Towards sustainable blue growth: Outline of the joint Baltic Sea and the North Sea research and innovation programme 2018-2023

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BONUS

SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

Towards sustainable blue growth

Outline of the joint Baltic Sea and the North Sea research and innovation programme 2018–2023

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The outline document of the joint Baltic Sea and the North Sea research and innovation programme was first submitted to the European Commission on 11 November 2015. Minor updates to this document have been made since to reflect the most current situation in the process of developing the new programme at the time of publication in February 2016.

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Preface

■ Publishing of this programme outline document is an important milestone: after almost three years of preparation, an outline document for the continuation and geographical extension of the joint Baltic Sea research and development programme BONUS, for the years 2018-2023, was submitted to the European Commission on 11 November 2015.

This proposal was prepared by EU member states adjacent to two northern European regional seas, the Baltic Sea and the North Sea. Scientific community, research funding institutions and ministries from Belgium, Denmark, Estonia, Finland, France, Germany, Latvia, Lithuania, the Netherlands, Poland, Sweden and the United Kingdom contributed to its development. As a curiosity and a reflection of the thoroughness of the negotiation process, the Secretariat filed almost 40 dated versions of the document prior its completion.

Those of us having been involved in the preparation process are convinced that the new programme will pave the way for enhanced policy development and new innovations which will support growth based on blue economies, while protecting the marine environment. The programme will produce new knowledge and scenarios about the marine ecosystem functioning in the changing climate, and increase understanding of how the seas are impacting economies, human behaviour and societies' values. This will be the basis for new regulations and incentives as well as clean technology solutions and products, and for creating jobs, increasing people's awareness and promoting ecological behaviour and everyday choices.

Will the new programme be as impactful as we anticipate? The foreseen impact will be evaluated by a specific ex ante impact assessment procedure performed by the European Commission during the winter 2016, before the proposal can be presented to the European Parliament and the Council.

It is a well-known fact that the impact of research can have many dimensions, such as impact on scientific quality, technology, environment, society, economy, organisation, health etc. and that the impact may become visible only after years or even decades from the point of time of the end of a particular project or programme. The research and funding collaboration in the predecessor BONUS programme has already had a major impact in the Baltic Sea and policy research landscape: instead of small national programmes, countries merge their research resources and encourage scientists to work in multinational projects. Immediate societal impacts are secured by active stakeholder consultation already in the earliest stages of defining needs for new knowledge and solutions. Impacts are visible as increased number of multinational publications and higher quality of scientific outcomes, and a large number of improvements in policies and regulations.

The outline document now published in the BONUS Publication Series (Number 15), has been written by research policy experts and scientists from all the Baltic Sea and the North Sea EU member states under supervision of an Ad Hoc Steering Group representing the BONUS EEIG as well as the key research and innovation funding institutions of Belgium, France and the Netherlands:

Andris Andrusaitis, David Cox, Antoine Dosdat, Kay Emeis, Joachim Harms, Maurice Heral, Peter Hermann, Floor ten Hoopen, Simon Jennings, Kerstin Johannesson, Kaisa Kononen, Fritz Köster, Maria Laamanen, Tonny Niilonen, Markku Ollikainen, Laura Raaska, Bo Riemann, Maija Sirola, Josef Stuefer, Mats Svensson, Ulrich Wolf.

In Helsinki, 10 February 2016,

Kaisa Kononen, Executive Director, BONUS
Fritz Köster, Chair of the Ad Hoc Steering Group, BONUS Steering Committee

