS will address the strategic objective 2

BONUS research will apply the catchment-coast-sea continuum concept, which has been developed in the context of the Land-Ocean Interaction in the Coastal Zone programme of the International Geosphere-Biosphere Programme. The objective will be addressed by studies where either the entire catchment-coast-sea continuum is considered or catchment-related topics are in focus. The BONUS research will include research and innovation dedicated to the catchment of the sea and beyond where a clear direct or indirect linkage to the ecosystem of the Baltic Sea system (including the sea and its coasts) is demonstrated or can be expected. The research and innovation will address impacts of natural and man-induced changes in the catchment land-cover patterns and responses of coastal systems to changes in climate and human-induced pressures. New knowledge, products and services will be produced on integrated approaches to coastal management, spatial planning and water quality improvement along the catchment-coast-sea continuum. Ecoinnovative approaches are called for in order to achieve a good environmental status in the Baltic Sea.

Theme 2.1
Natural and human-induced changes in catchment land cover patterns, including the role of e.g. agriculture, forestry and urbanisation

Understanding the pressures originating from developed areas in the catchment (e.g. urban complexes, industrial areas) and economic sectors (such as agriculture, forestry, transport, energy and recreation) is crucial in both understanding and managing environmentally the Baltic Sea. The transports of nutrients and contaminants to the Sea as well as the processes and sources in the catchment and their past and future changes need to be understood better. Climatic conditions over much of the Baltic Sea catchment have undergone changes in the recent decades and these changes are likely to continue, possibly at an increasing rate over the 21st century. Together with other natural and socio-economic drivers these changes seem likely to influence the structure and functioning of ecosystems, and may impact the

Research themes under strategic objective 2	
2.1	Natural and human-induced changes in catchment land cover patterns, including the role of e.g. agriculture, forestry and urbanisation
2.2	The role of the coastal systems in the dynamics of the Baltic Sea
2.3	Integrated approach to coastal management
2.4	Eco-technological approaches to achieve good ecological status in the Baltic Sea

services they provide for the society. Also, effects of global socio-economic trends with potential relevance to the Baltic Sea region have to be considered as drivers in the overall assessment and establishment of future management models. A holistic approach to management is therefore mandatory. The joint impact of the above pressures, including climate change, is currently under debate and solid scientific knowledge as a base for political decisions on management measures such as the Baltic Sea Action Plan needs to be further developed and improved.

Expected outcome: Integration of spatially distributed and mediated effects of environmental pressures in the catchment-coast-sea continuum, with the emphasis on development of decision making tools, both in the political and management domains. An integrated assessment of the impact of climate change, in particular, with a consideration of changes and impacts of extreme and rare events across the whole Baltic Sea catchment. The assessments are to be based on advanced, up-to-date projection and forecast tools using harmonised, holistic scenarios of all relevant drivers, and adequately addressing the different space and time scales of drivers, pressures and response actions, including e.g. appropriate down-scaling techniques. Relevant drivers to be considered must also include a variety of socio-economic drivers (such as life style, recreation, methods of farming and forestry, food prices, sewage treatment, energy production, traffic etc.). Improved understanding of sustainable development of the catchment-coast-sea activities and environmental preservation based on analyses of costs and benefits.

Theme 2.2
The role of coastal systems in the dynamics of the Baltic Sea

The coastal systems of the Baltic Sea (e.g. lagoons, estuaries, archipelagos and other areas of restricted exchange) serve as natural filters between the Baltic Sea and its watershed. Moreover, they are characterised by a close interlinkage of natural conditions and socio-economic drivers. Identifying, quantifying and predicting the role of such systems as biogeochemical barriers and their interaction with the open Baltic Sea under global and regional change scenarios is the key objective of this theme.

Expected outcome: Future projections, scenarios and support tools for decision makers that can be used to develop strategies for inner coastal waters with emphasis on trajectories of socio-economic development. Assessment of the present and future roles of coastal waters in the Baltic Sea area with regard to e.g. retention, transformation and transport of organic matter, nutrients and hazardous substances. Assessment of the physical and biogeochemical processes at the freshwater–seawater interface as well as changes in the food web dynamics. New systems of observations and monitoring and improved tools for projections and predictions of conditions in the context of climate change. Coupled physical-biogeochemical land surface, coastal zone and large-scale ocean models integration with regional climate models.

Theme 2.3
Integrated approaches to coastal management

Harmonised management of activities both onshore and offshore is required in order to minimise environmental impacts, foster the development and improvement of social assets. Being already a naturally complex environment, management of the coastal areas is even more difficult when taking into consideration dynamic changes evoked by natural process such as sea level changes, variation in atmospheric conditions, wave and current regime, as well as changes evoked by the processes in the drainage basins related to the precipitation and runoff. As wind and wave power projects develop rapidly in the coastal sea, innovative approaches to combined use of marine space with e.g. innovative aquaculture technologies may emerge.

Expected outcome: Tools for coastal zone management, protection and adaptation considering results of complex analysis of morphodynamic processes linked to the full range of possible scenarios of climate impacts and development of socio-economic activities (ports, fishery, energy production, tourism, aquaculture, etc.). New solutions and services for harmonisation of the existing use of coastal areas with the view to avoid conflicts of interest as well as science-based suggestions for diversifying the sustainable use of coastal areas. New solutions, including eco-technologies, for the coastal waters and for the maintenance of flood-prone arable land, and protection of agricultural, touristic and infrastructural land use along estuaries and inner coastal waters. Flood protection measures, land-use strategies and river management concepts.

Theme 2.4
Eco-technological approaches to achieve good ecological status in the Baltic Sea

Design and development of regulatory tools and incentives is required to promote cost-efficient eco-technological approaches. In the field of forestry and agriculture, attention should focus on sustainable production with minimum of nutrient leakage and emission of toxic substances. Research and development should also include integrated water, wastewater and solid waste management methodologies for urban and non-urban areas and economically sound nature-based nutrient retention and removal. There is a gap of knowledge and practical experience in regard to remediation and restoration of habitats in the Baltic Sea. Methods for remediation and restoration of coastal and offshore areas disturbed, either by human-induced effects such as oxygen depletion, pollution spills, hydro-technical constructions etc. or by natural causes such as coastal erosion and landlifts, shall be developed and tested.

Expected outcome: Economic models supporting elaboration of regulatory tools and incentives for eco-technological development and resource utilisation. Design studies for new soil drainage tech-

nologies and recirculation of nutrients and chemical substances, nutrient retention through aquaculture and creation of the eco-loops of nutrients, and rational forestry technologies. Methods for decentralised water management, recovery of substances from waste and sediments. Methods for retention and reduction of air pollution from energy production and transportation.

New cost-efficient, effective and simple methods to test the chemical status of sewage, leachate from landfills, integrated industrial wastewater and storm water, improved treatment efficiency for xenobiotics, new bioremediation methods. New efficient and feasible methods for restoration of marine and coastal habitats.

