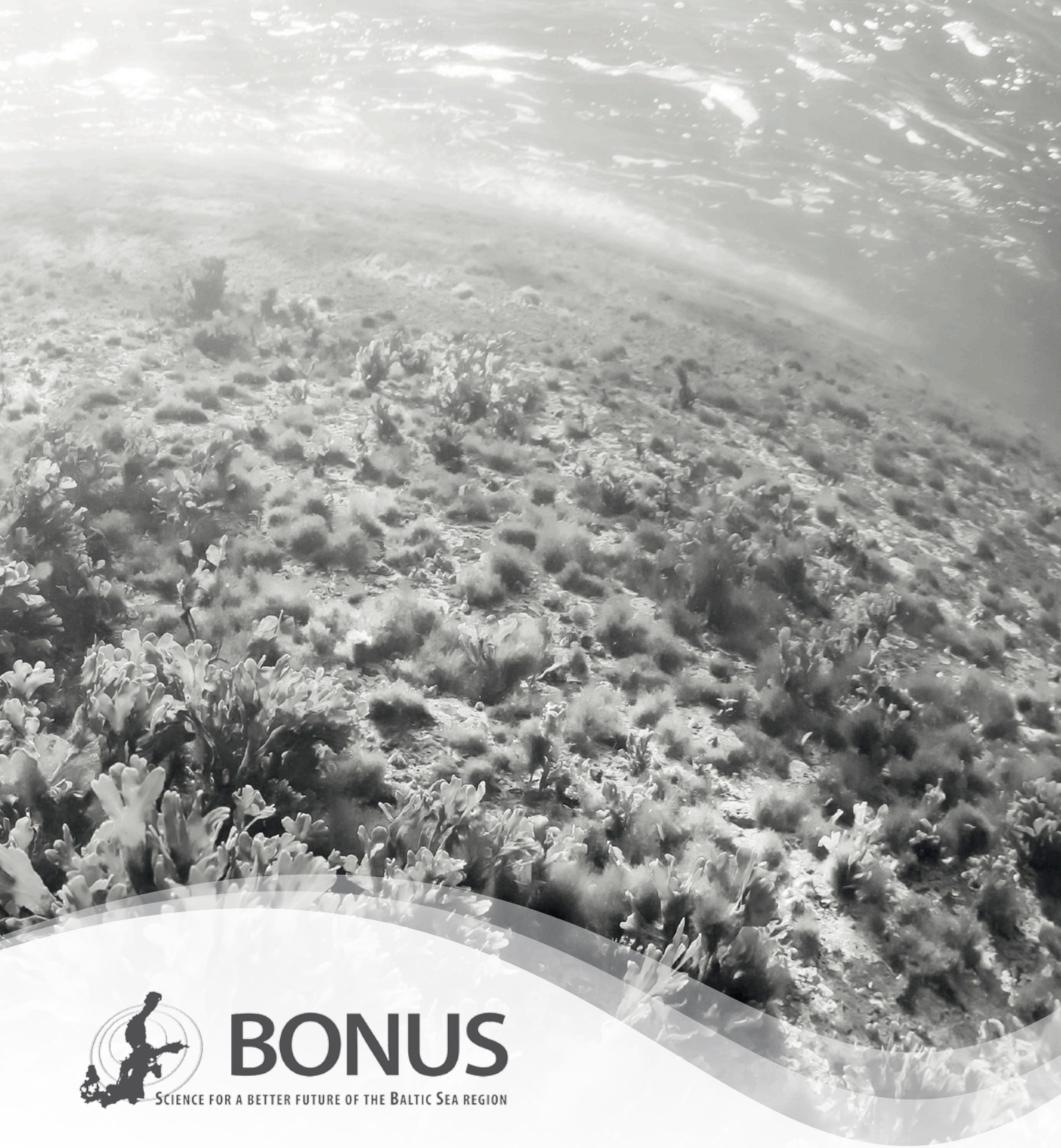
BONUS

SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

Strategic research agenda 2011–2017, update 2014

The joint Baltic Sea research and development programme

BONUS Publication No. 14



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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, coastal 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 challenges in the way of sustainable use of the Baltic Sea ecosystem goods and services in the coming decade and beyond:

- **Evaluating and developing relevant policies and collective governance**
- **Adapting to a sustainable way of living**
- **Adapting to the effects of climate change**
- **Restoring good environmental status of the Baltic Sea and its coasts**
- **Mitigating eutrophication that affects today nearly the entire Baltic Sea**
- **Achieving sustainable and safe use of the exploited coastal and marine ecosystem goods and services**
- **Planning of the use of marine space that fulfils the intensifying and diversifying needs from society**
- **Making fisheries management effective in order to secure the stability of the ecosystem and reproduction capacity of the Baltic Sea fish stocks**
- **Achieving safe maritime traffic imposing no risks to the environment**
- **Minimising the environmental threat of increasingly diversified use of chemicals and new materials**
- **Creating cost-efficient environmental information system**

The content of this BONUS strategic research agenda is policy-driven and solution oriented. The BONUS strategic research agenda addresses the major challenges of the Baltic Sea region by setting five **main strategic objectives** which build programme's overall framework:

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

The BONUS Steering Committee approved the BONUS strategic research agenda 2011–2017 in August 2011. Already then it was decided that the next review of the agenda will take place in 2013 through a similar process of transparency and flexibility as adopted during the initial creation of the agenda. The BONUS Secretariat completed this review together with key stakeholders and with a consideration of future knowledge demands in November 2013.

In September 2012, the BONUS Secretariat commenced the analysis of the framework of policies in the areas relevant to BONUS. This first step towards updating the research agenda identified over 80 regional, European and global parallel marine/maritime policy processes of relevance. Within, numerous crossing points emerged that either currently have or potentially could create win-win situations in shaping the management action towards sustainable ecosystem goods and services. The policy framework analysis was published at the combined BONUS Forum and the joint BONUS-HELCOM stakeholder conference in early March 2013. With the policy framework analysis distributed as a background material, the participants of the event were invited to contribute to a strategic research agenda update consultation session.

A dedicated international drafting team formed by experts of their field, and nominated by the national funding institutions participating in BONUS, reviewed carefully the five strategic objectives of the research agenda and proposed amendments reflecting the current and future knowledge demands. Their detailed review which resulted from consideration of all the earlier consultations and contributions, as well as the outcome of the BONUS call 2012 and the themes covered by the successful projects, were brought to Tallinn in September 2013 to the BONUS strategic orientation workshop. The scientific community, key stakeholders, representatives of the national funding agencies and the European Commission provided the final contributions to the now published update. To date, BONUS has engaged over 800 stakeholders in inception and update activities of its strategic research agenda.

The BONUS Steering Committee approved the agenda in November 2013 in time for it to underpin the BONUS calls for research and innovation proposals to be announced in 2014. The next review of the agenda will take place at the time when consideration of the BONUS future beyond the end of 2017 will be in centre stage.

We thank sincerely all who have invested their time and expertise in realising the BONUS strategic research agenda 2011–2017, and the update now completed. The policymakers and other stakeholders, the scientific community, the national funding institutions and the Commission services have all made this possible. In particular, we are grateful to the members of the dedicated drafting team who, together with the Secretariat and based on the knowledge and information obtained, prepared the materials for consideration of the September 2013 strategic orientation workshop.

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Executive summary

Within the Baltic Sea region, besides its complex policy situation, also physical and biological properties of the ecosystems evolve under many inter-connected pressures. In the coming decades additional external pressures on the Baltic Sea region are foreseen as global change, including climate change, and long-term and long-range influences are likely to intensify.

Entangled 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.

BONUS generates knowledge and know-how for the benefit of sustainable Baltic Sea region

The main aim of BONUS, the joint Baltic Sea research and development programme, is to respond to the 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 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 is a combination of Baltic Sea regional, European and global initiatives. Since signing in 1974 the Convention on the Protection of the Environment of the Baltic Sea Area, a vast number of other Baltic Sea regional collaborations with relevance to sustainability have emerged. Given that eight out of the nine coastal Baltic Sea countries are EU member states, also the common EU policies are important for the region. In addition, several global-level political agreements play an important role in the Baltic Sea region, in particular those dealing with the biological diversity, prevention of pollution from ships and climate change.

The transnational, cross-sectoral and transdisciplinary work of BONUS is carried out, in particular, in support of the HELCOM Baltic Sea Action Plan and integrated policy approaches of the European Union, such as the Integrated Maritime Policy (with Marine Strategy Framework Directive as its environmental pillar), the Water Framework Directive, and the newly issued proposal for the EU Framework Directive on Maritime Spatial Planning and Integrated Coastal Management aiming at employing an ecosystem-based approach. In this context, the development of a European macroregional policy within the Baltic region is viewed as a pioneering activity of critical importance.

Integrated approaches and integrated research for the Baltic Sea system are required at several levels in order to understand and predict the impacts of 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. Furthermore, critically important is to work together with relevant stakeholders, defining together with them knowledge needs and providing continuous opportunity of participation in shaping the strategic research agenda and exploiting its outcomes.

The overall framework of the BONUS strategic research agenda 2011–2017, including the current update 2014, consists of the five main strategic objectives and 19 specifically defined themes. In comparison to the original strategic research agenda, the update 2014 formulations of the expected outcomes under various themes have been streamlined significantly. New emphases have emerged while unnecessary details have been omitted in order to increase the explicitness of the kind of research that is needed, and therefore also expected, from the future applicants of competitive project proposals.

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.

In the update 2014, more emphasis has been put on the spatial aspects of the structure and function of the marine ecosystems, the role of organic matter in biogeochemical processes, and new pollutants as well as on nano and micro particles which potentially threaten the marine biota.

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. There are obvious linkages between integrated coastal management and maritime spatial planning addressed within the fourth BONUS strategic objective. 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.

In the update 2014, in particular the expected outcomes have been amended by scenarios of future sustainable land management with quantified effects on coastal ecosystem services, as well as a feasibility study of the new eco-technological solutions.

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 strategic research agenda will require further development in regards of the associated research needs.

In the update 2014, the sustainable aquaculture in the Baltic Sea is one of the most fundamentally reworked themes. An increase in sustainable aquaculture has the potential to support economic growth, exports, jobs and competence development and at the same time support an increased consumer demand of safe sea food. Now this theme has been included amongst both research as well as innovation domains given the need for further feasibility and cost-efficiency studies as well as development of eco-innovative solutions.

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.

In the update 2014, very explicit requirement has been made to develop models for comparative and consequential analyses of cumulative benefits and trade-offs of different marine ecosystem services and to fulfil specific tasks of research in support of maritime spatial planning. This is required now especially with the societies' ever intensifying and diversifying interest and capacity to occupy marine space as well as policy makers need to know the benefits derived from the ecosystem

goods and services, and the costs involved in protecting or improving them. It is important that planning the use of marine space and coastal management, addressed within the second BONUS strategic objective, are harmonised with each other.

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.

In the update 2014, emphasis is on the new research needs for monitoring: underwater noise and marine litter. In line with the evolution of the general concept it also provides clearer linkage between the opportunities provided by the development in the information and communication technologies and sustainable use of marine ecosystem services.

Putting the BONUS research programme into practice

The BONUS strategic research agenda 2011–2017, including the update 2014, 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 next review of the agenda will take place again through a transparent and flexible process that takes into account future knowledge 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. While putting the BONUS strategic research 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.

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, the 'Horizon 2020'.