Contents

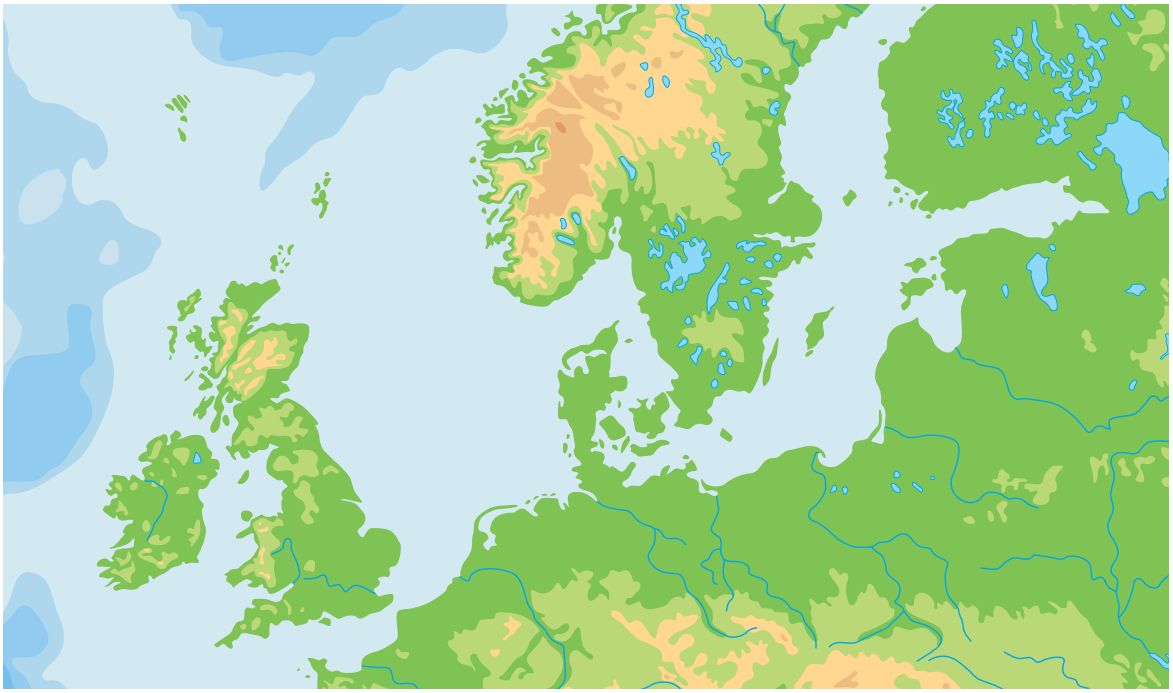
Preamble

■ Eleven member states of the European Union (Belgium, Denmark, Estonia, Finland, France, Germany, Latvia, Lithuania, The Netherlands, Poland and Sweden, negotiations are also ongoing with the United Kingdom), adjacent to two northern European regional seas, herewith propose to create a joint Baltic Sea and North Sea research and innovation programme. This programme is envisaged to be implemented from 2018 onwards in accordance with Article 185 of the Treaty on the Functioning of the European Union (TFEU) and linked to Horizon 2020, the EU Framework Programme for Research and Innovation. The programme is designed to underpin and develop EU and national policies and strategies, with particular consideration of Europe's blue growth strategy.

The outline of the joint Baltic Sea the North Sea research and innovation programme consists of two parts, namely A: Objectives and implementation and B: Similarities and contrasts between the Baltic Sea and the North Sea.

Part A provides justifications of the participating states' decision to jointly propose an Article 185 TFEU initiative: it identifies the main challenges and formulates respective objectives of the programme, summarises the indicative financial commitment of the participating states and assesses the EU-relevance of the initiative and its potential structuring effect at EU, macro-regional and national levels. Affirming the ambitious intention of scientific, management and financial integration by all participating states, this part presents the scope and expected outcomes and impacts of the initiative, as well as its basic functioning mechanisms. The final chapters of part A are devoted to a preliminary SWOT analysis and a selection of measurable criteria of the proposed programme's progress towards its objectives.

Part B gives an overview of the two seas and their ecosystems, describes their interlinkages and the surrounding societies in terms of uses of the ecosystem services and human-induced pressures on the ecosystems, as well as the respective types of policy responses. Throughout part B, information is presented in a comparative way, highlighting the similarities and contrasts between the Baltic Sea and the North Sea regions, thereby providing a rationale for establishing this now proposed, joint northern European regional seas' programme.