Strategic objective 3: Enhancing sustainable use of coastal and marine goods and services of the Baltic Sea

Rationale

The Baltic Sea provides numerous goods and services that are expanding dynamically and hence creating an underlined demand for sound knowledge on their exploitation. Shipping and fisheries are the most traditional, and until now, the most important maritime sectors of economy. Despite the decades-long effort by the governments of the Baltic Sea states, neither shipping nor fisheries can be regarded as being in a state that ensures minimum impact on the environment, sustainability of resources and safety of operations. Fundamental improvement in both interlinked sectors requires substantial amounts of research and development to fulfill the objectives of Baltic Sea Action Plan and EU Marine Strategy Framework Directive. Interest in new maritime economy sectors is growing rapidly worldwide. In particular, this is the case with renewable offshore energy and offshore mining. Hence, the review of the BONUS strategic research agenda in 2013 can potentially extend the scope of this strategic objective to the new marine goods and services.

State of the art

Research and development aiming at improving shipping safety is relevant to BONUS as much as it contributes to minimising the environmental risks. Previous research has primarily focused on analytical methods and practices targeting specific risks. A multi-disciplinary risk analysis enabling the modelling of all the risks with their occurrence frequencies and consequences are needed. The increasing likelihood of extreme weather events can increase the risk levels, consequently the preventive options have not been studied thoroughly. New technologies for clean shipping are much researched today. However, assessments are required on the effect of environmentally improved operations of vessels and harbour facilities, including reduction of emissions and noise, marine litter, ballast water treatment as well as waste water and solid waste management.

The principle of ecosystem approach to management was introduced into the various management plans a decade ago. Although the recent research has focused on integrated analyses of the impacts and regime shifts caused by various pressures on the Baltic Sea food-webs and ecosystem as a whole, including fisheries, the knowledge base is not sufficient for implementing the EU Marine Strategy Framework Directive and supporting the revision of EU Common Fisheries Policy. There is a lot of information about various aspects controlling individual fish stocks. However, there is still a need for integration of this information into multi-species and -stock models so that the concept of maximum sustainable yield of commercially exploited stocks could be implemented. The question of uncertainty in assessments and risks against achieving management objectives needs to be solved. Sufficiently elaborated bio-economic models as well as climate and fisheries scenarios are missing in order to address the economic drivers and longer time-horizons of the management plans. Furthermore, the potential of broader and more variable exploitation of aquaculture has not been addressed sufficiently.

Research themes under strategic objective 3	
3.1	Enhanced , holistic cross-sectoral and cross-border maritime risk analysis and management, including effects of new technologies, human factor, climate change effects in open water and in ice, and interaction with onshore activities
3.2	Assessing the effects of air and water pollution (including noise) by shipping activities on the marine environment and integrated water management in harbours
3.3	Improving stock assessments and resolving spatial heterogeneity and temporal dynamics of the Baltic Sea fish stocks
3.4	Evaluation framework for fisheries management
3.5	Sustainable aquaculture in the Baltic Sea

How BONUS will address the strategic objective 3

BONUS will promote research and development aiming at minimising the environmental risk caused by shipping and contributing to the knowledge on effects of the ships' pollution on the Baltic Sea ecosystem. Projects are expected to support quantification of the Maritime Strategy Framework Directives qualitative Good Environmental Status descriptors in regards to introduction of non-indigenous species *(2)*, contaminants originating from shipping *(8)*, marine litter *(10)* and introduction of energy, including noise *(11)*, and propose science-based solutions that fulfilling these criteria.

BONUS research will improve fundamentally the management of fisheries sector and the technologies applied therein. Research will focus on improving the stock assessments as well as the fisheries management framework. The outcome will help to fulfill the objectives of Baltic Sea Action Plan and EU Marine Strategy Framework Directive and to quantify good environmental status descriptors. In particular, the good environmental status criteria characterising biodiversity *(1)*, level of exploitation of living resources *(3)*, integrity of food webs *(4)* and contaminant level in fish and other seafood *(9)* greatly depend on prudent governance and management of fisheries.

Theme 3.1
Enhanced, holistic cross-sector and cross-border maritime risk analysis and management, including effects of new technologies, human element, climate change effects in open water and in ice, and interaction with onshore activities

Safety of marine traffic is not only vital for the industry but, to a great extent, it also determines the environmental risks posed by shipping. Traditionally, the safety of marine traffic has been improved by developing various analytical methods and practices to identify and control risks. Multidisciplinary risk analysis, cross-sector and cross-border risk management are the most important tools enabling the modelling of all the risks with their occurrence frequencies and consequences. At the end, the risk control options are also examined in relation to the costs and benefits. Any maritime accident is typically a result of interaction of multiple causes including the human element. Climate change with increasing likelihood of extreme weather events occurring at shorter intervals can increase the risk levels of marine traffic substantially if the possible preventive options have not been studied thoroughly in advance. Ice conditions also greatly increase risks in winter navigation. Climate change will challenge the maintenance of the expertise needed to operate ships in harsh weather conditions. For example, while there is a growing concern about mariners not having experience on ice navigation and thus losing the knowledge for this skill, the rare extreme winters are even more demanding to navigators and create dangerous navigational situations. There is a lack of scientific research related to the risk modelling of the navigation in ice.

Expected outcome: Proper methods and decision support tools based on multidisciplinary risk analysis to guide the authorities in decreasing risk in a cost-effective way, in particular, the environmental risk associated with shipping. Analysis of the effects of the transmitted real-time and predicted meteorological conditions (wind, waves, ice) combined from both onboard and from shore-based stations' measurements of observed traffic situations in determining the risk levels and safest route for the vessel to follow both in open water and in ice. Proper methods and decision support tools for preventing of maritime accidents and crisis management, in particular taking into account the human behaviour in various accidental scenarios, enhancing the safety cultures, effects of proper training and various aspects of interaction between humans and technical tools. Evaluation of the risks of the future maritime activities related to the renewable energy developments.

Theme 3.2
Assessing the effects of air and water pollution (including noise) by shipping activities on the marine environment and integrated water management in harbours

Shipping is increasingly being addressed by more stringent international requirements for reducing harmful environmental impacts, such as atmospheric emissions as well as noise on and to the water. Alternative fuels (e.g. liquefied natural gas, bio-fuels, hydrogen) and application of new technologies for clean shipping are much researched today. However, assessments are required on the effect of environmentally improved operations of vessels, including reduction of emissions and noise, ballast water treatment as well as waste water and solid waste management. The assessments should consider also facilities that are located on the coast line and along the rivers. Furthermore, analyses of the ecological, economic and societal effects of possible new environmental requirements for shipping to support decision-making in the future are topical.