Besides outlining its strategic objectives and themes, the overall framework of the BONUS strategic research agenda 2011–2017, including the update 2014, 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

The maximum funding available for running BONUS calls 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 EU Seventh Research Framework Programme, and the other half by the participating funding institutions.

The BONUS call 2012, worth a total of EUR 33 million, was the first call based on the BONUS strategic research agenda 2011–2017. The implementation phase of the successful projects receiving BONUS funding from this call begins in 2014 with a total duration of up to four years for the viable ecosystem projects and up to three years for the innovation projects.

BONUS will announce two further calls in 2014. A research call titled BONUS call 2014: Sustainable ecosystem services opens on 16 January and closes on 16 April 2014. In the second half of 2014, a further call

covering both research and innovation themes is being considered. In the latter call, some of the themes opened but left unaddressed in the previous BONUS calls may be reopened, depending on funding limits.

In addition to the Baltic Sea research and innovation calls, BONUS supports programme-level cooperation actions such as workshops, conferences, training courses, synthesis work as well as dissemination and specific stakeholder events.

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

1. Facing major challenges in the Baltic Sea region

The dependence of humans on the seas is strong and manifold. The seas provide numerous goods and services that are not priced at a market, such as e.g. regulation of climate, retention of carbon or offering emotional nature experiences in addition to those that are priced at a market, such as e.g. fish, tourism and offshore energy that offer profits and jobs for many (see figure 1). Harnessing the full potential of the 'blue economy' is seen today as one of the most promising means to boost growth, employment opportunities and competitiveness (European Commission, 2012a). Thus, a widely accepted political goal of the modern society entails the use of the diverse services of the marine environment while safeguarding also its health. This goal is pursued on all geo-political levels from the United Nation's environment and science programmes (UNEP, UNESCO) and regulations set by the International Maritime Organisation (IMO) and the directives of the European Union to, in the case of the Baltic Sea, the recommendations and the action plan adopted by the Baltic Marine Environment Protection Commission (HELCOM). In order to overcome current and future challenges, sound, scientific knowledge is needed. Also, fit-for-purpose policies are required to determine the direction of future development. In order to reach different policy objectives, politicians and government officials need the most advanced tools to set up smart regulations and effective management practices across and beyond the boundaries of traditional sector divisions.

During the past two decades there has been an unprecedented development in the marine and maritime policy landscape directly impacting the Baltic Sea and its drainage area (see the following chapter for further details). Nevertheless, a number of studies and assessments (e.g. HELCOM, 2010a) witness increasing magnitude and intensity of human pressures that affect cumulatively all areas of the Baltic Sea. The use of the services of the Baltic Sea remains far from sustainable and the status of its environment continues to raise concerns.

Despite environmental protection efforts that stretch already across several decades, the countries surrounding the Baltic Sea have yet to find efficient solutions to sustain the health of the Baltic Sea ecosystem. Current and emerging environmental and sustainability challenges in the Baltic Sea area are as many as are the related knowledge needs (see box 1).

The know-how and solutions that the science generates are necessary in resolving challenges that the Baltic Sea region faces in the coming decade and beyond. The task is not simple. The objective – to build region where the economic and ecological prosperity is based on sustainable use of resources, the 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 achieved. Albeit being ambitious, it is also the only thinkable goal for

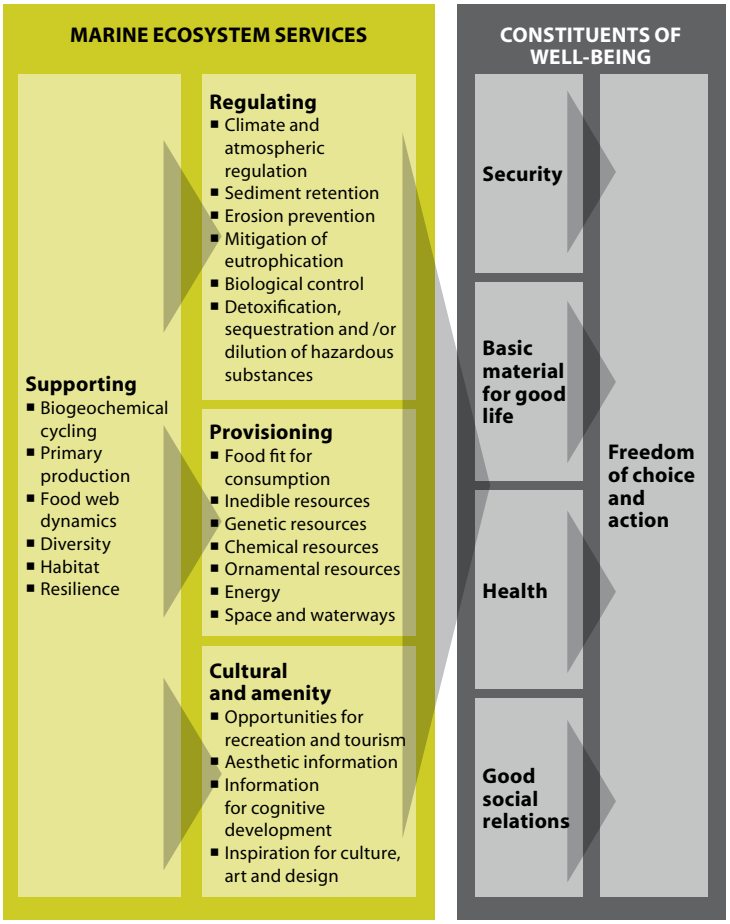

Figure 1: Schematic presentation of the relation of four categories of marine ecosystem services with human well-being. Lists of the ecosystem services are not exclusive. Based on Millennium Ecosystem Assessment, 2005; Garpe, 2008 and de Groot et al., 2010[1].

[1] Alternative systems have been presented e.g. by Haines-Young and Potschin, 2010, and Meas et al., 2013

today's responsible society which strives to save the planet for the future generations.

In order to move towards a truly 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 that support the much required change of modern lifestyles towards a more sustainable way of living are urgently needed. The understanding of the linkages between the structure and functioning of the Baltic Sea ecosystem and various human activities within the Baltic Sea drainage area and coast is critical. Also critically important is that the advantages of the newest technologies are harnessed in order to satisfy ever increasing needs of marine and maritime information.

The multifaceted research challenges of today can be approached only from the multi- , inter- and transdisciplinary perspectives[2]. 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.

Parallel to the development of the marine and maritime policies, the European Research Area process has

BOX 1: CHALLENGES FOR BUILDING SUSTAINABLE USE OF THE BALTIC SEA ECOSYSTEM GOODS AND SERVICES IN THE COMING DECADE AND BEYOND. (THE LIST IS INDICATIVE ONLY.)

Evaluating and developing relevant policies and collective governance

A governance framework that applies an integrated approach at every level, as well as horizontal and cross-cutting policy tools, are 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 elaborated urgently and adopted based on sound natural science and socio-economic analyses. 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.

Adapting to a more sustainable way of living

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

Adapting to the effects of climate change

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 effects without compromising the life quality and targets of environmental status depends crucially on our capacity to project climate change. Since the end of the 19th century, the Baltic Sea region has warmed faster than Earth as a whole (HELCOM, 2013a). The anticipated future changes include increased precipitation, which consequently increases the land-based leaching and loading. Also, lengthening of the growing season and changing conditions for agriculture may have their impact on proportions of land use and the relative shares of economic sectors in the region. Changes in temperature, salinity and acidity regimes may dramatically impact ecosystem structure and functioning. There is a need to be prepared for extreme events, flooding and intensified erosion. Adapting to climate change necessitates urgent development of policies and plans that are coherent on macro-regional, European and global scales (see e.g. European Commission's Directorate-General for Climate Action; HELCOM, 2013b; United Nations, 2012.

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 people living on the coasts and beyond. Implementing the EU Marine Strategy Framework Directive and the HELCOM's Baltic Sea Action Plan are the key commitments. While working towards resolving many of the pressures faced in the region, implementation of these initiatives require a massive amount of knowledge derived from natural science and socio-economics.

Mitigating eutrophication that 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 practical and cost-efficient options to reduce eutrophication.

Achieving sustainable and safe use of 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 use the marine goods and services sustainably. These entail both the 'traditional' ones, such as shipping, fishing and recreation, as well as the dynamically evolving newer goods and services such as harvesting renewable energy, marine biotechnologies, CO^2 sequestering etc. The ecosystem services used by humans directly are supported by the indirect services, such as biological and habitat diversity, productivity, biogeochemical cycling of matter and system resilience, as well as many others. The sustainable blue growth is of pivotal interest to the integrated maritime policy of the EU and the EU Strategy for the Baltic Sea Region. The key elements in resolving this challenge include cross-sectoral cooperation and knowledge-based management.

2 Although at present there is no widely accepted definition of these terms, it is assumed for the purpose of the BONUS SRA that:
multidisciplinarity in research is combining or involving several academic disciplines or professional specialisations in an approach to a topic or problem but not trying to synthesise cognitive structures,
interdisciplinarity is a process in which researchers work jointly, but from each of their respective disciplinary perspectives, to address a common problem,
transdisciplinarity is a process by which researchers work jointly to develop and use a shared conceptual framework that draws together discipline-specific theories, concepts, and methods to address a common problem (definitions based on EURAB, 2004 and Pohl et al., 2010).

been in place since early 2000. It supports the harmonisation of national research and development policies in the European countries, together with giving the possibility of pooling national and EU research funds. The initial steps towards close cooperation among the relevant research funding agencies were taken during the BONUS ERA-NET project (2004-2008). At the time, this novel governance structure of the Baltic Sea system research, and the consequent launch of the policy-driven BONUS programme, began to pave the way for a more structured contribution of Baltic Sea system research to efforts that aim to ensure better future of the region. Also, BONUS became a model for other regional seas in Europe and elsewhere. After having tested mechanisms of joint research programming in the BONUS+ call during 2009-2011, the national research funding agencies in the BONUS member states started together with the EU implementing an ambitious joint programme that runs until the end of 2017. In the core of this programme are calls for research proposals in support of sustainable development of the Baltic Sea region. Between years 2012 and 2014 sought for are cross-disciplinary and transnational research and innovation projects with total value running up to EUR 100 million.

BOX 1 CONTINUES

Planning of the use of marine space that fulfils the intensifying and diversifying needs from society

The common welfare and goods of the Baltic Sea region as a whole, not issues of national interests alone, need attention of the Baltic Sea countries. 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 different nations and sectors of economy. Efficient maritime spatial planning requires a harmonised approach considering the comprehensive knowledge on spatial characteristics of ecosystem and examination of the economics and societal impacts across the region.

Making fisheries management effective in order 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. Unsustainable fishing methods directly harm other components of the ecosystem as well. There is an urgent need to adopt the maximum sustainable yield approach as well as implementing the ecosystem approach to the fisheries management.

Achieving safe maritime traffic imposing no 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). To this end, environmental safety and clean shipping must be enhanced by development of sophisticated communication and logistic methods, as well as by studies of risk management and better prevention of accidents[3].

Minimising the environmental threat of increasingly diversified use of chemicals and new materials

The Baltic Sea is a recipient of an increasing number of chemicals from different local and regional sources, introduced through rivers, the atmosphere and by direct discharges. These include for example organic contaminants, heavy metals, dumped chemical weapons and new kinds of hazardous materials such as pharmaceuticals, nanoparticles and marine litter, including microplastics. More information is needed regarding their forthcoming effects on biodiversity and ecosystems. It is crucial to understand the combined effects of the environmental pressures.