Executive summary

Rationale

Europe has taken a course towards unlocking the potential of its blue economy. The European Commission has formulated its blue growth strategy to increase jobs, welfare and safety, going along with the fundamental principles formulated in the Europe 2020 strategy: growth must be smart, sustainable and inclusive; *smart* with respect to integration of cutting edge science-based, innovative solutions and industrial leadership, *sustainable* in economic, social and ecological terms tackling societal challenges and *inclusive* considering the multitude of coastal, marine and maritime activities and trade-offs between them. Historically, many maritime activities have had detrimental impacts on marine ecosystem structure and functioning; the new blue growth strategy requires mitigation of impacts and restoration of ecosystem resilience, to conserve and increase their ability to provide goods and services.

Focus on blue economy is driven by four main factors: (a) technological evolution enabling exploitation of until now unexplored or unreachable marine resources, as well as optimised exploitation of traditional marine resources, (b) humankind's increased demand for various living and non-living natural resources, (c) need for space to accommodate intensified marine and maritime activities and (d) need for adaptation to the effects of climate change. Furthermore, increasing welfare and changed demographic structure stimulate tourism depending on good environmental status of the sea, coast and catchment.

The northern seas of Europe are at the forefront of the global surge to develop marine and maritime potentials. Already today the blue economies of the Baltic Sea and the North Sea account for around EUR 50 billion annual turnover and sustain at least 1.5 million work places[1] with significant capacity to expand further. This enormous body of economy is directly and critically dependent on the quality and extent of the ecosystem services provided by the two regional seas and their coasts. Nevertheless, fragmentation among nations and sectors, gaps in interdisciplinary knowledge, too little information on potential synergies and trade-offs, insufficient exchange of knowledge among scientists, industries and policy makers as well as too little attention to the inclusiveness and human well-being issues pose serious challenges to achieving the aims of the EU blue growth strategy.

The time is ripe for launching a joint cutting-edge research and innovation programme which supports generation and sharing of region-wide knowledge on ecosystems and the marine environment, the development and testing of new technologies, new methods of cross sector management and new approaches to transnational governance. This approach in turn enables the creation of new jobs while it supports sustainable blue growth in an aligned political environment that optimally backs integrated regional development.

The Baltic and the North Seas are exceptionally well suited for a joint research and innovation programme: they face similar challenges associated with climate- and sea level change and are influenced by runoff from large, densely populated and heavily exploited catchment areas resulting in loading with nutrients, contaminants and marine litter. Both seas are interconnected, and forced by the same weather patterns and water exchange with the North Atlantic. The regulatory and management frameworks are similar, and both sea areas exhibit rather homogeneous cultures and visions with respect to exploiting marine resources and conducting maritime activities.

The programme is designed as an EU-level test case taking the next steps towards the creation of a regionally structured and integrated marine and maritime research and innovation agenda, thus catalysing sustainable blue growth in all European sea basins.

Challenges

By launching this programme, the participating states commit to address several critical challenges that

1 See chapter *Human uses of ecosystem services* for more information.

threaten the sustainable development of the Baltic Sea and the North Sea regions:

a. **Fragmentation delays and increases costs of development.** Current marine and maritime research and innovation activities by member states are too fragmented to enable effective implementation of major directives, e.g. the Marine Strategy Framework Directive (MSFD), policies, e.g. the Common Fisheries Policy (CFP) and strategies, e.g. the EU blue growth strategy. Achieving a joint European marine and maritime research and innovation area is a prerequisite for environmentally, economically and socially sustainable blue growth on national and regional levels. Due to the structuring effect of BONUS (predecessor of this initiative) and the EU Strategy for the Baltic Sea Region (EUSBSR), a large part of marine and increasingly also maritime research and innovation funding in the Baltic Sea region is channeled through transnational programmes, while the North Sea related research and innovation activities are still predominantly nationally-driven, with various ministries being responsible for different and partly competing sectors.
b. **Gaps in interdisciplinary knowledge prevent sustainable solutions.** Closing the scientific and technological knowledge gaps within and among different services provided by marine ecosystems calls for a truly interdisciplinary approach. Holistic assessments of development scenarios and risks to the maritime sectors and to ecosystems, and transferring this knowledge into fit-for-purpose policies, regulations and design of effective management tools are required. There is an urgent need to create a knowledge basis, innovative solutions and tools for blue growth without compromising the quality of the marine environment and the capacity of the marine ecosystems to offer increasing quantity of high quality goods and services.
c. **Lack of identified synergies and trade-offs among blue economy sectors hampers development of best strategies and smart specialisation.** Knowledge about potential synergies and trade-offs among and between maritime activities remains insufficient to devise optimal future exploitation and management strategies and to underpin prudent specialisation among the littoral states. Optimisation of emerging marine and maritime activities, such as renewable energy, aquaculture, biotechnology, tourism and recreation, underwater mining on one hand, and traditional sectors like maritime transport, fisheries, and off-shore oil and gas extraction on the other, is not possible in the absence of comprehensive and truly interdisciplinary analyses which consider all maritime activities and their environmental, economic and social impacts.
d. **Insufficient knowledge exchange.** The role of communications and knowledge transfer has become crucially important for knowledge-based policy making. In order to enable every citizen to make informed everyday decisions, including those which eventually drive markets and policies, sound contemporary knowledge must be embraced by broad society. In spite of best efforts, optimal models for exchange of two-way knowledge transfer between academia and industry and within the triangle of academia, industry and policy that enable sustainable blue growth still remain to be found.
e. **Human health and wellbeing aspects of blue growth are not considered.** Human health and wellbeing is intrinsically connected to and impacted by the seas. Extreme weather events such as storms and flooding as well as human exposure to marine-borne pathogens and chemical pollution pose significant threats to human health. At the same time, the seas provide numerous benefits. Understanding and creating human wellbeing from this complexity can only be achieved with an interdisciplinary approach, drawing on expertise across a diverse range of disciplines within natural, social and economic sciences, public health and medicine.

Aim and objectives

The ultimate goal of the programme is to elevate the Northern European regions' research and innovation capacity to a level necessary to achieve a decisive boost in the development of a sustainable marine and maritime economy. The enduring structuring effect necessary to this end will be achieved by integrating front-edge research and innovation activities into a durable, cooperative, interdisciplinary and focused multinational programme at the scale embracing both the Baltic Sea and the North Sea regions. Focus will be on those issues where a collaborative sea-basin approach can bring better, faster and more cost-effective results compared to either the broader EU or narrower national-level approaches.

The strategic objectives of the programme, which are vital for both the Baltic Sea and the North Sea macro-regional development and at the same time relevant to the objectives of Horizon 2020 and broader EU strategies and policies, will be:

- **Overcoming fragmentation in research and innovation:** to structure the Baltic Sea and the North Sea EU member states' marine and maritime research and innovation effort to enable concerted

and efficient responses to the basin-wide challenges across national borders and sectors.

- **Supporting ecosystem based management**: to promote interdisciplinary research and innovation that enables ecosystem-based management of human activities along the land-coast-sea continuum, protects sustainability of different ecosystem services of the Baltic and North Seas and supports the goals of achieving and maintaining good environmental status in these seas and their catchment areas; and to improve the observation, assessment and forecasting capacity of both the natural and societal systems under global change.
- **Fostering sustainability of blue growth:** to deliver a new knowledge base for appraising the socio-economic value of different ecosystem services of the Baltic and North Sea areas and to provide innovative tools for comprehensive planning and management of maritime activities and mitigating the trade-offs among different uses; this will serve as an input to integrated coastal management and maritime spatial planning and as a contribution to the EU 2020 strategy towards smart, sustainable and inclusive growth and its implementation in the EU Strategy for the Baltic Sea Region as well the European Commission's Investment Plan for Europe.
- **Transferring knowledge to practice**: to achieve the level of knowledge transfer and collaboration necessary for (a) devising fit-for-purpose regulations, policies, management tools, practices, and incentives and (b) stimulating the development and implementation of innovative technologies of maritime industries that in turn enable sustainable blue growth and enhance human wellbeing without jeopardising good environmental status.
- **Supporting human wellbeing**: to deliver new knowledge base for supporting social sustainability of blue growth and wellbeing of both genders, including health aspects and fair distribution and inclusive access to the benefits of blue growth among citizens of different regions and states, representatives of different groups of society and people of different occupation.