Expected outcome: Improved knowledge on effects of the ships' pollution on the Baltic Sea ecosystem. In particular, a quantification of the Marine Strategy framework Directive's good environmental status descriptors in regard of contaminants originating from shipping operations, marine litter and introduction of energy, including noise *(8, 10, 11)*. Science-based solutions for achieving good environmental status in accordance with these criteria. Analysis of the economic, societal and ecological effects of new environmental requirements for shipping.

Theme 3.3
Improving stock assessments and resolving spatial heterogeneity and temporal dynamics of the Baltic Sea fish stocks

Spatial heterogeneity both within and between the different sub-systems is a strong feature of Baltic fish stocks. Recently significant biomass distribution changes have been observed for several stocks, potentially depending on stock size, environmental factors and/or fishing pressure. Not only do these changes affect critically the stock

dynamics and population state, but also species interactions and food-web configurations. Lack of understanding and consequent neglect of them may threaten the success of ecosystem-based management actions and validity of Marine Strategy Framework Directive's descriptors 3 and 4 and related indicators. Knowledge on (i) habitat requirements for different life-stages of fish stocks, (ii) migration patterns and exchange rates between different areas, and (iii) the causes of temporal variability in spatial biomass distributions is still insufficient. While analytical assessments for most important Baltic fish stocks to describe temporal stock dynamics are available, these are lacking for important flatfish stocks.

Expected outcome: Closing a critical knowledge gap by conducting re-analysis of spatial data, design of a sampling programme that resolves the habitat requirements of different life-stages of commercially and ecologically important fish stocks by combined use of traditional and modern techniques. Developing the knowledge base for implementing sufficiently sensitive and robust analytical assessment of flatfish in the Baltic. Increased involvement of industries in order to improve data collection and strengthen the participatory spirit in these studies.

Theme 3.4
Evaluation framework for fisheries management

A successful long-term management of marine living resources requires consideration of ecological, environmental, economic and social drivers and constraints as well as an appropriate institutional/governance structure. Frameworks that are able to evaluate scenarios of fisheries management options under changing ecological, environmental and fisheries conditions should be elaborated.

Expected outcome: Development of new management evaluation tools that cover the whole fishery system and the related environmental aspects, i.e. i) biological interactions involving fish stocks and other ecosystem components, ii) technical interactions involving fleet development, with consideration of economic drivers and environmental constraints for different fleets, iii) assessment and advisory procedures leading to agreement of management measures, iv) success in implementation of measures and industry compliance and, finally, v) feedback to the fisheries, advisory and management systems after implementation of management measures. Development of evaluation tools and elaboration of a suite of ecosystem, economic and social indicators for major fish stocks in the Baltic considering the maximum sustainable yield and the precautionary approach, in particular, quantification of the Marine Strategy Framework Directive's good environmental status descriptors related to the status of exploited populations and marine food webs *(3, 4)*. Improved predictive capability, both with respect to stocks and fisheries dynamics, the ecological, environmental and economic effect of management measures and the likelihood of achieving management objectives.

Theme 3.5
Sustainable aquaculture in the Baltic Sea

Increasing aquaculture production in the Baltic and at the same time reducing environmental impact from the industry is possible by the introduction of innovative solutions and new technologies. Aspects and components from e.g. the recirculation technology have proven to be commercially and environmentally sustainable in fresh water trout and salmon smolt farming. However, further knowledge and development of the technology is needed.

Expected outcome: New knowledge characterising the dynamics and kinetics of the processes involved that provides the basis for system dimensioning and production planning regarding farming of large fish in saline and brackish waters. New knowledge on biofilter function and kinetics in brackish water, focusing on organic matter and the nitrification and subsequent removal of nitrogen through denitrification processes. Development of operational solutions applicable in practical farming.

Strategic objective 4: Improving the capabilities of the society to respond to the current and future challenges directed to the Baltic Sea region

Rationale

Societal features and individual attitudes and behaviour are the main drivers that determine the environmental state of the Baltic Sea. Therefore, responses to the main problems in the Baltic Sea need well-performing institutional solutions and governance structures that take into account the various current political and administrative settings in the Baltic Sea region and that also build new institutions that perform better than earlier ones in relation to the environmental state of the Baltic Sea.

State of the art

Cost effectiveness and politically acceptable allocation of abatement efforts and measures are in a key position when improving the capability of the countries to respond to the challenges of the Baltic Sea. There are a number of studies on various aspects of cost-effectiveness of the current measures, in particular studies concerning cost effectiveness of nutrient reduction in regional, coastal or diffuse sources. However, missing are studies which would cover the whole Baltic Sea area in sufficient depth and detail for general policy

Research themes under strategic objective 4	
4.1	Governance structures, policy performance and policy instruments
4.2	Linking ecosystem goods and services to human lifestyles and well-being
4.3	Maritime spatial planning from local to Baltic Sea region scale

implications and advice. Research is needed for optimal design and implementation of policies using spatially differentiated policy instrument mixes. Also, the aspect of linking the ecosystem services to human well-being, as well as valuation and different pricing approaches of the ecosystem services have been studied very little. Research supporting maritime spatial planning as governance tool has started to flourish recently, but it is still comparatively new subject in general spatial planning domain. Research is needed for future sea space usage, holistic maritime spatial planning decision making and evaluation tools under uncertainty and tradeoffs.

How BONUS will address the strategic objective 4

BONUS aims at providing a solid scientific base for policy making in the Baltic Sea region. BONUS involves the top societal research in order to provide political decision makers and administrators good governance tools. With the help of science, it is possible to identify and develop models to support management of the most critical natural and human induced threats in the marine environment. Policymakers will be provided knowledge about the benefits derived from the ecosystem goods and services as well as the costs of protecting or improving them.

In response to societies' ever intensifying and diversifying interest and capacity to occupy marine space, maritime spatial planning has emerged recently on a global scale as a cross-sectoral governance tool. The performance of different planning systems will be analysed and compared in order to set sensible targets and develop optimal tools for the Baltic Sea region.

Theme 4.1
Governance structures, policy performance and policy instruments

The institutional capacities of a society are critical in order to reach the full potential of given policies. Since Baltic Sea region is probably the most densely governed sea area in the world, it is important to look at the policy instrument choices and analyse coherence and performance of policies in different policy settings and at different scales of time and space. It is of special interest to understand how certain governance features affect the environmental governance and policy performance. Moreover, how values and ethics shape institutions and governance structures need also further investigation. Behaviour and attitudes are not only reflected in voluntary environmental actions but they are also affecting the performance of policy instruments, thus these aspects need to be investigated. It is still to be understood how the presence of overlapping and multi-level governance structures affect policy performance in different policy sectors and how the geographical governance (within political jurisdictions) interact with the topic-based governance. Identifying the impact of the existing policy setting, such as the EU Common Agricultural Policy, is important in order to ensure the potential performance of different policy instruments, especially with regard to environmentally harmful subsidies and legislation. Furthermore, analysis related to uncoordinated vs. coordinated actions of policy measures, sectors and countries as well as spatial differentiation of policies is needed. A lot of research has been carried out addressing the cost-effective allocation of different abatement measures reducing the load of nutrients to the Baltic Sea. However, there is still a lack of both benefit and cost data for many countries as well as environmental problem areas, such as hazardous substances and biodiversity that are necessary for providing sound basis for policy making. Also, research related to implementing new policy instruments, such as nutrient trading schemes, need to be conducted. It is important that this analysis is performed taking into account the perspective of the entire drainage area. In order to evaluate policy instruments properly, data and methods are needed for addressing policy choice criteria, such as environmental effectiveness, cost-effectiveness, administrative costs, synergy effects, equity and flexibility.