Creating cost-efficient environmental information system

Today, information related to marine issues is scattered in different databases or is not necessarily accessible by all. 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. Creating a new generation of integrated marine and maritime observation and information handling systems is crucial in order to fully utilise today's achievements in data acquisition as well as information and communications technologies and this way support the broader societal challenges. We need to respond to today's demands in regard to the accessibility, operational qualities, cost-efficiency and versatility of data as well as its interpretation. This urgency is clearly emphasised by the EU Integrated Maritime Policy, the European Strategy for Marine and Maritime Research, the Global Earth Observation System of Systems and the Global Monitoring for Environment and Security. The re-establishment of a central Baltic Sea environmental information system is necessary in order to support HELCOM's new monitoring and assessment strategy.

3 Maritime technologies in support of development of cleaner shipping are tackled by other initiatives of cooperation in research governance, e.g. European technology platform WATERBORNE and Era-Net MARTEC II.

2. Policies shaping the future direction

The policy landscape of today is a combination of Baltic Sea regional, European and global initiatives. Since signing in 1974 the Convention on the Protection of the Environment of the Baltic Sea Area a vast number of other Baltic Sea regional collaborations with relevance to sustainability have also emerged. Given that eight out of the nine coastal Baltic Sea countries are EU member states, also the common EU policies are important for the region. In addition, several global-level political agreements play an important role in the Baltic Sea region, in particular those dealing with the biological diversity, prevention of pollution from ships and climate change.

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 (implemented by the Baltic Marine Environment Protection Commission known as HELCOM) 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 2).

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. As a response to the urgency of elaborating and applying common principles in the use of marine space in the Baltic Sea region, the Baltic Sea countries are committed to put in place national frameworks for coherent maritime spatial planning by 2017. Furthermore, by 2020, they are committed to draw and apply mutually coherent and ecosystem-approach based maritime spatial plans throughout the Baltic Sea region. The two central intergovernmental organisations of the region: HELCOM and Visions and Strategies Around the Baltic Sea (known as VASAB) (see box 2) lead together the development of coherent maritime spatial planning of the Baltic Sea.

In parallel, a considerable number of networks and collaborations, such as the Council of the Baltic Sea States (CBSS), Baltic Sea Parliamentary Conference (BSPC), Baltic Sea States Subregional Cooperation (BSSSC), Baltic Sea Forum, Baltic Development Forum (BDF) and Baltic Sea Action Group have been established, all aiming at facilitating the implementation of the environmental and sustainability objectives.

BOX 2: KEY REGIONAL COLLABORATIONS WITH RELEVANCE TO SUSTAINABILITY

The Baltic Sea Action Plan (BSAP) was adopted in 2007 by nine Baltic Sea coastal states as an ambitious cooperative action programme – under the auspices of HELCOM. The HELCOM Baltic Sea Action Plan 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. Progress in implementing the Baltic Sea Action Plan has been reviewed and commitment to its goals endorsed in two successive Baltic Sea Ministerial Meetings of 2010 (Moscow) and 2013 (Copenhagen).

Visions and Strategies around the Baltic Sea (VASAB) established in 1992, is an intergovernmental forum for cooperation 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.

European Union policy instruments with relevance to the Baltic Sea

With eight out of the nine coastal countries being member states of the European Union (EU), also the common EU policies (see box 3) are legitimate and important for the Baltic Sea region. 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

BOX 3: EUROPEAN UNION LEGISLATION AND POLICY INSTRUMENTS WITH RELEVANCE TO THE BALTIC SEA

EU FRAMEWORK DIRECTIVES

The Water Framework Directive, adopted in 2000, commits EU 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. In order to ensure the sustainability of all activities that impact on water and better implementation of current water legislation and integration of water policy objectives into other policies, the European Commission published in 2012 a communication titled "A blueprint to safeguard Europe's water resources" (European Commission, 2012b).

The EU Marine Strategy Framework Directive was adopted in 2008. It 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 4 for a complete list of qualitative descriptors for determining GES). It 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. Among the most urgent tasks is translating the qualitative descriptors of good environmental status (see box 4) into testable criteria and measurable indicators. Although much more research is still needed, the European Commission has adopted already a decision on criteria and methodological standards in good environmental status in marine waters in order to streamline the related assessment system. 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.

Both the Water Framework Directive and the Marine Strategy Framework Directive integrates where appropriate the requirements of a number of other, more specific EU directives issued earlier[4].

The EU Waste Framework Directive, adopted in 2006 and revised in 2008, presents a comprehensive framework of requirements of waste management in the EU member states. It calls for prevention or reduction of waste production as well as reduction of harmful wastes by developing clean technologies. Furthermore, it calls for minimising waste in manufacturing, use and disposal of products, developing appropriate techniques for final disposal of dangerous substances contained in waste, recovering and recycling waste as well as fostering its use as energy source. Consequently, it provides also certain impetus for the development of related ecoinnovation.

OTHER EU POLICY INSTRUMENTS

The EU Integrated Maritime Policy (IMP) was launched 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, the EU Integrated Maritime Policy 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.

In 2011, the European Parliament and European Council adopted an EU regulation establishing a programme to support the further development of the EU Integrated Maritime Policy (European Union, 2011).

Although the potential of the seas and coasts in support of growth, jobs and competitiveness is still far from being fully utilised, they are drivers of the European economy in many ways. In 2012, the European Commission published a communication on **Opportunities for marine and maritime sustainable growth (the Blue Growth)** – a long term strategy to support sustainable growth in the marine and maritime sectors. The Blue Growth strategy is the contribution of the EU Integrated Maritime Policy to achieve the goals of the Europe 2020 strategy for smart, sustainable and inclusive growth. The three components of the Blue Growth strategy are: (1) specific integrated maritime policy measures including marine knowledge, maritime spatial planning and integrated maritime surveillance, (2) sea basin strategies to ensure the most appropriate mix of measures to promote sustainable growth that take into account local climatic, oceanographic, economic, cultural and social factors and (3) targeted approach towards specific activities, in particular such focus areas as renewable marine energy, aquaculture, maritime and coastal tourism, marine biotechnology and marine mineral resources. The European Commission in collaboration with the EU member states has committed to assess in 2013–14 the development options in the focus areas highlighted in this Blue Growth communication.

The reform of **the EU Common Fisheries Policy (CFP)** was finalised in 2013 by an agreement between the Council of Ministers and the European Parliament. This enters into force on 1 January 2014. However because there is a need for the sector to adapt and to be able to deliver results, implementation of the new policy will be progressive. The aim of the new Common Fisheries Policy is to put an end to overfishing and make fishing environmentally, economically and socially sustainable. The main elements include: discard ban, adoption of the concept of maximum sustainable yield in the fisheries management, inclusion of the social dimension in the sphere of fisheries policy, regionalisation and application of transferable fishing concessions. The Common Fisheries Policy reform recognises the importance of integrating it into the overall maritime policy context. It is supported by the 'Community framework for the collection, management and use of data in the fisheries sector'.

The EU Common Agricultural Policy (CAP) is due to be reformed by the end of 2013. The Commission presented in November 2010 a communication titled "The CAP towards 2020", which outlines its future options. Through its response to the new economic, social, environmental, climate-related and technological challenges facing our society, the Common Agricultural Policy aims to intensify its contribution towards developing intelligent, sustainable and inclusive growth. One of the main objectives is the 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 as well as climate change mitigation and adaptation actions.

4 E.g. Groundwater directive of 1979, Birds Directive of 1979 with later amendments, Drinking water Directive of 1980, Urban waste water Directive of 1991, Habitats Directive of 1992, Bathing waters directive of 2006.

BOX 3 CONTINUES

The EU Strategy for the Baltic Sea Region (EUSBSR) was launched in 2009, following a request from the EU Parliament. The aims of this strategy are to make the Baltic Sea region an environmentally sustainable, prosperous, accessible, attractive, secure and safe region. The action plan of the EU Strategy for the Baltic Sea Region, as revised in 2013, is based upon 17 priority areas, each implemented through series of flagship projects. Implementation of the EUSBSR is supported also by four crosscutting horizontal actions including strengthening of the multi-level governance by involving civil society, business and academia and encouraging the use of maritime and land-based spatial planning in all EU Member States around the Baltic Sea.

In 2011, the European Commission adopted **the EU 2020 Biodiversity Strategy** aiming at reversing biodiversity loss by 2020 and speeding up the EU's transition towards a resource efficient and green economy. In order to achieve this objective, the EU Biodiversity Strategy sets out six distinct but mutually supportive and inter-dependent targets regarding conserving and restoring nature, maintaining and enhancing ecosystems and their services, ensuring sustainability of agriculture, forestry and fisheries, combating invasive alien species, and contributing to averting of the global biodiversity crisis.

In 2013, the EU Commission adopted **the EU strategy on adaptation to climate change** aiming to make Europe more climate-resilient. It focuses on three key objectives: encouraging all member states to adopt comprehensive adaptation strategies, promoting adaptation in key vulnerable sectors such as agriculture, fisheries and cohesion policy, and addressing gaps in knowledge about adaptation and further development of the platform for climate adaptation information in Europe.

In 2013, the European Commission issued also a proposal for **the EU Framework Directive on Maritime Spatial Planning and Integrated Coastal Management**. The main purpose of the proposed directive is to promote the sustainable growth of maritime and coastal activities and the sustainable use of coastal and marine resources by establishing a planning framework for optimal distribution of maritime space among relevant stakeholders and the coordinated management of coastal zones. It is emphasised in the proposed directive that in order to ensure the sustainability and environmental health of these various uses, maritime spatial planning and integrated coastal management will have to employ an ecosystem-based approach.

The knowledge needed for expansion of the sustainable blue economy and for achieving the good environmental status of the seas needs to be delivered in non-fragmented, inter-operable, open and freely accessible format for non-restrictive use by industry, public authorities, researchers and society. To this end, the European Commission has launched in 2010 **the Marine Knowledge 2020 initiative**. Its central tool is **the European Marine Observation and Data Network (EMODNET)**. Up to date, six thematic data gateways: hydrography, chemistry, biology, habitats and physics, have been created as EMODNET prototype. The long-term governance and funding options of EMODNET are under discussion.

In 2007–2013, the EU implemented the Seventh Research Framework Programme (FP7) that linked all research-related EU initiatives together and played a crucial role in reaching the goals of growth, competitiveness and employment. The broad objectives of FP7 were grouped into four categories: Cooperation, Ideas, People and Capacities. For each type of objective, there was a specific programme corresponding to the main areas of the EU research policy. All specific programmes under the FP7 worked together to promote and encourage the creation of European scientific excellence.

In 2014, the European Union launches a new **Framework Programme for Research and Innovation, Horizon 2020**. Compared to the previous Framework Programme, Horizon 2020 envisages major changes to the EU research and innovation funding mechanism in order to make participation easier, increase scientific and economic impact and provide better value for money. Running until 2020 the Horizon 2020 will combine all research and innovation funding currently provided through the Framework Programmes for Research and Technical Development, the innovation related activities of the Competitiveness and Innovation Framework Programme, and the European Institute of Innovation and Technology. Simplification of the design, rules, financial management, and implementation is the central aim of the Horizon 2020.