Commitment by the EU member states surrounding the Baltic Sea and the North Sea

Responding to the challenges posed by the Europe 2020 strategy, eleven states of the European Union (Belgium, Denmark, Estonia, Finland, France, Germany, Latvia, Lithuania, The Netherlands, Poland, and Sweden), adjacent to two northern European regional seas, the Baltic Sea and the North Sea, express strong political and financial commitment to create a joint, transnational research and innovation programme supporting sustainable blue growth in the Baltic Sea and the North Sea and propose to the European Union to support this initiative in accordance with Article 185 TFEU. Commitment is under negotiation with the United Kingdom. These commitments indicate a clear understanding of the added value achieved by pooling of resources and strong willingness to align national investments for transnational research and innovation.

Participating states have announced financial contributions in cash, totaling at least EUR 66.7 million. Furthermore, a number of funding institutions and research performing institutions have expressed their willingness to finance the proposed programme with in kind contributions up to EUR 33.3 million. Anticipating matching contribution of European Community funds, the financial volume of the proposed programme would reach as a minimum EUR 200 million.

The Norwegian Research Council as well as other research funding and implementing institutions of Norway are invited to collaborate and join the initiative. Republic of Ireland has expressed interest to become observer of the proposed programme. The international dimension of the proposed initiative will be strengthened through anticipated collaboration with the Russian Federation based on the approach tested within the ongoing BONUS programme (2011-2017).

Structuring impact

The proposed programme will play an important role in Europe's efforts to promote and develop diverse and often conflicting sectors of blue economy and align them with societal goals including good environmental status of our seas. Through mobilisation of the relevant national research and innovation funders, the programme ensures the necessary level of cooperation among the participating states and their financial and management integration.

Besides the strong structuring effect at the macro-regional level, a powerful consequence is also expected on the national level. Previously isolated research and innovation efforts by several research and innovation funders supporting interests of different sectors become much more impactful when structured under a durable, jointly coordinated programme.

The proposed programme is envisaged to play a key role in fostering joint programming within the EU as well as with the international actors involved in the relevant research and innovation arena of regional seas, including funders, academia, industries and public governance institutions. It will at the same time support EU macroregional and sea-basin strategies and contribute to building the EU marine and maritime research and innovation area. The programme

is designed to improve Europe's competitiveness and strengthen nascent or existing structures of supra-national research and innovation in the marine and maritime realms.

Coordination and synergy will be ensured with activities under the European Structural and Investment Funds (ESIF), e.g. the European Maritime and Fisheries Fund (EMFF) and INTERREG financed by European Regional Development Fund, as well as with other relevant international initiatives, such as the European Technology Platforms.

The programme will complement the joint thematic programming effort by the EU member states, in particular the Joint Programming Initiative 'JPI Healthy and Productive Oceans', as well as 'JPI Water Challenges for a Changing World', 'JPI Climate' and 'JPI Agriculture, Food Security and Climate Change' by (a) adding focus on important macro-region priorities and thematic directions, e.g. on the land-sea interaction and bridging between marine and maritime research and (b) by forging a long-lasting integration in funding research and innovation, based upon cooperation among scientists, enterprises, policy makers, government officials and other stakeholders.

By investigating ecosystem structure and functioning in the Baltic and the North Sea regions, the proposed programme will deliver a rigorous assessment of both the potential of sustainable blue growth and the threats to achieving it, thus underpinning both the EU growth strategy Europe 2020, the implementation of the European Commission's Investment Plan for Europe (EC IPE), EU regional strategies, and relevant EU policies and directives.

European added value

Thematically the programme contributes to meeting several of the seven key societal challenges highlighted in the EU Horizon 2020 Framework Programme for research and innovation. A particular focus is on societal challenges related to *Food security, sustainable agriculture and forestry, marine, maritime and inland water research and the bioeconomy;* but also *Secure, clean and efficient energy; Smart, green and integrated*

WHY WE PROPOSE AN ARTICLE 185 TFEU ACTION?

The programme is designed as an Article 185 of the Treaty on the Functioning of the European Union (TFEU Article 185) activity linked to Horizon 2020, the EU Framework Programme for Research and Innovation, because its objectives are most optimally met and the desired long-lasting structural effect achieved by a regionally focused, concerted long-term effort with a high level of scientific, financial and management integration across EU member states.