Expected outcome: Better understanding of how the linkages between individual attitudes, behaviour and governance structures shape environmental policies, policy instrument choice and therefore also policy performance. Analysis of the performance and history of existing policy instruments, including their impact on human behaviour, and suggestions of new instruments based on a set of policy choice criteria. Identification of the most cost-effective measures based on the most reliable cost estimates across the Baltic Sea drainage area. Development of methods dealing with the synergy effects of measures in cost estimates.

Theme 4.2
Linking ecosystem goods and services to human lifestyles and well-being

It is vital to describe the importance the Baltic Sea has for human lifestyles and well-being in order to obtain public and political support for taking the necessary actions for improving and/or protecting the state of the Baltic Sea. Identifying the services and goods provided by the marine ecosystems of the Baltic Sea and linking them to human lifestyles and well-being requires interdisciplinary research between natural and social scientists. It is also important to capture the links between different goods and services, and whether there exist any positive or negative synergy

effects between them. That these goods and services, as well as their impact on human lifestyles and well-being, are spatially explicit, affected by distribution of rights and responsibilities, as well as property rights, must be considered in an analysis. In order to quantify, and if possible, define a monetary value of these goods and services, the dynamics of the ecosystems providing these goods and services, as well as how they are affected by different scenarios, must be addressed. There are a number of methods to estimate a monetary value of ecosystem goods and services with a consideration of their pros and cons. The preferred evaluation method depends on the characteristics of the ecosystem service or good in question as well as how it is linked to human lifestyles and well-being and whether it is dominated by use values or non-use values. The total economic value ecosystem services generate to humans can be separated between use values (e.g. fish landings, recreation) and non-use values (e.g. the value attached to knowing that it will be passed on to future generations in a good condition). However, the pros and cons of using or not using valuation estimates in policymaking, and exploring the alternatives and their implications, could also be addressed under this theme.

Expected outcome: Quantification and evaluation of the impact of environmental state of the Baltic Sea and human lifestyles and well-being, and the link between this state and human lifestyles and well-being. Quantification of the value of intermediate ecosystem services (e.g. resilience).

Theme 4.3
Maritime spatial planning from local to Baltic Sea region scale

Marine space is being regulated predominantly within the limits of individual economic sectors. Maritime spatial planning has emerged only recently as a cross-sectoral governance tool. Therefore already existing knowledge on performance of different maritime spatial planning systems should be completed with analysis on their development including comparative analysis of related education at different levels, and communicated to different stakeholder groups at different geographical scales. There is a deficit of maritime spatial planning tools for planning under uncertainty, monitoring and evaluating the effects of the planning process in relation to the jointly agreed targets. Maritime spatial planning suffers from a lack of adequate knowledge on spatial and temporal properties of ecosystems and their elements. There is a need to identify spatial needs and requirements of different ecosystem services, in order to improve evidence base. It is desirable that studies on such issues as resilience, carrying capacity of the environment, food webs and habitat modelling would pay attention to spatial considerations. Equally important are studies supporting spatial management in relation to provisioning services such as off-shore energy production or integrated aquaculture. Despite all policy efforts to date, the land-sea integration within maritime spatial planning is still not satisfactory. This leads to user-user and user-environment conflicts in the coastal and marine environment and may also lead to a claim for sea space for development that could be accommodated onshore. Research for improving the capabilities of the society to respond to the current and future challenges directed to the Baltic Sea region is needed. Research is also needed to find the optimal ways how the underwater cultural heritage can be explored and protected in sustainable way in the exclusive economic zone (EEZ).

Expected outcome: Practical planning tools for maritime spatial planning structures to improve performance in different settings and regions and minimising possibility of suboptimal use of marine space. Methods and tools for monitoring and evaluation of maritime spatial planning outcomes. Models for comparative and consequential analyses of cumulative benefits and tradeoffs of different types of use of sea space and their marginal costs. Methodology options for cross-border maritime spatial planning. Analysis of the options for sea planning targets for the Baltic Sea region e.g. on mariculture or maritime landscapes preservation and, in particular, offshore energy production. Improved evidence base in such topical areas as e.g. space requirements of different marine species throughout their life cycle, impact of human induced barriers such as noise pollution on connectivity and on carrying capacity of different habitats. The improved evidence base is of particular importance in relation to effects of construction and operation of the offshore wind farms in the Baltic. New scientific evidence for planning of co-existence of different usages of marine space, e.g. combination of energy production with aquaculture or aquaculture with environment protection. New scientific evidence for planning and sustainable management of the underwater cultural heritage. Methods, tools and databases for spatial planning that will contribute to maintenance and development of ecosystem services along the catchment-coast-sea continuum. Solutions for connection between offshore activities, resources' use, and the onshore communities that are dependent on these activities and resources. Functional linkage of conservation issues in biologically and ecologically sensitive marine and terrestrial areas, as well as 'blue' land-sea corridors. Good practices and developments on regulatory framework for integration of the Sea and terrestrial space are expected.

Strategic objective 5:
Developing improved and innovative observation and data management systems, tools and methodologies for marine information needs in the Baltic Sea region

Rationale

Data and information on marine ecosystems as well as on catchments and the human activities impacting these ecosystems are needed for multitude of purposes. In particular, the Marine Strategy Framework Directive requires development of a regionally coordinated monitoring programme covering wide range of information characterising both the ecosystem state and the magnitude of human-induced pressures.

State of the art

The observation systems within the Baltic Sea are parts of and developing within various global and European observation networks. Notable for the Baltic Sea and its catchment area is that it extends over different climatic zones. Therefore, observation and data integration issues are strongly influenced by several area-specific factors like high shipping activity, extensive ice cover, brackish and turbid sea waters, physical and ecosystem patchiness with strong and variable stratification of the water column, variety of river influence areas, coastal bays and archipelagos. These features present a unique challenge and development opportunity to the global and European Earth observation initiatives.

How BONUS will address the strategic objective 5

The focus will be given to the area-specific technological and methodological innovations which can be applied establishing the next generation monitoring programmes by combining the progress of traditional and operational monitoring systems with the advanced research methods. These innovations could be used as prototypes also in other areas of the global ocean.