BOX 4: QUALITATIVE DESCRIPTORS FOR DETERMINING GOOD ENVIRONMENTAL STATUS REFERRED TO IN THE EU MARINE STRATEGY FRAMEWORK DIRECTIVE

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.

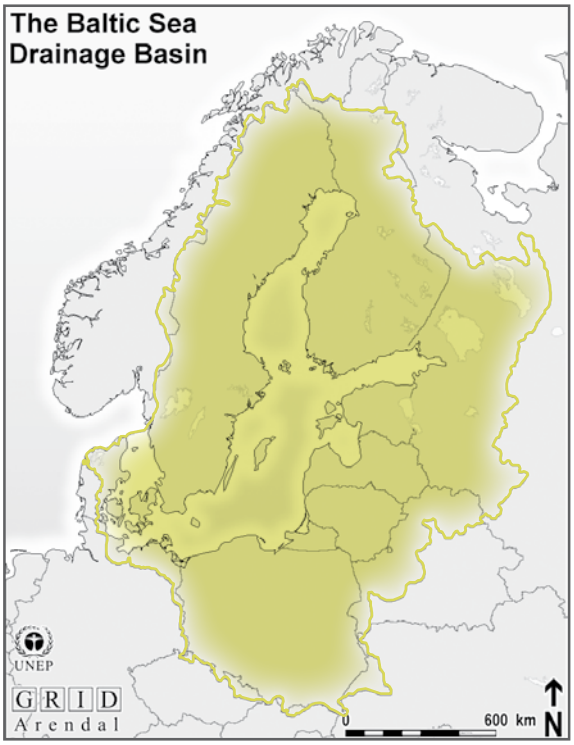

Figure 2: The Baltic Sea drainage basin and the countries in the region. The drainage basin represents all water that drains into the sea, through rivers and ground water. http://maps.grida.no/go/graphic/baltic_sea_drainage_basin

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, implements its own Maritime Doctrine which in many aspects has mutual goals with the Baltic Sea Action Plan. Therefore, also Russia, although indirectly, contributes to the implementation of the EU's Marine Strategy Framework Directive in the Baltic Sea region.

International conventions with relevance to the Baltic Sea

The Baltic Sea countries are involved in several global-level political agreements of key importance, in particular dealing with the biological diversity, prevention of pollution from ships and climate change (see box 5). The environmental impact assessment of transboundary nature has an increasing importance for the region of growing economic activities. The sources of potential transboundary threats include sub-sea pipelines and cables and off-shore wind parks among other.

Marine research and innovation 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 the European Strategy of Marine and Maritime Research** and with a 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 varying duration of 3-5 years. With the development of BONUS, most of these national programmes have been merged into the joint BONUS 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 the Strategy for Marine and Maritime Research 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 new forms of research governance that seek consensus among all parties concerned and 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. Since publication of this communication, the emerging European marine and

BOX 5: INTERNATIONAL CONVENTIONS WITH RELEVANCE TO THE BALTIC SEA

The Convention on the Protection of the Marine Environment of the Baltic Sea Area, 'Helsinki Convention', was signed in 1974 by 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 seabed. Measures are also taken in the entire catchment area of the Baltic Sea to reduce land-based pollution.

The Convention of Biological Diversity (CBD) was adopted in 1992. It relates to the conservation of biological diversity and sustainable use, including the Baltic Sea. One of the Convention of Biological Diversity 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 Tenth Conference of the Parties took 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.

The International Convention for the Control and Management of Ships' Ballast Water & Sediments 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.

The International Convention for the Prevention of Pollution from Ships (MARPOL), adopted in 1978, 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. In addition to the general requirements, the Baltic Sea is listed as a special area, where due to particular sensitivity, specific measures are necessary to prevent pollution by oil, air pollution (SOx), garbage and, as from 2013 (entry in force) – by sewage from ships.

The United Nations Framework Convention on Climate Change (UNFCCC), adopted in 1992, sets an overall framework for intergovernmental efforts to tackle the climate change challenge. Under the United Nations Framework Convention on Climate Change, 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.

The Convention on Environmental Impact Assessment in a Transboundary Context, '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.

The Convention on Long-Range Transboundary Air Pollution, 'Geneva Convention', from 1979 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.

The UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, 'Aarhus Convention', adopted in 1998, 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.

maritime research governance networks, for example MARCOM+ Forum, have taken further the mission to improve interactions between researchers, industries and policymakers.

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**, 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.

In 2011, **the Joint Programming Initiative "Healthy and Productive Seas and Oceans" (the JPI Oceans)** was launched, as a coordinating and integrating long-term platform, open to all EU member states and associated countries who invest in marine and maritime research. The JPI Oceans is built on the principle of variable geometry and it aims to add to the value of investments into marine

research and innovation by: avoiding fragmentation and unnecessary duplication; planning common and flexible initiatives; facilitating cooperation and foresight; establishing efficient mechanisms for interaction and knowledge transfer between the scientific community, industry and policy makers at a high level in order to more effectively solve the grand challenges regarding the European seas and oceans. While the objectives of the JPI Oceans are compatible with the tasks that have been undertaken by BONUS in the Baltic Sea region, and while six of the BONUS countries are involved in the JPI Oceans, optimal ways for closer collaboration in the future are sought actively.

In 2014, the European Union starts **the Framework Programme for Research and Innovation, Horizon 2020**. It proposes major changes to the EU research and innovation funding in order to make participation easier, increase scientific and economic impact and provide better value for money. Running until 2020 with an approximate projected EUR 80 billion budget, the Horizon 2020 will combine all research and innovation funding currently provided through the Framework Programmes for Research and Technical Development, the innovation related activities of the Competitiveness and Innovation Framework Programme, and the European Institute of Innovation and Technology. Simplification of the design, rules, financial management, and implementation is the central aim of the Horizon 2020.

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 6.

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 following page. This way BONUS can help in reaching the good environmental status of the Baltic Sea.

BOX 6: SIGNIFICANT MILESTONES OF KEY POLICIES

2011	Reform proposals on EU Common Fisheries Policy (CFP reform process, European Commission, 2009c)
2011	Legal proposals for the future EU Common Agricultural Policy (CAP) presented (European Commission, 2010)
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, European Union, 2008)
2012	EC first report to the Council and European Parliament on the implementation of the European Strategy for Marine and Maritime Research (ESMMR, European Commission, 2008)
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, HELCOM, 2007)
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, HELCOM, 2007)
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, HELCOM, 2007)
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, European Commission, 2008)
2013	The HELCOM Baltic Sea Action Plan nutrient reduction scheme is revised (HELCOM Ministerial Declaration 2010, HELCOM, 2010b)
2013	EU Common Agricultural Policy (CAP) due to be reformed (European Commission, 2010)
2014	New EU Common Fisheries Policy comes into force (EU CFP, European Commission, 2013)
2014	The European Commission to report on progress in the establishment of marine protected areas (MSFD, European Commission, 2008)
2014	Establishment and implementation of a monitoring programme for on-going assessment and regular updating of targets (MSFD, European Commission, 2008)
2014	The Baltic Sea monitoring programme is reviewed and updated (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2014	A recommendation on sustainable aquaculture aiming at limiting potential environmental impacts of aquaculture activities such as the introduction of non-indigenous species, ecological and genetic impacts on wild fish stocks from unintended releases of farmed species, nutrient pollution, as well as introduction of antibiotics and other pharmaceuticals is developed (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2015	Development of a programme of measures designed to achieve or maintain good environmental status in all European marine regions (MSFD, European Commission, 2008)

BOX 6 CONTINUES

2015	Where possible, populations of commercially exploited fish and shellfish should be within safe biological limits, exhibiting a population age and size distribution indicative of a healthy stock and capable of producing Maximum Sustainable Yield (MSY) exploitation rates (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2015	Continuous decline of catches by the European fleet come to an end (European Commission, 2013)
2015	The discard ban is introduced under the EU Common Fisheries Policy (European Commission, 2013)
2015	Next generation of River Basin Management Plans under EU Water Framework Directive should be fully climate-proofed (Climate Change Adaptation White Paper, European Commission, 2009b)
2015	A regional action plan to prevent and reduce marine litter from land- and sea-based sources, causing harmful impacts on coastal and marine habitats and species, and negative impacts on various economic sectors, such as fisheries, shipping or tourism is developed (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2015	A regional Baltic Sea 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, VASAB, 2010)
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, UNEP, 2010)
2015	All protected areas and protected area systems are integrated into a wider land and seascape and other relevant sectors, by applying the ecosystem approach and taking into account ecological connectivity, likely climate impacts and where appropriate, the concept of ecological networks (CBD Aichi Biodiversity Target, UNEP, 2010)
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, VASAB, 2010)
2015	The Baltic monitoring guidelines and manuals are reviewed and updated (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
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, VASAB, 2010)
2016	Entry into operation of the programme of measures designed to achieve or maintain good environmental status (MSFD, European Commission, 2008)
2016	The second holistic assessment of the Baltic Sea health is developed, inter alia with contribution of a comprehensive assessment of status, environmental risks and opportunities of maritime activities in the Baltic Sea region (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2016	A set of indicators including technical standards which may be used for monitoring ambient and impulsive underwater noise is established; the levels of ambient underwater noise across the Baltic Sea are mapped; a register of the occurrence of impulsive sounds is set up (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2016	Adequate reception facilities necessary to set in force the IMO designation of the Baltic Sea as a special area in regard sewage from ships are put in place (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2017	National frameworks for coherent Maritime Spatial Planning reflecting HELCOM-VASAB MSP principles, including the ecosystem approach and taking into account the relevant EU policy instruments for the Baltic Sea countries being EU Member States, are put in place (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2018	Assessment, determination of good environmental status and targets are reviewed within the second 6-year round of implementation of the EU Marine Strategy Framework Directive (MSFD, European Commission, 2008)
2019	EU Water Framework Directive reviewed and possibly revised (Blueprint to safeguard Europe's Water resources, European Commission, 2012b)
2019	The European Commission to publish the first evaluation report on the implementation of Marine Strategy Framework Directive (European Commission, 2008)
2020	Achieve or maintain good environmental status in the marine environment (MFSD, European Commission, 2008)
2020	Monitoring programmes are revised within the second 6-year round of implementation of the EU Marine Strategy Framework Directive (MSFD, European Commission, 2008)
2020	Full-scale return to sustainable and profitable European fisheries (European Commission, 2013)
2020	Maritime spatial plans which are coherent across the borders and apply the ecosystem approach are drawn up and applied (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2020	Additional nutrient input reduction measures are developed and in place as needed based on cost-efficiency (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2020	Ecologically coherent network of well-managed marine protected areas in the Baltic Sea is established (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2020	The loss of all red listed marine habitats and biotopes in the Baltic Sea is halted and they have largely recovered, and their degradation and fragmentation have been significantly reduced. The progress will be measured with a core indicator to be produced (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2020	Incentives and subsidies which could be harmful to biodiversity are eliminated in order to improve the buffering capacity of the marine and coastal ecosystems for a better resilience (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2020	Technology for removal of microplastics and nanoparticles in municipal waste water treatment plants is developed and tested (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2020	Concrete measures for prevention and reduction of marine litter from its main sources with the aim of achieving significant quantitative reductions are reviewed for the first time (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)