Criterion a: a clear definition of the objective to be pursued and its relevance to the objectives of Horizon 2020 and broader Union policy objectives*

The rationale of the proposed programme originates from the Europe 2020 strategy. Its objectives are directly addressing Horizon 2020's key societal challenges: 'Food security, sustainable agriculture, marine and maritime research and bio-economy'. It also addresses challenges 'Secure, clean and efficient energy', 'Smart, green and efficient transport', 'Climate action, resource efficiency and raw materials' and 'Health, democratic change an wellbeing' in the maritime context. Also, addressed are Horizon2020 priorities of 'Excellence in science' and 'Industrial leadership'. The programme has a strong integrating effect across nations and sea related sectors.

***Criterion b:** indicative financial commitments of the participating countries, in cash or in kind, including prior commitments to align national and/or regional investments for transnational research and innovation and, where appropriate, to pool resources*

Participating states have committed both politically and financially, the latter by allocating at least EUR 66.7 million funding as cash and up to 33.3 million in kind. These commitments indicate a clear understanding of the added value achieved by pooling of resources and strong willingness to align national investments for transnational research and innovation.

***Criterion c:** the added value of the action at Union level*

The proposed programme will focus its effort on those issues where European Union objectives can only be successfully achieved by an approach at a regional sea scale. In this way the programme will effectively supplement the efforts at pan-European and national scales. The programme addresses all relevant EU strategies and policies.

***Criterion d:** the critical mass, with regard to the size and the number of programmes involved, the similarity or complementarity of activities and the share of relevant research they cover*

The proposed programme will involve the key national research and innovation funders, a research community of up to 10 000 active scientists and innovative industries covering all aspects of marine and maritime development.

***Criterion e:** the appropriateness of Article 185 TFEU for achieving the objectives*

The proposed programme envisages achieving an ambitious level of scientific, financial and management integration. It will (a) handle systematic calls for transnational research and innovation proposals in accordance with a commonly adopted strategic agenda and rules, (b) manage the resulting transnational projects through a coherent financial and professional framework. This level of integration is only achievable by involving a dedicated implementation structure mandated to handle the pooled national and EU funds.

* *Article 26, Regulation (EU) No. 1291/2013 of the European Parliament and of the Council of 11 December 2013 establishing Horizon 2020 – the Framework Programme for Research and Innovation (2014-2020)*

transport; Climate action, resource efficiency and raw materials; Health, demographic change and wellbeing.

The goal of industrial leadership is addressed by the programme's focus on innovation through coupling research, innovation and policy development and removing barriers to innovation.

The policy-driven nature of the programme accommodates scientific and technological support to various EU policies, such as the Integrated Maritime Policy, the Common Fisheries Policy and the Common Agricultural Policy. Similarly, relevant EU directives, such as the Marine Strategy Framework Directive and the Directive on Maritime Spatial Planning will be in focus of the proposed programme in cooperation with the regional seas conventions HELCOM and OSPAR.

The programme will focus its effort on those issues where European Union objectives can only be successfully achieved by an approach at a regional sea scale, e.g. to (a) resolve structure, functioning and linkages of ecosystems and to distinguish between the effects of natural and anthropogenic drivers upon them, (b) achieve good environmental status by coordination of national and international efforts in monitoring, assessment and management, (c) optimise sustainable exploitation of ecosystem services by considering activities of all relevant actors and (d) achieve optimum innovation potential by cross disciplinary collaboration and across the region. In this way the programme will effectively supplement the efforts at pan-European and national scales.

Contributions will be made to global policies, programmes and institutions, such as the Convention on Biological Biodiversity (CBD), the International Maritime Organisation (IMO), the United Nations Environment Programme (UNEP) and the World Climate Research Programme (WCRP).

Finally, based on a jointly agreed stakeholder communication strategy and plans, the programme aims to ensure high visibility in regional, European and international fora. It will seek and seize opportunities to enhance knowledge and its use across policy and socio-economic landscape by transferring aims, progress and results to all key stakeholder groups for their action and use. Support will be provided to the EU and national funding institutions' communications efforts on different levels for various audiences, inclusive the public at large.