Theme 5.1
Developing and improving scientific basis for integrated monitoring programmes for continuous assessment of ecological status and human pressures

Monitoring and indicator-based assessment of environmental state, pressures and impacts are the basis for adaptive management. Marine Strategy Framework Directive requires member states to develop a comprehensive integrated regionally coordinated monitoring programme. There are also requirements for Baltic-wide monitoring and assessment to follow up the Baltic Sea Action Plan implementation. In order to support member states in meeting this challenge the development and improvement of scientific basis for integrated monitoring programmes for continuous assessment of ecological status and human pressures is required. Development should advance integration of the marine ecosystem and catchment-coast-sea observatories (as coherent networks of observation facilities), traditional monitoring programmes, 'cutting edge' research efforts and observing systems. It should also contribute to providing cost-effective high-quality Global Monitoring for Environment and Security (GMES) downstream services, combining the efforts in *in situ* observations, remote sensing and numerical modelling.

Expected outcome: Contribution to regional implementation of the Marine Strategy Framework Directive and HELCOM's development of an integrated monitoring programme. Integrating recently done or planned infrastructure investments for marine research, environment and traffic into comprehensive next-generation monitoring and assessment activities.

Research and innovation themes under strategic objective 5	
5.1	Developing and improving scientific basis for integrated monitoring programmes for continuous assessment of ecological status and human pressures
5.2	Developing and testing innovative *in situ*, remote sensing and laboratory techniques
5.3	User-driven new information and communication services for marine environment, safety and security in the Baltic Sea area

Theme 5.2
Developing and testing innovative in situ***, remote sensing and laboratory techniques***

Baltic-specific conditions pose additional requirements to the observation techniques and instruments. There is a need to develop and test new innovative *in situ*, remote sensing and laboratory techniques specifically adapted to the Baltic conditions. The developments should focus on one or several items of the tentative list, like new sensors and methods for *in situ* physical, chemical, biological and geological sampling and observations (including sampling methods and observation techniques onboard research vessels, ships of opportunity, automated underwater biochemistry laboratories, automatic profiling stations and mobile platforms, non-contact underwater acoustic methods), specialised cost-effective observing platforms (multi-parameter profiling stations, drifters, gliders, remotely operated vehicles, autonomous underwater vehicles, especially for biochemical and/or ice measurements, or enabling significant increase in sampling frequency and/or area of coverage), development of remote sensing products (adaptation of recent developments in satellite sensor technology for validation of models, improved ice monitoring, maritime spatial planning and risk reduction of winter shipping, broadening remote sensing applications to new, at present poorly covered subjects, including rivers, sea surface currents, ecological indicators) and new advanced methods for laboratory analysis (high-precision and/or effective determination of new chemicals/contaminants, marine genomics, biomarkers, isotopes, and/or making significant advances in eco-toxicology tests, mesocosm studies etc.). The techniques should advance studies of biogeochemical processes in the water column, with emphasis on processes under oxygen depleted conditions. Moreover, there is still a need to develop reliable energy sources for monitoring instruments.

Expected outcome: Advanced scientific information collection techniques specific to the Baltic Sea area amplifying, in mature stage, the performance of next-generation monitoring programmes. These techniques should have a potential to generate commercial value, and be used in other sea areas.

Theme 5.3
User-driven new information and communication services for marine environment, safety and security in the Baltic Sea area

Several large scale initiatives like Global Monitoring for Environment and Security (GMES) and European Marine Observation and Data Network (EMODNET) promote, collate and synthesise data from regional Earth System observations (GEOSS) into useful information for the benefit of different user groups. Development of internet usage (including new generation of mobile communication devices, web-accessed historical and operational databases, social and professional networks) enables creation of a number of user-driven marine information services that are yet to be developed. The need of such services has been already reported by the groups 'maritime professionals' and 'citizens'. The interests of marine professionals include, for example, better information services for environmental management, combating and/or mitigating marine disasters etc. While developing new systems, particular emphasis should be on data quality assurance, including quality expertise independent from data originator and automatic quality filtering methods. Different citizens' groups need, for enhancing their life quality, mobile information services providing detailed marine and coastal now- and forecasts of various properties of sea for recreational leisure time activities such as boating, surfing, fishing etc. In combination with technical developments, socio-economic studies need to be conducted to reach a good commercial value of the service products. The newly manufactured information system components should be linked to the existing and/or developing systems and data repositories and form self-contained but interoperable information tools.

Expected outcome: New information and communication technology-based tools and services responding to the contemporary and future marine and maritime information needs in one or several end-user areas. The results should be integrated into long-term running 'core' systems.

4. From vision to action

The legal basis of BONUS was set out by the European Parliament and Council codecision in summer 2010, referred to as BONUS Law(38). According to the Law, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden (the participating states) undertake jointly the Joint Research and Development Programme BONUS and with the European Community participating. The Law stipulates the governance structure, financial basis and general principles of the implementation of the programme. The implementation phase of the programme extends from 2012 until 2016.

Firm governance structure casts the foundation

The programme is managed by a dedicated implementation structure, BONUS European Economic Interest Grouping (EEIG) and its Secretariat, located in Helsinki and established by the key national funding institutions from all eight Baltic Sea EU Member States. The programme governance structure is presented in figure 3 and it includes:

- **Steering Committee** composed of representatives of national funding institutions as the highest authority of BONUS EEIG, forming its decision-making body and board governing the Secretariat; Steering Committee's Executive Committee is formed by the current chair, vice-chair and the previous chair.

- **Secretariat** as the management body implementing Steering Committee's decisions;

- **Advisory Board** consisting of scientists of high international standing and representatives of relevant key stakeholders. It assists by providing independent advice, guidance and recommendations regarding scientific and policy-related issues of BONUS.

- **BONUS Forum** composed of representatives from ministries and other actors dealing with Baltic Sea system research and governance. It acts as a platform for consultations from the decision-making perspective

- **Forum of Project Coordinators** composed of coordinators of ongoing projects funded through BONUS. It assists the Secretariat in matters dealing with the scientific coordination of BONUS.

Funding institutions in Russian Federation and other 3rd countries (countries that are not participating in BONUS nor are EU member states or associated with EU's 7th framework programme) may support their national project participants in the BONUS programme through separate agreements.

The programme is open for funders that are currently not members of the BONUS EEIG, but are willing to fund a particular BONUS call. Funders will have representatives in call steering committees that are to be formed for each call opening separately, and to which they provide funds to. The respective call steering committee addresses all issues related to the call that require decision making capacity. In addition, each funding institution will appoint a national contact person to a call task force, which assists the BONUS Secretariat with administrative issues.

Detailed implementation procedures are described in a separate set of guidelines that will include proposal evaluation scheme, procedure for integrating research infrastructures and guidelines for project participants. The relationships among the BONUS EEIG, the European Commission and the national funding institutions are governed by a set of relevant implementation agreements.