BOX 6 CONTINUES

2020	A seamless multi-resolution digital seabed map of European waters is developed (Marine Knowledge 2020, European Commission, 2012c)
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). Offshore energy meets 4% of all the European Union's electricity demand, creating 170 000 jobs (Blue Growth initiative, European Commission, 2012a)
2020	Aquaculture provides 50% of fish protein consumption worldwide (Blue Growth initiative, European Commission, 2012a)
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, UNEP, 2010)
2020	All populations of commercially exploited fish and shellfish should be within safe biological limits, exhibiting a population age and size distribution indicative of a healthy stock and capable of producing Maximum Sustainable Yield (MSY) exploitation rates (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2020	At least 10% of coastal and marine areas – especially areas of particular importance for biodiversity and ecosystem services – are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and by other effective area-based conservation measures (CBD, Aichi Biodiversity Target, UNEP, 2010)
2021	Programmes of measures are revised within the second 6-year round of implementation of the EU marine Strategy Framework Directive (MSFD, European Commission, 2008)
2021	Good environmental status in the Baltic Sea is achieved (HELCOM BSAP, HELCOM, 2007)
2023	The Commission to review the Marine Strategy Framework Directive and propose any necessary amendments (MSFD, European Commission, 2008)
2025	Significant quantitative reduction of marine litter compared to 2015 is achieved (HELCOM Ministerial Declaration 2013, HELCOM, 2013b)
2030	Offshore energy meets 14% of all European Union's electricity demand, creating 300 000 jobs (Blue Growth initiative, European Commission, 2012a)
2030	Provision of fish protein from aquaculture for human consumption reaches 65% worldwide (Blue Growth initiative, European Commission, 2012a)

3. BONUS research programme responding to challenges

The BONUS research and development programme aims to facilitate generation of fit-for-purpose knowledge and know-how necessary to overcome the major challenges faced by the Baltic Sea region. These efforts aim to ensure ultimately the long-term sustainability of the Baltic Sea ecosystem services. In order to achieve this, BONUS works to improve the efficiency and effectiveness of the Baltic Sea region's research programming by integrating the research activities into a durable, cooperative, interdisciplinary 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 these five strategic objectives. While understanding the complexity of the Baltic Sea ecosystem structure and functioning (1) is the core objective of this agenda, pressures on the ecosystem originating from its catchment area and coasts (2) or from the unsustainable exploitation of marine goods and services need to be studied and understood (3). Similarly, the knowledge-based ecosystem approach to management of the 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 marine goods and services. Improving society's capability and motivation to respond to these impacts (4) depend greatly on the ability to understand the rules of governance and socio-economy and 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 will require careful consideration taking into account the outcomes of the BONUS+ projects, linkages among various themes and opportunities to benefit from synergies arising among projects addressing a complex problem or a suite of inter-related issues in a concerted manner. Last but not least, the time factor inherent in various relevant processes (see e.g. the compilation of the main policy milestones presented in box 6) must be taken into account to make the research effort more efficient and, as much as possible, ensure most up to date and fit-for-purpose knowledge is delivered throughout the relevant policy cycles.

Figure 3 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 an extensive, joint process of strategic research agenda development with the key stakeholders across the region. Although these six challenges are critically important to be addressed in order to ensure sustainability in the Baltic Sea region, this is not a comprehensive reflection of all the challenges facing the region. Rather than that, in line with the scope of BONUS, this list emphasises those challenges that are critically dependant on knowledge-based management of human activities related to the Baltic Sea ecosystem in the future.

Figure 4 demonstrates how five out of seven major research topics defined by the European Strategy for Marine and Maritime Research requiring cross-thematic approach are also in the centre of attention of BONUS: 1) impacts of climate change, 2) impact of hu-

man 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 (European Commission, 2008) 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 (Andrusaitis et. al., 2013). Moreover, by putting into the picture the whole circle from socio-economic drivers controlling the pressures on environment to societal responses upon the effects of unsatisfactory environmental status, 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 innovative and improving existing observation and data management systems		
	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 3: The BONUS strategic objectives' and research themes' links to the major challenges. Solid circles indicate links that are considered critical, hollow circles indicate links that are considered supplementary.

Cross-disciplinary research topics of the 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 innovative and improving existing observation and data management systems		
	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 4: 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). Solid circles indicate links that are considered strong, hollow circles indicate links that are considered supplementary.

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 able to restore and maintain good environmental status of the Baltic Sea and use its resources sustainably. 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 EU 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, follow the concept of adaptive ecosystem-based management of human actions. They depend critically on robust assessments of the environmental status, which in turn must be based on solid scientific 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 and hazardous substances, as well as dynamics of food webs, can only be described in approximate terms. Model-based estimates of the reductions of nutrient loads into the sub-basins underpin the current policy effort to curb eutrophication. However, the level of uncertainty with regard to system's responses to pressures and mitigation measures still needs to be diminished. The interaction between e.g. climatic driving forces and human induced pressures on various ecosystem levels is not understood sufficiently. Also, spatial and temporal differences in ecosystem responses to pressures are not sufficiently known to enable locally adapted measures.

Although considerable knowledge about the properties of the Baltic Sea biodiversity has been accumulated, there is lack of knowledge on factors and processes affecting species and functional diversity at different taxonomic levels in different parts of the Baltic Sea. New knowledge on the role of brackish habitats, and evolutionary processes operating within them need to be produced. Ecosystem impacts and societal consequences of establishing of non-indigenous species should be assessed, and the relative role of fisheries in comparison to other environmental pressures on fish stock conditions, should be quantified. Currently, results from biogeochemical models and food-web models cannot be easily combined. This hampers making holistic scenarios on, e.g. the effects of climate change on the ecosystem of the Baltic Sea.

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, particularly their sublethal effects, and interaction with other environmental pressures, have to be studied more intensively. Similarly, occurrence and effect of new emerging contaminants need closer scientific examination. In relevance to these emerging contaminants, also the cost-efficiency of the measures to prevent pollution and the potential remediation actions should be investigated.

How BONUS will address the strategic objective 1

The research will address the knowledge gaps regarding the Baltic Sea ecosystem. It will thus enhance our capabilities to protect the marine ecosystem and to improve the state of the Baltic Sea. It will also enable us to use the marine space, resources and ecosystem services in a sustainable way. It will thus support implementation of the Baltic Sea Action Plan and the Marine Strategy Framework Directive.

Research on SO1 will also derive new information on the qualitative descriptors (see box 4 for the full list) relevant to biological diversity and non-indigenous species *(1,2)*[5], status of exploited populations *(3)*, integrity of marine food webs *(4)*, eutrophication *(5)*, seafloor integrity *(6)*, hydrographical conditions *(7)*, levels of contaminants in environment and seafood *(8, 9)*. As BONUS is a Baltic wide programme, it provides excel-

5 The numbers in brackets denote respective qualitative descriptors for determinig good environmental status as defined in the EU Marine Strategy Framework Directive. (see box 4)

lent possibilities for comparative analyses of processes structuring the marine ecosystem at different spatial and temporal scales.

The research will provide improved knowledge of the physical and biogeochemical processes affecting the sea response to variable external drivers. Reliable quantification of impacts of combined human pressures on ecosystem structure and functioning will be gathered. Improved models incorporating all key trophic levels, complex food web interactions and biogeochemical feedback mechanisms will be created. 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 will also generate new knowledge on contaminants' cumulative impacts at organism, population and community levels. Novel information on sources, fate and risks of new emerging contaminants, and interactions between hazardous substances and other pressures, will enhance the ability to design optimal protective measures and ultimately mitigate the effect of hazardous substances on the ecosystem and humans.

Studies need to be interdisciplinary, and they also need to take into account various natural and human-induced processes in the catchment area, and beyond.

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

Despite the long tradition of physical and biogeochemical studies, there are still major knowledge gaps concerning climatic variations on fundamental processes, such as multiscale three-dimensional circulation, changes in salinity and vertical stratification, discharge and redistribution of key elements like carbon (dissolved organic matter - DOM), nutrients and pollutants, as well as consequences of these variations to physical-biological interactions. Also, there are too few spatially resolving models to describe the biogeochemical processes in the different basins of the Baltic Sea. Consequently we are not able to make reliable scenarios of the development of the biogeochemical processes of the Baltic Sea at policy-relevant time and space scales and to define locally adapted eutrophication mitigation measures.

The Baltic Sea-wide research needs to include all ecologically relevant system components, external drivers and internal physical and biogeochemical processes, in order to increase the scientific understanding of what controls resilience and dynamics of the Baltic Sea. In particular, there are significant knowledge gaps in relation to e.g. inter- and intra-basin three-dimensional circulation mechanisms responsible for temperature, salinity, oxygen and nutrient distribution, and ice-period preconditioning of water masses affecting spatial patterns of biological production. CNP stoichiometry, oxygen removal and supply, biogeochemical control by microorganisms, internal loading of nutrients and greenhouse gas fluxes among other are vital in putting into practice the ecosystem approach to management of human activities.

Reliability of forcing of ecosystem models must be improved. Regional forcing data obtained from downscaling of global climate models do not sufficiently reflect the amplitude of multi-decadal to centennial climatic variability recorded by instrumental and sediment proxy-climate data.

Effects of the most significant natural internal driver on ecosystem changes, the ongoing glacio-isostatic land uplift, have not been studied properly. It is not known how changing basin shape and size will affect water exchange between the sub-basins and resuspension of nutrients and hazardous substances from the Baltic sediments.

Expected outcomes:

- Assessment of additive, synergistic and cumulative effects of various human pressures on ecosystem structure and functioning at different spatial and temporal scales.
- Experimental studies and modelling that enable assessing how multi-scale physical processes affect biogeochemical processes, including fate and effects of external and internal nutrient loading.
  Improved understanding of cold season and sea ice dynamics, and effects of climate change on biological productivity.
- High resolution calculations of sedimentary fluxes, identification of periodicities in climate variability and synchronisation of climate records in the North Atlantic region at high resolution.
- Better understanding of the coupling between nitrogen and phosphorus cycles as well as dynamics of DOM and the microbial loop, and their implications for determining nutrient abatement measures.
- Comparative analyses of the differences of ecosystem dynamics at different spatial and temporal scales and in different basins; designation of locally adapted measures to reach good environmental status.
- Development of indicators and their reference and acceptable deviation values when implementing the Marine Strategy Framework Directive.

THEME 1.2
Causes and consequences of changing biodiversity

Because of the complex web of natural and human-induced pressures in the Baltic Sea, biodiversity cannot be studied by addressing one pressure at a time. Instead, biodiversity must be studied and assessed by using an integrated holistic and multidisciplinary approach at several ecological levels: species, communities, habitats and ecological landscapes, and with both species and functional diversity accounted for.

On species and population 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 community and 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. Also, there is a lack of information on the impact of marine biodiversity on the production of ecosystem goods and services.

Expected outcomes:

- New knowledge on sensitivity, resilience and functional diversity of marine ecosystems, under different environmental scenarios, that supports defining relevant measures and policy instruments.
- New knowledge on the coupling between structural and functional diversity and the ecosystem services.
- New knowledge on the spatial and temporal dynamics of species, populations and communities that helps in identifying conflicts between human activities and ecosystems and, hence, supports maritime spatial planning.
- Information on the vectors of introduction and ecology of non-indigenous species that helps to prevent their introduction and establishment: New knowledge on spatial dynamics of biodiversity that helps to develop an ecologically coherent network of marine protected areas and to enhance their efficiency and management.
- Studies on how biodiversity indicators respond to management measures; establishment of an evaluation framework for assessing and testing the indicators and descriptors of biodiversity.
- New quantitative information on the socio-economic consequences of changes in marine biodiversity.

THEME 1.3
Food web structure and dynamics

Transforming of nutrients and harmful substances by food webs are both important ecosystem services. Integration of the food web processes in ecosystem models is a prerequisite for projecting ecosystem effects of changes in nutrient and contaminant loading, climate forcing, introduction of non-indigenous species and fisheries. Furthermore, individuals and populations of plants and animals are directly and indirectly affected by 'bottom-up' forces (i.e. availability of resources affecting production on all trophic levels up to the fishes and top predators) and by 'top-down' forces in the food web (i.e. grazing, predation, harvesting). Trophic cascading, whether initiated by humans (e.g. resource exploitation, eutrophication/pollution, bioinvasions) and/or natural factors, may contribute to ecosystem changes, and newly established species interactions may prevent recovery of food webs. Despite an increasing number of studies demonstrating trophic cascading and regime shifts in the Baltic ecosystems, the food web consequences of top-down vs. bottom-up effects (e.g. fisheries vs. eutrophication and climate change) are weakly understood. Adding complexity, the structuring effects of climate change, introduction of non-indigenous species and the role of contaminants have to be considered in food web studies.

Expected outcomes:

- Improved understanding of the relative impacts of major drivers (eutrophication, climate forcing, non-indigenous species, hazardous substances and fisheries) on food web structure and function.
- Quantitative information on temporal and spatial dynamics of predators, prey, competitors and pathogens, as well as their consumption, reproduction and mortality rates, that helps in taking management actions.
- Integrated models that encompass all key trophic levels and include complex physical-biological and biogeochemical processes; model scenarios that project the effects of changes in various external and internal drivers identifying thresholds between different ecosystem states (i.e.regime shifts).

- Assessment of the effects of environmental degradation on the capability of Baltic Sea food webs to cycle and transform nutrients and hazardous substances.
- Assessment of the consequences of achieving good environmental status on the capability of the Baltic Sea food webs to sustainably produce ecosystem goods and services including seafood that is safe for consumption, and other ecosystem goods and services.

THEME 1.4
Multilevel impacts of hazardous substances

The reliable ecotoxicological risk assessment of hazardous chemicals, including emerging contaminants still needs improvement. As both underestimating and overestimating the risk may have significant undesirable economic consequences, 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 have been studied separately from contaminant dynamics, but the research is shifting towards a multi-stressor approach, e.g. taking into account interactions between eutrophication and contaminant effects as well as climate and other pressures on the ecosystem. Understanding, assessing and modelling contaminants transfer from the source to the sea as well as cycling between ecosystem compartments (sediment, coastal waters, open sea, biota) are essential particularly in the context of new environmental pressures and potential threats. In addition, investigations of sediment processes, such as in situ detoxification, compound transformation and burial, and their susceptibility to changed external forcing need more attention.

Climate and land uplift strongly impact on the fate of hazardous substances. There is a need to identify and improve the characterisation of the release of hazardous substances from re-suspended sediments. Although many of the pollutants have been banned, due to the ongoing uplift these pollutants will be released from older contaminated sediments. There are no tools that forecast their fate, transport and subsequent impact on the Baltic Sea ecosystem under projected ecosystem changes.

There is also an increasing need for early detection of the emerging contaminants, given their potential relevance to food webs, and in the context of implementing the EU regulation concerning the 'registration, evaluation, authorisation and restriction of chemicals' (REACH). While a number of these emerging contaminants, including nanoparticles and microplastics, have already been identified, the evaluation of their occurrence, incorporation into food webs, toxicity, ecological risk and impact on biogeochemical processes is still urgently needed. In addition to the number of commercial chemicals, others, including transformation products formed through metabolism and environmental reactions, may represent new threats to the ecosystem.

Expected outcomes:

- New information on cycling, transformation and effects of hazardous substances that helps in developing measures that most effectively mitigate their impact in the marine ecosystem.
- Assessment of the interactions and cumulative impacts of hazardous substances with other stressors, such as eutrophication and climate driven changes in the marine environment.
- Cost-effective methods for detection, risk assessment and monitoring of the effects of hazardous substances, as well as their reduction and remediation.
- Novel information related to sources, fate and impacts of new emerging contaminants including i.a. pharmaceuticals, nanoparticles and microplastics, and their transformation products, supporting development of a science-based regulatory framework in regard to emerging contaminants.
- Development of indicators and descriptors of concentrations and effects of hazardous substances in various matrixes; practical methods of reference level identification for harmful substances, that take into account the natural variability as reflected in sediments.

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 area in relation to the Sea area and its 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 and 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 and changing societies, there is a need for an integrated modelling approach that takes into account a hierarchy of scales ranging 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.

So far, most studies have addressed current or past situations. New knowledge is needed to design alternative scenarios for future sustainable land use and predict their effects on ecosystem functions and services, taking into account the global change and changing societies.

How BONUS will address the strategic objective 2

The 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. Effects of future sustainable land use strategies on ecosystem functions and services will be explored. Land use scenarios should be combined with strategies for coastline defense or realignment, to cope with expected sea level rise and associated groundwater rise in coastal lowlands.

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, aquaculture, 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 socioeconomic drivers these changes seem likely to influence the structure and functioning of ecosystems, and may impact the services they provide for the society. Also, effects of global and regional socioeconomic 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. Furthermore, alternative scenarios of future land uses should be designed and their effects on ecosystem functions and services should be predicted in order to improve land use planning and informed decision making, and new land use / land cover zonation based on integrated modelling.

Expected outcomes:

- 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.
- Improved understanding of sustainable development of activities affecting the catchment-coast-sea continuum based on analyses of costs and benefits and considering i.a. a variety of socio-economic drivers.
- New concepts shall be developed for zoning different land uses such as urban, agriculture, forest and wetlands based on hydrological modelling and long term projections of land cover change. These are needed to reduce nutrient loading of streams in the catchment.

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, wetlands, 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. On the other hand, sea level rise may reduce or increase wetland extension, depending on topographic conditions, thus also reducing or increasing the biogeochemical barrier function.

Expected outcomes:

- Future projections, scenarios and support tools for decision makers that can be used to develop sustainability of ecosystem services in inner coastal waters. Emphasis should be on scenarios 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. Changes in biogeochemical functions of coastal wetlands with sea level rise.
- 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 processes 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. Sea level rise may influence inland stream water levels and alter valley groundwater levels, with subsequent effects on habitat and land use suitability.

Following the principles endorsed by HELCOM and VASAB and embedded in the proposal for establishing a framework for maritime spatial planning and integrated coastal management in the EU, the spatial planning for land and for the sea should be tightly interlinked, consistent and supportive to each other. The synergies with research supporting maritime spatial planning and integrated coastal management should be strengthened by considering the theme 4.3 “Maritime spatial planning from local to Baltic Sea region scale”

as one of the supplementary themes of the project proposals addressing this theme as the key.

Expected outcomes:

- Tools for coastal zone management, protection and adaptation considering results of complex analysis of i.a. morphodynamic processes linked to the full range of possible scenarios of climate impacts and development of socio-economic activities (e.g. ports, fishery, energy production, tourism, aquaculture etc.) and various types of ecosystem services.
- New solutions and services for harmonisation of the existing use of coastal areas in order 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 management of the open coast and coastal waters, treatment of flood-prone arable land as well as protection of land along estuaries and inner coastal waters for agriculture, tourism and infrastructures.
- Protection measures against flooding and extreme events, managed re-alignment of coastlines, land-use strategies and river management concepts.
- Scenarios of future sustainable land management, taking into account climate, morphodynamic and socioeconomic changes, with quantified effects on coastal ecosystem functions and services.

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.

Although many countries have made good progress in reducing nutrient emissions from waste water and other point sources, eutrophication from diffuse sources such as agriculture, erosion and mineralisation of peat soils is still ongoing. There is a general 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 land lift, shall be developed and tested.

Expected outcomes of research:

- Economic models supporting elaboration of regulatory tools and incentives for eco-technological development and resource utilisation.
- An evidence-based review of the feasibility of new technological solutions (including geo-engineering) and/or biomanipulation methods that intend to speed up achieving the good ecological status in the Baltic Sea.

Expected outcomes of innovation:

- Design studies for improvement of retention and recirculation of nutrients and other chemical substances through catchment-based eco-technological methods, new soil drainage technologies, nutrient retention through biomanipulation and wetland design, aquaculture and creation of the eco-loops of nutrients as well as rational forestry technologies.
- New methods for improved wastewater treatment efficiency for xenobiotics and persistent micro- and nanoparticles applicable also in decentralised water management.
- New methods for recovery of substances from waste and sediments including methods of bioremediation.
- New methods for retention and reduction of air pollution from energy production and transportation.
- New cost-efficient, effective and user-friendly methods to test the chemical status of sewage, leachate from landfills, wastewater and storm water.
- 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 of increasing importance hence creating an urgent demand for sound knowledge on their sustainable exploitation. Shipping and fisheries are the most traditional, and until now, the most economically important maritime sectors. 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 several overarching policy objectives, amongst others those stated in the Baltic Sea Action Plan, the EU Marine Strategy Framework Directive, the Common Fisheries Policy, the Ballast Water Management Convention and the reduction of sulfhur emissions of the International Maritime Organization (IMO). Interest in new maritime economy sectors is growing rapidly worldwide. In particular, this is the case with renewable offshore energy and aquaculture. The research should lead to improved condition for sustainable economic growth, exports, jobs and competence development.

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 multidisciplinary 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, and the preventive options and mitigating measures 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. This must be combined with state of the art monitoring programmes.

The principle of ecosystem approach to management was introduced into various management plans a decade ago. Recent research has focused on integrated analyses of the impacts and associated changes in ecosystem states caused by various pressures on the Baltic Sea food webs and ecosystem as a whole, including fisheries. However, the knowledge base is not sufficient for implementing the EU Marine Strategy Framework Directive and supporting implementation of the revised EU Common Fisheries Policy. While there is a lot of information about various aspects controlling individual fish stocks, there is still a need for integration of this information into multi-species and multi-fisheries 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 addressing the economic drivers and longer time-horizons of the management plans are missing.

Aquaculture, the farming of fish, algae and shellfish, is the fastest growing food production sector globally (8.8 % per year). Increased aquaculture is needed to satisfy a growing consumer demand for safe seafood without an increased pressure on natural fish and shellfish populations. However, EU and specifically the Baltic Sea region have not had similar growth in the industry, partly due to controversies related to environmental issues. Although any type of aquaculture has its ecological consequences, neither related systematic review on the Baltic Sea region scale nor its potential in future development of the Baltic Sea region has been considered to date in an evidence-based manner. Research into perspectives of sustainable development of aquaculture is now urgently needed in order to utilise this potential contributor of the blue growth in the Baltic Sea region.

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 (GES) descriptors (see box 4) 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 fulfilling these criteria. In addition, research projects should

provide basic information and methods for an internationally harmonised surveillance strategy.

The BONUS research will fundamentally improve the management of the 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 the Baltic Sea Action Plan, the revised Common Fisheries Policy and the EU Marine Strategy Framework Directive as well as to quantify GES descriptors. In particular, the GES criteria characterising biodiversity (1), level of exploitation of living resources (3), integrity of food webs (4), sea floor integrity (6) and contaminant level in fish and other seafood (9), greatly depend on prudent governance and management of fisheries.