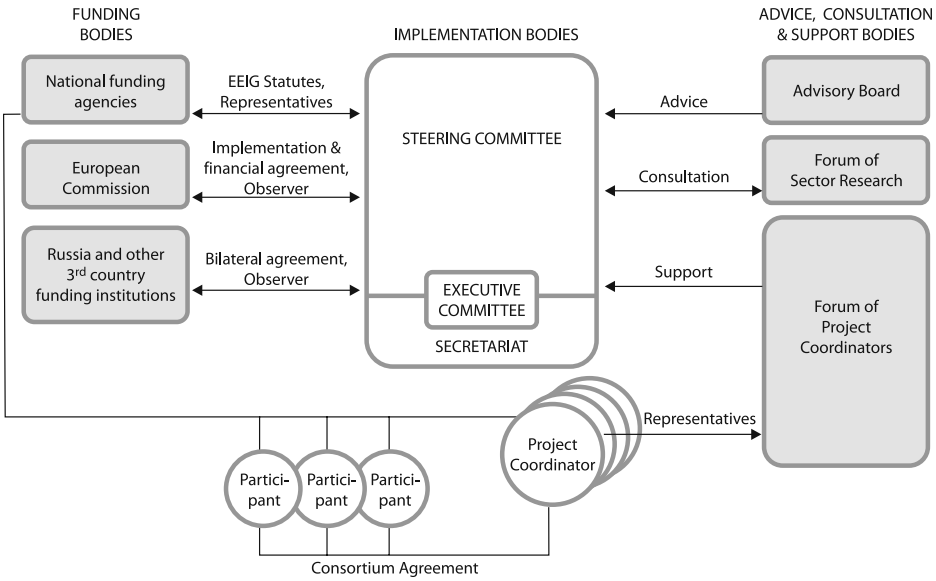

Figure 3: Programme governance and management structure

Synergies are forged between research and innovation

True progress towards economically and ecologically prosperous, sustainable Baltic Sea region requires also development of eco-technological approaches, new technological tools and supportive policy measures. Fostering such development is possible through collaboration within the so-called 'triple helix' in which academia, industry and policy constitute the three helices and work together. The need for sustainability solutions arises from society and involves a major potential, which is capable of triggering emergence of globally leading research and development networks and hubs based on market and business-demand.

When launching its strategy for this decade (EU2020)(34), the EU acknowledged that there is a need to make a steep change in EU's research and innovation performance. Lessons learnt from the current programming period is that research and innovation funding has to provide better value for money in the future through increased scientific and economic impact. There has to be more focus on outcomes to be achieved and research and innovation has to be better linked. It has to leverage effect on other public and private resources and be used more efficiently to support the strategic alignment and pooling of national and regional funds.

By launching calls on themes dedicated to innovation, BONUS is pioneering the implementation of the basic idea behind the EU's emerging strategic framework for research and innovation funding(34). In order to implement innovation oriented calls BONUS will collaborate with the relevant macroregional networks of companies, research actors and financiers that have emerged within the EU strategy for the Baltic Sea region.

Best research is selected

BONUS aims to launch calls that will be published with a view of funding projects which address the strategic objectives of the research agenda (Figure 4). Research themes addressing the issues which are critical for successful and timely implementing of the major relevant policy initiatives, in particular, the EU Marine Strategy Framework Directive and the HELCOM Baltic Sea Action Plan have been prioritised while designing the thematic content of the calls. The BONUS calls are targeting multi-partner and transnational projects only, encouraging adequate participation of small and medium-sized enterprises and other end users. As human capacity building and channeling of scientific knowledge to the broad society are vital priorities of the BONUS programme, the proposers of each project will be requested to complete their proposal with a training and dissemination plans, and reserve appropriate funding for these activities. The projects to be funded will be selected according to the principles of transparency, independent evaluation, co-financing, non-profit, non-retroactivity and financing not cumulated with other EU sources. During the evaluation of proposals a strong care will be taken to avoid duplication with studies already occurring within the EU Framework Programme for Research and Technological Development. Potential synergies with the activities initiated and supported by other General Directorates of the European Commission, in particular, Environment, Maritime Affairs and Fisheries and Regional Policy, will be taken into account while assessing potential impact of the project proposals.

The first thematic call

- Launch date: 1 December 2011
- Duration: Start latest by January 2013 to finish by the end of 2016, total duration of projects will be up to four years
- The first thematic call includes:
    - Themes 1.1, 1.2, 1.3, 1.4, i.e. all four themes addressing strategic objective 1 'Understanding the Baltic Sea ecosystem structure and functioning'
    - Themes 2.1 and 2.2, as most of the pressures to marine ecosystem originate from the catchment while the coastal systems serve as primary recipients and transformers of these pressures
    - Themes 3.3 and 3.4, as ecosystem approach to fisheriesis based on understanding the ecosystem structure and functioning and biodiversity controls.
    - Theme 5.1, as developing the science basis of monitoring is a logical element for inclusion since themes of strategic objectives 1 and 3 address quantification of Marine Strategy Framework Directive's good environmental status descriptors
    - Theme 4.1, as this will allow incorporating the governance and policy issues into broad multi-disciplinary research proposals, as well as to design research proposals with societal responses and driving forces as the central subject
- Research proposals addressing all call themes will be evaluated in accordance with the evaluation guidelines.
- Each proposal will be requested to identify one leading theme and two to four supplementary themes from those opened for this call

Budget: up to EUR 40 million depending on the outcome of evaluation.

The second thematic call

- Launch date: December 2012
- Duration: Start latest by January 2014 to finish by the end of 2017, total duration of projects will be up to four years
- The second thematic call will tentatively include:
  - Themes 3.1 and 3.2, as well as 4.3 and 2.3. to cover issues related to shipping and spatial planning
  - Theme 4.2 to address the issues of linking ecosystem goods and services to human lifestyles and well-being
  - Theme 4.1, similarly to the first thematic call, to allow proposing broad multi-disciplinary projects involving governance and policy issues
  - Depending on the evaluation outcome of the first thematic call also some first call themes may be decided to be re-opened if considered inadequately covered

Budget: Indicatively up to EUR 20 million.