The BONUS research will improve the integration of sustainable aquaculture in the context of an ecosystem based marine planning and coastal management of the Baltic sea and thereby support both social development and reduce environmental impact on costal and wetland areas. The BONUS research will also build networks and interdisciplinary knowledge enabling implementation of the now rapidly developing technology of closed and semi closed production systems suitable in both coastal and inland localities. The research will contribute to increased understanding of GES criteria as risk for genetic contamination and spread of disease of wild fish population (1), non-indigenous species (2), food security (3) and eutrophication (5). Furthermore, by encompassing development of aquatic catch crops as e.g. algae and mussels, as well as fisheries by-products, aquaculture has the potential to be the first food production system with a balanced nutrient budget.

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 it is also one of the key factors determining 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. In addition, real time/near real time information services (on e.g. wind, waves, ice) supporting navigators are reducing the risks due to shipping. At the end, the risk control options and possible mitigation measures 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. Consequently, 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 outcomes:

- Proper methods, decision support tools and recommendations 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 on-board 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. The results should contribute to implement the application of so called e-navigation in daily shipping practices.
- Proper methods and decision support tools for the prevention 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 and providing cost-efficient solutions for mitigation of the risks associated with the future maritime activities related to the renewable offshore energy developments.

THEME 3.2

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

Shipping is increasingly being addressed more stringent international requirements for reducing harmful environmental impacts, such as atmospheric emis-

sions 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 on open sea, coastal an river approaches and harbours. Thus 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 are topical to support decision-making in the future. Concepts such as Clean Shipping Index and other clean shipping initiatives should be included in the analysis.

Expected outcomes:

- 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 and smaller pleasure boats, marine litter and introduction of energy, including noise (8, 10, 11). Science-based solutions for achieving good environmental status in accordance with these criteria. Assessments of 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 on open sea, coastal and river approaches and harbours.
- Analysis of the economic, societal and ecological impacts of environmental requirements for shipping to support development of the related policies in the Baltic Sea region.

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 critically affect the stock dynamics and the state of a population, but also species interactions and food web configurations. A lack of understanding and consequent neglect of fish spatial dynamics and related species interactions in stock assessment may threaten the success of ecosystem-based management actions and validity of the Marine Strategy Framework Directive's good environmental status 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, (iii) the causes of temporal variability in spatial biomass distributions, (iv) its impact on food web structures and fish stock production and (v) better and improved identification and delineation of local populations requires further research. However, most importantly, the interactions between different drivers of key processes need to be quantified and predicted. The resulting process knowledge on temporal and spatial stock dynamics, including species interactions as well as fisheries operating on these stocks, is the basis for a sound ecosystem based fisheries management.

Expected outcomes:

- Closing a critical knowledge gap by conducting re-analysis of spatial data at different time-scales, designing and testing sampling programmes that resolve the habitat requirements of different life-stages of commercially and ecologically important fish populations/stocks, by combined use of a variety of appropriate techniques.
- Sufficiently sensitive and robust analytical, spatially explicit multi-species assessments of commercial fish stocks in the Baltic are developed and implemented as prerequisites for spatial fisheries and ecosystem management and for reaching the goals specified by Marine Strategy Framework Directive (GES) descriptors 1, 3, 4 and 6. 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. Spatially explicit frameworks should be elaborated that are able to evaluate scenarios of fisheries management options, e.g. maximum sustainable yield and elimination of discards, as well as fisheries management plans and technical measures, e.g. selective fishing gears under changing ecological, environmental, economic and fisheries conditions.

Expected outcome:

- New management evaluation tools developed to cover the whole fishery system and the related environmental aspects, i.e. i) biological interactions involving fish stocks and other ecosystem components, ii) technical and mixed fisheries interactions involving fleet and fishing gear development, with consideration of economic and social 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 (including governance) and, finally, v) feedback to the fisheries, advisory and management systems after implementation of management measures.

THEME 3.5
Sustainable aquaculture in the Baltic Sea

An increase in sustainable aquaculture has the potential to support economic growth, exports, jobs and competence development and at the same time support an increased consumer demand of safe sea food. It is important to investigate the feasibility and cost efficiency as well as the regulatory preconditions of using farmed aquatic organisms, such as mussels and algae, in fish feed, in order to contribute to the reduction of eutrophication in the Baltic Sea.

To advance sustainable aquaculture in the Baltic Sea region, transdisciplinary research of high quality is needed. Technical, modelling, economic, social and legislative systems must be developed which support production systems with a sustainable nutrient utilisation including negligible effluent. The ultimate goal of such research must be a nutrient neutral broader food production system with a broad consumer acceptance. Developing economically and environmentally sustainable farming systems based on recirculation technology in closed and semi-closed systems is urgently needed to foster development of sustainable aquaculture as a contribution to the blue growth in the Baltic Sea region. Even though recirculation technology have now reached a fully commercial scale, practical and operational solutions to cost-efficient removal of nitrogen and phosphorous are still missing. The dissolved inorganic nitrogen and phosphorus are present in high concentrations in the discharge from recirculation systems. Research and innovation aimed at improving farming technology and especially the end-of-pipe treatment for reducing final discharge and environmental impact are needed.

Expected outcomes of research:

- Scientifically justified transdisciplinary criteria and suggestions of policy guidelines and solutions (social, economic and ecological) enabling implementation of an environmentally balanced and socially accepted aquaculture production to be applicable across the Baltic Sea region. This outcome will be underpinned by the methodology of evidence-based environmental management and be achieved in synergies with other research areas like maritime spatial planning, costal management, and rural development in environmental, economic and social perspectives.
- This study shall include, among other, an investigation of the feasibility and cost efficiency as well as the regulatory preconditions of using farmed aquatic organisms, such as mussels and algae, in fish feed, in order to contribute to the reduction of eutrophication in the Baltic Sea.

Expected outcomes of innovation:

- New regionally based fish feed ingredients to be produced using recaptured nutrients supporting development of green industries.
- Commercially viable recirculation and other technologies to be developed to allow an efficient removal or retrieval of nutrients and pathogens and minimised risk of escapees.

STRATEGIC OBJECTIVE 4

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

Rationale

The socio-cultural traditions, attitudes, habits and other human behaviour are the primary influences on the environmental state of the Baltic Sea. Effective institutional solutions, governance structures and public engagement practices need to take into account the various socio-cultural, political, administrative, economic and ecological settings in the Baltic Sea region. Their ability to perform should be matched in turn with the ecological scales they are defined to manage in order to improve ecosystem based and adaptive management. There is a need to establish a clear link between marine ecosystem services and the communities that are dependent on these services. In order to achieve this, solutions are needed for regulatory framework and good management practices in particular, and they should be based on findings of interdisciplinary research.

State of the art

Cost effectiveness and politically acceptable allocation of abatement efforts and measures are keys to improving the capability of the countries to respond to the major challenges of the Baltic Sea. There are a number of studies on various aspects of cost effectiveness of the current measures, particularly studies concerning 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 implications and advice. Integrated socioeconomic and ecological research is needed for socioeconomic implications, optimal design and implementation of policies using spatially differentiated policy instrument mixes. The relationship of ecosystem services to human wellbeing, as well as valuation and different pricing approaches of the ecosystem services, is also necessary. Integrated socioeconomic and ecological research supporting maritime spatial planning as governance tool has started to flourish recently although it is still comparatively new subject in the general spatial planning domain. Integrated 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, administrators and other stakeholders with good governance tools and information sources. With the help of interdisciplinary 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. Policy makers 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 the 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 environmental governance and policy performance. Moreover, the effects of various socio-cultural values and ethics on institutions and governance structures need further investigation. Behaviour and attitudes affect both voluntary environmental actions and the effectiveness of policy instruments. It is still to be understood how the presence of over-lapping 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. For example, environmental problem areas, such as hazardous substances and biodiversity conservation that are necessary for providing sound basis for policy making need sound cost-benefit analysis. Research related to implementing new policy instruments, such as nutrient trading schemes, also needs 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 outcomes:

- Better understanding of how the linkages between socio-cultural traditions, values and ethics; individual attitudes and behaviour; and governance structures shape environmental and resource management 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 socioeconomically efficient measures based on the most reliable cost and benefit estimates across the Baltic Sea drainage area.
- Decision support methods and tools dealing with the synergy effects of policy measures.

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, including the intermediate 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 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, beauty). 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. 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.

Expected outcomes:

- Evaluation of impact of measures on provision of ecosystem services. Proposal of new methods linking good state ecosystem services with human well-being.
- Quantification of the value of ecosystem services (including value of change). This analysis shall include intermediate services that support other ecosystem services that can be turned into benefits for humans.
- Models for comparative and consequential analyses of cumulative benefits and tradeoffs of different marine ecosystem services and types of use of sea space including their marginal costs.

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

The marine space is being used predominantly within the limits of individual economic sectors that have introduced certain sectorial oriented regulations/limitations at the sea. Maritime spatial planning has emerged only recently as a management tool aiming to combine cross-sectorial balancing of the maritime related interests as well as introducing benefits of multi-level governance of marine related affairs. Maritime spa-

tial planning faces currently two challenges that need research support. These are related to integration of scales and perspectives: coherent planning of marine space from national to the Baltic scale recognising economic, social as well as environmental perspectives. The first challenge is in bringing together the predominantly national efforts in order to ensure Baltic wide coherence of the planning efforts. Meeting of this challenge would require both: (i) knowledge on functioning of Baltic Sea ecosystem in spatial terms and (ii) new planning tools and methods.

In many sea areas there is too little adequate information on the spatial properties of ecosystems and their elements: populations, communities and habitats. There is a need to identify spatial demand and requirements to ensure proper quality of different ecosystem services (supporting, regulating, provisioning and cultural services), in order to improve evidence base to plan optimal use of sea space. The research should ultimately help in answering what should be the Baltic Sea regional targets that maritime spatial planning should observe e.g. how much space and where should be reserved for certain purposes.

New planning tools should allow better cross-border coordination of maritime spatial planning and aid agreement on joint activities among the Baltic Sea countries. New spatial-economic tools for finding optimal location of different activities disregarding administrative borders should be developed. The research should help also in cross-border communication, in preparation of tools and techniques for cross-border consultations and fostering of cross-border stakeholder dialogue.

The second challenge is in assessing the potential overall impact of maritime spatial planning on sustainability of the Baltic Sea ecosystem services, as well as maritime economy and blue growth. Meeting of this challenge would require new tools for impact assessment and sustainability appraisal of the integrated management efforts such as maritime spatial planning.

Following the principles endorsed by HELCOM and VASAB and embedded in the proposal for establishing a framework for maritime spatial planning and integrated coastal management in EU, the spatial planning for land and for the sea should be tightly interlinked, consistent and supportive of each other. The synergies with research supporting integrated coastal management should be strengthened by considering the theme 2.3 "Integrated approaches to coastal management" as one of the supplementary themes of the project proposals addressing this theme as the key.

Expected outcomes:

- New knowledge and know-how for creation of practical maritime planning tools ensuring sustainable use of marine space for different purposes.
- Methods and tools for evaluation and monitoring of maritime spatial planning solutions from different perspectives – spatial efficiency, functionality of ecosystems, navigation, economic cost reduction as well as contribution for social welfare.
- Methods for cross-border maritime spatial planning. Developing efficient methods for cross-border communication, collaboration and stakeholder involvement.
- Analysis of the options for spatially relevant common targets based on improved evidence base for the Baltic Sea, e.g. in offshore energy production, mariculture, preservation of maritime landscapes, underwater cultural heritage etc.
- Methods, tools and databases for spatial planning that will contribute to development, mapping and maintenance of biodiversity and ecosystem services along the coast-sea continuum, and to establishing of linkage of conservation issues in biologically and ecologically sensitive marine and terrestrial areas.

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

State of the art

Observation and data integration issues in the Baltic Sea regions are strongly dependent on several area-specific factors like brackish and turbid sea waters, extensive ice cover, physical and ecosystem patchiness with strong and variable stratification of the water column, high shipping activity, variety of river influence areas, coastal bays and archipelagos, with a mosaic of seabed types and benthic habitats. 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. The Marine Strategy Framework Directive requires member states to develop a comprehensive integrated and regionally coordinated monitoring programme. There are also requirements for Baltic-wide monitoring and assessment to follow up the implementation of the Baltic Sea Action Plan.

The monitoring methods and programmes should provide information that, in addition to assessing the present environmental status and trends, identifies the causes of the change and thus help in updating the remediation measures chosen. 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 and 'cutting edge' research efforts and observing systems. It should also contribute to providing cost-effective high-quality downstream services in the frame of existing national and international monitoring and forecasting initiatives, combining the efforts in in situ observations, remote sensing and numerical modelling.

Expected outcomes:

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

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 including real-time devices, remote sensing and laboratory techniques specifically adapted to the Baltic conditions to achieve the real-time information. The developments should focus on one or several items such as new sensors and methods for in situ physical, chemical, biological and geological sampling and observations (including sampling methods and observation techniques on-board 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, coastal erosion, underwater topography and benthic habitats as well as 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:

- Developing and testing of innovative marine scientific information collection techniques specific to the Baltic Sea area. These techniques should have a potential to improve next-generation monitoring programmes (requiring monitoring methods on new parametres, e.g. underwater noise and marine litter), 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 international initiatives promote, collate and synthesise data into useful information for the environmental, societal and economic benefit of different user groups. The 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 'marine/maritime professionals' and 'citizens'. The interests of marine/maritime 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 use of quasi-standards for data quality control and automatic filters as recommended by EuroGOOS. 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. Therefore standardised vocabulary for parameters and Open Geospatial Consortium standards for data exchange should be used.

Expected outcome:

- New information and communication technology-based tools and services to address the contemporary and future user-driven marine and maritime information needs. These new tools should provide information in support of developing sustainable use of marine ecosystem goods and services. Technically they should be interoperable and 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 co-decision in 2010, referred to as the BONUS Law (European Union, 2010). 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.

In line with the BONUS Law, the detailed implementation modalities and conditions for EU support are defined within an implementation agreement concluded between the European Commission and BONUS EEIG on 18 October 2012. The implementation phase of the programme extends from 2012 until 2017.

Firm governance structure casts the foundation

The programme is managed by a dedicated implementation structure, the 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 5 and it includes:

- **Steering Committee** composed of representatives of national funding institutions as the highest authority of the 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 the 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 the Russian Federation and other third countries (countries that are not participating in BONUS nor are EU member states or associated with EU's Seventh 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. Such funders are invited to the Steering Committee as observers thus having a possibility contribute to the decisions concerning issues related to the respective call.

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 include proposal preparation and evaluation schemes, 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.

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 research and innovation framework programme for the latter part of this decade (Horizon 2020, European Commission, 2011), the EU acknowledged that there is a need to make a steep change in the 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 strategic framework for research and innovation funding, Horizon 2020, and EU's initiative of 'blue growth' in sustainable way. 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. Research themes addressing the issues which are critical for successful and timely implementation of the major relevant policy initiatives, in particular, the EU Marine Strategy Framework Directive and the HELCOM Baltic Sea Action Plan are prioritised while designing the thematic content of each call (see figure 6).

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

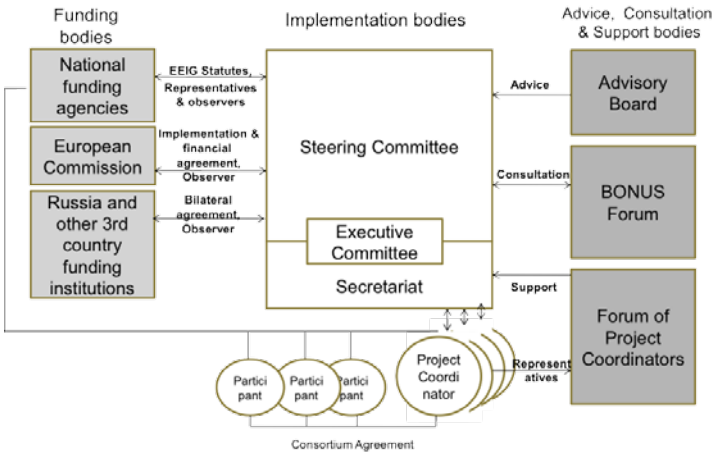

Figure 5: Programme governance and management structure

EU Framework Programme for Research and Technological Development, Horizon 2020. Potential synergies with the activities initiated and supported by other General Directorates of the European Commission will be taken into account while assessing potential impact of the project proposals, in particular important are synergies with the activities of Environment, Maritime Affairs and Fisheries and Regional Policy. 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 also a statement explaining how impact will be achieved.

Details of each call are announced through call specific call fact sheets. More detailed guidance is provided through the call specific applicant and participant guidelines. Also guidelines for the independent evaluators are issued for each call separately. The various guidelines take into consideration different, specific requirements set for each BONUS call announced.

The BONUS call 2012 was the first call based on the BONUS strategic research agenda 2011–2017. The Viable ecosystem part of the call was open for a three month period from 12 November 2012 until 14 February 2013 and given the novelty of an Innovation part in a call announced within a regional research funding governance structure, this part remained open for a month longer period from 12 November 2012 until 12 March 2013. The successful projects receiving BONUS funding from the BONUS call 2012 commence their implementation in 2014 with a total duration of up to four years for the Viable ecosystem projects and up to three years for the Innovation projects.

Two further calls will open in 2014. A research call titled 'BONUS call 2014: Sustainable ecosystem services' is open from 16 January 2014 for three month period and covers six research themes (see figure 6). In the second half of 2014, a further call covering both research and innovation themes is being considered

and further details will be made available through a dedicated call fact sheet in a due course. Tentatively this call will invite research and innovation proposals addressing themes 2.4 "Eco-technological approaches to achieve good ecological status in the Baltic Sea" and 3.5 "Sustainable aquaculture in the Baltic Sea region". In addition, some of the themes opened but left unaddressed in the previous calls (i.e. at that point both BONUS call 2012: Viable ecosystem and Innovation, and BONUS call 2014: Sustainable ecosystem services), may be reopened, depending on funding limits.

In addition to the Baltic Sea research 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. The most comprehensive practical information related to the past and future BONUS calls can be found on the internet at www.bonusportal.org/calls.

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 free to projects as in kind contributions the participating states will also increase total funding volume of the programme which will be matched by EU funds 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 (European Commission, 2009a). In short, this means that

This call has been postponed until 2015. For updates, visit www.bonusportal.org

Research themes (abbreviated titles)	BONUS call 2012: Viable ecosystem and Innovation closed in February/March 2013	BONUS call 2014: Sustainable ecosystem services opens 16 January 2014	BONUS research and innovation call 2014 opens in second half of 2014
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 framework 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 6: Research and innovation themes of the BONUS strategic research agenda announced in the BONUS calls 2012 and 2014. Symbol '○' indicates themes opened that may reopen within the funding limits of BONUS in order to fill in thematic gaps.

- 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.

Open access refers to the practice of granting free internet access to research articles. BONUS fully supports the European Commission objective to optimise the impact of publicly funded scientific research including developing and implementing open access to research results from projects funded by the EU Research Framework Programmes, namely FP7 and Horizon 2020[6].

While emphasising the principle of openness and sharing of data, BONUS acknowledges the intellectual property rights in cases of projects with commercial potential. The matters related to the intellectual property rights are stipulated in the BONUS grant agreements that are concluded with the funded projects.

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.

6 See more on the open access publishing in http://ec.europa.eu/research/participants/data/ref/h2020/grants_manual/hi/oa_pilot/h2020-hi-oa-pilot-guide_en.pdf

Communication with the society is planned and activated

Stakeholder involvement is one of the key priorities of the programme. A dedicated communications plan addressing the wide area of dissemination, project results uptake and stakeholder engagement, including end-users, is required to be planned and integrated to each BONUS project from the very beginning of the project cycle. 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 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 critical 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, update 2014

Aarhus convention	The UNECE Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters
BONUS EEIG	Baltic Organisations' Network for Funding Science, European Economic Interest Grouping
BSAP	Baltic Sea Action Plan
DPSIR	Drivers – Pressures – State – Impact – Responses
BDF	Baltic Development Forum
BSPC	Baltic Sea Parliamentary Conference
BSSSC	Baltic Sea States Subregional Cooperation
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
CBSS	Council of the Baltic Sea States
CFP	EU Common Fisheries Policy
CNP	carbon, nitrogen, phosphorus
DOM	dissolved organic matter
EMODNET	European Marine Observation and Data Network
ERA	European Research area
ESMMR	European Strategy for Marine and Maritime Research
Espoo Convention	UN Convention on Environmental Impact Assessment in a Transboundary Context
EU	European Union
EuroGOOS	European Global Ocean Observing System
EUSBSR	EU Strategy for the Baltic Sea Region
GES	Good Environmental Status
Geneva Convention	UN Convention on Long-Range Transboundary Air Pollution
HELCOM	Baltic Sea Environment Protection Commission
Horizon 2020	European Union's Framework Programme for Research and Innovation launched in 2014
ICT	Information and communications technology
IMP	EU Integrated Maritime Policy
IMO	International Maritime Organisation
JPI Oceans	Joint Programming Initiative "Healthy and Productive Seas and Oceans"
MARPOL	International Convention for the Prevention of Pollution from Ships
MSFD	EU Marine Strategy Framework Directive
MSP	Maritime Spatial Planning
MSY	Maximum Sustainable Yield
REACH	EU regulation concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals
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

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 civilisation, and finally, the ability to accurately predict future changes with sufficient advanced notice to mitigate the predicted effects.

Biodiversity in the 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.

Blue growth is EU's initiative to harness the untapped potential of Europe's oceans, seas and coasts for jobs and growth.

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 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.

(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 services is a collective name of the benefits enjoid by humankind that originate from a multitude of resources and processes that are supplied by ecosystems. Ecosystem services include provision of products such as clean drinking water and processes such as the decomposition of waste. The United Nations 2005 Millenium Ecosystem Assesment grouped the ecosystem services into four broad categories:provisioning, regulating, supporting and cultural.

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.

Interdisciplinarity is a process in which researchers work jointly, but from each of their respective disciplinary perspectives, to address a common problem.

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.

Multidisciplinarity in research is combining or involving several academic disciplines or professional specialisations in an approach to a topic or problem but not trying to synthesise cognitive structures.

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

Transdisciplinarity is a process by which researchers work jointly to develop and use a shared conceptual framework that draws together discipline-specific theories, concepts, and methods to address a common problem.

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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SEVENTH FRAMEWORK PROGRAMME

BONUS is supported by national research funding institutions in the eight EU member states around the Baltic Sea and the EU Research Framework Programme. Scientists from Russia participate in BONUS through bilateral agreements.