The third thematic call

- Launch date: December 2013
- Duration: Start by the end of 2014 to finish by the end of 2017, total duration of the projects will be up to three years
- The content of the third thematic call will be determined by the second strategic orientation workshop (spring 2013) based on development of research needs in the Baltic Sea region and themes insufficiently covered by the previous thematic calls
- Indicatively funding volume of the third thematic call is ca. EUR 13 million, depending greatly on the committed funding left after previous calls

Innovation calls

BONUS research agenda envisages opening of two innovation calls in collaboration with innovation funding agencies of the participating countries, tentatively the following has been decided:

- Launch dates: spring 2012 and spring 2013
- The first innovation call will include the themes under strategic objective 2 and 5
- The second innovation call will address the strategic objectives 3 and 5

Research themes (abbreviated titles)	Calls			
	T 2012	I 2012	T 2013	I 2013
1.1 Dynamics of biogeochemical processes	●			
1.2 Changing biodiversity	●			
1.3 Food web structure and dynamics	●			
1.4 Impacts of hazardous substances	●			
2.1 Changes in catchment land cover patterns	●			
2.2 The role of the coastal systems	●			
2.3 Integrated coastal management			●	
2.4 Eco-technological approaches		●		●
3.1 Maritime risk analysis and management			●	
3.2 Effects of air and water pollution by shipping			●	
3.3 Improving stock assessments, spatial heterogeneity of stocks	●			
3.4 Evaluation franework for fisheries management	●			
3.5 Sustainable aquaculture in the Baltic Sea				●
4.1 Governance structures, performance and policy instruments	●		●	
4.2 Linking ecosystem goods and services to human lifestyles and well-being			●	
4.3 Maritime spatial planning			●	
5.1 Integrated monitoring programmes	●			
5.2 Innovative measurement techniques		●		●
5.3 User-driven ICT services		●		●

Figure 4: BONUS thematic and innovation calls 2011-2013 as these address the research themes of the strategic research agenda.
Key: T=Thematic calls, I=Innovation calls

- Budgets: Indicatively ca. EUR 10 million for both innovation calls, depending on involvement of funding institutions specialising in innovation
- Strong participation of private enterprises (especially SMEs) in these calls is expected with the respective Seventh Framework Programme funding rules applied

Given that projects funded by BONUS are to generate new knowledge, products and services in support of decision-making in the Baltic Sea region in particular, the project proposers are

expected to provide a statement explaining how impact will be achieved.

In addition to the thematic and innovation calls BONUS will support programme-level cooperation actions such as workshops, conferences, training courses, synthesis work as well as dissemination and specific stakeholder events. These activities will be implemented either directly by the BONUS Secretariat as part of its running costs or as integrated within the BONUS projects

Research facilities provided in kind and data are shared

The Baltic Sea countries own and operate a considerable amount of research infrastructures. For BONUS, the most crucial are research vessels as well as marine and coastal field research stations. BONUS encourages joint use of these infrastructures by providing an inventory of the facilities available and by coordinating communication between infrastructure owners. By providing research facilities in kind for the use of BONUS the participating states will also increase total funding volume of the programme for the benefit of the Baltic Sea.

BONUS follows a data policy which is based on the principle that publicly funded research data should be used for the public interest and therefore be openly available to the maximum extent possible. In particular, the aim is to ensure that the results and data follow the standards of the European Marine Observation and Data Network(22). In short, this means that

- securing high quality of the data produced by BONUS projects is obligatory
- data are shared without any delays within the programme
- data is stored in publicly available data bases
- results are published in open access publication fora

All BONUS projects are requested to include a data management plan in the research proposals. The adequacy of the plan will be part of one of the criteria in the proposal evaluation. The BONUS Secretariat maintains a metadata base of all data produced within the programme.

Communication with the society is planned and activated

Stakeholder involvement is one of the key priorities of the programme. BONUS projects are requested to activate from the very beginning of the project cycle a dedicated communications plan addressing the wide area of dissemination, project results uptake and stakeholder engagement, including end-users. Furthermore, BONUS requests its projects to involve the key end-users of the research results already in the planning phase of the project proposal. Given the policy oriented nature of the BONUS, it is essential that projects and end-users communicate with each other throughout the programme. During the projects' implementation, the key stakeholders should be involved as members of the project advisory board or steering committee or even as project participants.

When executed well, and considered throughout the project implementation, the dialogue with stakeholders can have a huge impact in improving the relevance of the research at the decision making level and the society at large, stimulate and raise aspirations, develop knowledge and understanding and enable stakeholders to contribute to the research.

In addition, the BONUS Secretariat, based on its programme level communication strategy, seeks and seizes opportunities to enhance scientific knowledge and its use across policy and socio-economic landscape by transferring aims, progress and results of its research programme to various stakeholder groups for their action and use. At the programme level, the main mechanism for stakeholder involvement is the BONUS Forum, which convenes once a year.

Its role is to discuss planning, outcomes and emerging research needs from the decision-making perspective. The Forum shall facilitate and advance the pan-Baltic integration of research, including the joint use and planning of infrastructure capacities, assist in highlighting research needs, advance the effective utilisation of the research results and facilitate the integration of research funding.

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Glossary

Abbreviations and acronyms used in the BONUS strategic research agenda 2011-2017

BONUS EEIG	Baltic Organisations' Network for Funding Science, European Economic Interest Grouping
BSAP	Baltic Sea Action Plan
EEZ	Exclusive Economic Zone
DPSIR	Drivers – Pressures – State – Impact - Responses
Aarhus convention	The UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters
BWM	Convention - the International Convention for Control and Management of Ships' Ballast Water and Sediments
CAP	EU Common Agricultural Policy
CBD	Convention of Biological Diversity
CFP	EU Common Fisheries Policy
EMODNET	European Marine Observation and Data Network
ERA	European Research area
ESMMR	European Strategy for Marine and Maritime Research
Espoo Convention	Convention on Environmental Impact Assessment in a Transboundary Context
EUSBSR	EU Strategy for the Baltic Sea Region
GES	Good Environmental Status
GEOSS	Global Earth Observation System of Systems
GMES	Global Monitoring for Environment and Security
HELCOM	Baltic Sea Environment Protection Commission
ICES	International Council for the Exploration of the Seas
ICT	Information and communications technology
ICZM	Integrated Coastal Zone Management
IMP	EU Integrated Maritime Policy
IMO	International Maritime Organisation
MARPOL	International Convention for the Prevention of Pollution from Ships
MSFD	EU Marine Strategy Framework Directive
MSP	Maritime Spatial Planning
MSY	Maximum Sustainable Yield
ROV	Remote Operated Vehicle
RTD	Research and technological development
SOW	Strategic Orientation Workshop
SRA	Strategic Research Agenda
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
VASAB	Visions and Strategies around the Baltic Sea
WFD	EU Water Framework Directive

Definitions of frequently used and/or key terms of the BONUS strategic research agenda 2011-2017

Ballast water is the sea water that ships carry in separate containers, ballast tanks, to provide stability and adjust trim, stress and torsion for optimal steering and propulsion. Ballast water commonly contains plankton and other marine organisms and discharging water originating in one environment into another can introduce alien species.

Baltic Sea is a body of water stretching from the north in the Bothnian Bay; to the Belts and the Kattegat Strait, where the sea meets the deep North Sea. The Baltic Sea can be subdivided into nine sub-areas with their respective drainage areas.

Baltic Sea catchment area is the land area that drains freshwater into the Baltic Sea. The Baltic Sea catchment covers an area of 2.13 million km^2 with a (an increasing) population of 85 million people in 14 countries.

Baltic Sea drainage area (see Baltic Sea catchment area)

Baltic Sea region is a geopolitical entity including countries neighbouring with the Baltic Sea: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Norway, Poland, Russian Federation (North-Western part) and Sweden. Eight of the Baltic Sea region countries are EU member states and jointly implement EU Strategy for the Baltic Sea region.

Baltic Sea ecosystem is a summary term used to denote all ecosystems occurring in the Baltic Sea, including its coastal waters. It embraces all the living organisms living in the sea, as well as all non-living components of the environment with which the organisms interact.

Baltic Sea system is a term derived from the Earth system science concept. In the context of the BONUS programme, the Baltic Sea system includes the Baltic Sea ecosystem with its living and non-living elements as well as the catchment, the climatic system, as well as the societal system depending on and interacting with the natural compartments of the system.

Baltic Sea system research aims to understand how the Baltic Sea is changing and what are consequences of this, i.e. identification and description of how system changes, the ability to identify and measure the primary forcing on the Baltic from both natural and human activities, knowledge of how the Baltic system responds to changes in these forcings, identification of the consequences of these changes for the environment and human civilization, and finally, the ability to accurately predict future changes with sufficient advanced notice to mitigate the predicted effects.

Biodiversity in its broadest sense of the word refers to the variety of all forms of life, from genes to species, through to the broad scale of ecosystems (for ecosystem, see Baltic Sea ecosystem).

Blue corridor is a marine analogue to the terrestrial 'green corridor'. This is an area of protected habitat connecting populations otherwise separated by human activities. The 'blue corridor' concept emerged along with the development of the Baltic Sea network of marine protected areas. As several Baltic Sea fish and bird species migrate between sea and inland, establishing of the land-sea corridors needs to be considered in the context of biodiversity protection.

BONUS European Economic Interest Grouping (EEIG) and its Secretariat is the legal management organisation of BONUS, the joint Baltic Sea research and development programme.

BONUS Law stipulates the governance structure, financial basis and general principles of the implementation of the BONUS programme.

BONUS Steering Committee is the highest authority of BONUS EEIG, forming its decision-making body and board governing its Secretariat.

BONUS Advisory Board consists of scientists of high international standing and representatives of relevant key stakeholders and assists by providing independent advice, guidance and recommendations regarding scientific and policy-related issues of BONUS.

BONUS Forum is composed of representatives from ministries and other actors dealing with Baltic Sea system research and governance. It acts as a platform for consultations from the decision-making perspective.

BONUS Forum of Project Coordinators is composed of coordinators of ongoing projects funded through BONUS. It assists the Secretariat in matters dealing with the scientific coordination of BONUS.

Call Steering Committee consists of representatives of all the funding institutions taking part in a call, this committee is formed for each call opening separately and addresses all issues related to the call that require decision making capacity.

Call Task Force consists of national contact points appointed by each funding institution taking part in a call to assist the BONUS Secretariat with administrative issues.

Catchment-coast-sea continuum is a concept emphasising the linkage of processes in the catchment, coastal area (both dry land and marine), and the open sea. Most often termed "catchment-coast continuum".

(EU) Directive is a legislative act (of the European Union). In the case of the EU, a directive requires member states to achieve a particular result without dictating the means of achieving that result. It can be distinguished from regulations which are self-executing and do not require any implementing measures. Directives normally leave member states with a certain amount of leeway as to the exact rules to be adopted. Directives can be adopted by means of a variety of legislative procedures depending on their subject matter.

Earth system research is a field of science studying the interactions between and among events and the earth's spheres: lithosphere, hydrosphere, atmosphere and biosphere.

Ecoinnovation is a term used to describe products and processes that contribute to sustainable development and is the commercial application of knowledge to elicit direct or indirect ecological improvements; these range from environmentally friendly technological advances to socially acceptable innovative paths towards sustainability.

Ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Essentially it considers the effects of actions on every element of an ecosystem, based on the recognition that all elements of an ecosystem are linked.

Ecosystem goods and services are of vital importance for the functioning of the biosphere, and provide the basis for the delivery of tangible benefits to human society. Goods produced by ecosystems include food, water, fuels, and timber, while services include water supply and air purification, natural recycling of waste, soil formation, pollination, and the regulatory mechanisms that nature uses to control climatic conditions and populations of animals, insects and other organisms.

Ecosystem resilience is the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes. A resilient ecosystem can withstand shocks and rebuild itself when necessary.

End-users consists of the direct and indirect users of the BONUS science results in both the public and private sectors e.g. relevant national ministries and institutions, sectoral bodies, scientific community, marine science associations, non-governmental organisations, industry.

Eutrophication is ecosystem's response to activities that fertilise water bodies with nitrogen and phosphorous, often leading to changes in animal and plant populations and degradation of habitat and water quality.

Good environmental status (GES) is the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations. EU Marine Strategy Framework Directive Annex I lists the qualitative descriptors to determine good environmental status for any particular marine region or subregion.

Green and White Papers Green Papers are documents published by the European Commission to stimulate discussion on given topics at European level. They invite the relevant parties (bodies or individuals) to participate in a consultation process and debate on the basis of the proposals they put forward. Green Papers may give rise to legislative developments that are then outlined in White Papers. When a White Paper is favourably received by the Council, it can lead to an action programme for the Union in the area concerned.

Hazardous substances are any harmful substances which due to the intrinsic properties are persistent, toxic or liable to bio-accumulate.

Hypoxia is used to describe the reduced dissolved oxygen content of a body of water detrimental to aerobic organisms.

Innovation generally refers to the creation of better or more effective products, processes, technologies, or ideas that are accepted by markets, governments, and society. Innovation includes effective innovation systems and an entrepreneurial culture and is realised in collaborations between different actors: researchers, companies with specialist competence, consultants, financiers etc. Driving the partnership is a common vision of what can be achieved.

Intelligent sea transport corridors are specially designated and electronically monitored sea traffic lanes in order to prevent ship accidents and take appropriate actions should such incidents occur.

Interdisciplinary research refers to research or study that integrates concepts from different disciplines resulting in a synthesised or co-ordinated coherent whole

Maximum Sustainable Yield (MSY) is the maximum annual catch which on average can be taken year after year from a fish stock without deteriorating the productivity of the fish stock. Fishing above MSY in the short term will lead to lower catch opportunities in the longer term as the fish stock is fished down

Multi-disciplinary research is a non-integrative mixture of disciplines in that each discipline retains its methodologies and assumptions without change or development from other disciplines within the multidisciplinary relationship.

Non-Indigenous species is a species living outside its native distributional range that has arrived there by human activity, either deliberate or accidental. Often termed as alien species.

Socio-economic drivers relate to, or involve a combination of social and economic factors. In the context of this agenda they are socio-economic and socio-cultural forces driving human activities that increase or mitigate pressures on the environment.

Stakeholders are, in the broadest sense of the word, every person, group or organisation who/that affects or can be affected by the actions of BONUS.

Trophic is of or involving the feeding habits or food relationship of different organisms in a food chain.

BONUS
SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

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