Implementation

The proposed programme is designed on the basis of BONUS, the joint Baltic Sea research and development programme (2011-2017), and will be implemented utilising the rich experience accumulated by this preceding programme. This experience has shown that the necessary high level of administrative integration (e.g. handling systematic calls for transnational research and innovation proposals in accordance with a common agenda and rules and coherent financial and scientific managing of the resulting projects) can only be achieved by involving a dedicated implementation structure (DIS). Finances will be pooled and invested based on common rules, for achieving the programme's objectives through the DIS reflecting the participating countries commitment to integration not only at scientific and financial but also at management level.

The strategic research and innovation agenda (SRIA) of the proposed programme will be developed based on the preliminary analysis of challenges and potential identified in part B of this document, through intensive stakeholder consultations in 2016-2017 and thereafter through an iterative process of regular updates (1–2 times during the implementation period). Through profound and wide-reaching engagement of the key stakeholders and end-users, the process is planned to substantially broaden the community involved in defining the research and innovation agenda and realising the maximum benefit from the implementation outcomes.

The main implementation instruments of the programme are transnational collaborative research and innovation projects. Specific innovation projects led by enterprises are encouraged and supported, and a new model of joint actions will be developed, involving different parts of the innovation chain, from creating new knowledge for solving specific challenges towards commercializing the potential solutions via proof of concept, leading to commercial endeavors and feedback into the experimental phase.

Furthermore, based on the BONUS model, the proposed programme will support wide programme-level cooperation actions such as workshops, conferences, training courses, synthesis work as well as dissemination and specific stakeholder events. A particular emphasis is put also into the training and other activities for young scientists, the leaders of tomorrow. Key communications and dissemination tools and means such as strong online and social media presence, publications, promotional materials and partner collaboration are used to full potential in efforts supporting the realisation of the new programme's ambitious aims.

Part A:

Objectives and implementation

Challenges

The commitment to deliver smart, sustainable and inclusive blue growth poses several fundamental challenges:

- **Fragmentation delays and increases costs of development.** Current marine and maritime research and innovation activities by member states are too fragmented to enable effective implementation of major directives, e.g. the Marine Strategy Framework Directive, policies, e.g. the Common Fisheries Policy and strategies, e.g. the EU blue growth strategy. Achieving a joint European marine and maritime research and innovation area is a prerequisite for environmentally, economically and socially sustainable blue growth on national and regional levels. Due to the structuring effect of BONUS (predecessor of this initiative) and the EU Strategy for the Baltic Sea Region, a large part of marine and increasingly also maritime research and innovation funding in the Baltic Sea region is channeled through transnational programmes, while the North Sea related research and innovation activities are still predominantly nationally-driven, with various ministries being responsible for different and partly competing sectors.
- **Gaps in interdisciplinary knowledge prevent sustainable solutions.** Closing the scientific and technological knowledge gaps within and among different services provided by marine ecosystems calls for a truly interdisciplinary approach. Holistic assessments of development scenarios and risks to the maritime sectors and to ecosystems, and transferring this knowledge into fit-for-purpose policies, regulations and design of effective management tools are required. There is an urgent need to create a knowledge basis, innovative solutions and tools for blue growth without compromising the quality of the marine environment and the capacity of the marine ecosystems to offer increasing quantity of high quality goods and services.
- **Lack of identified synergies and trade-offs among blue economy sectors hampers development of best strategies and smart specialisation.** Knowledge about potential synergies and trade-offs among and between maritime activities remains insufficient to devise optimal future exploitation and management strategies and to underpin prudent specialisation among the littoral states. Optimisation of emerging marine and maritime activities, such as renewable energy, aquaculture, biotechnology, tourism and recreation, underwater mining on one hand, and traditional sectors like maritime transport, fisheries, and off-shore oil and gas extraction on the other, is not possible in the absence of comprehensive and truly interdisciplinary analyses which considers all maritime activities and their environmental, economic and social impacts.
- **Insufficient knowledge exchange.** The role of communications and knowledge transfer has become crucially important for knowledge-based policy making. In order to enable every citizen to make informed everyday decisions, including those which eventually drive markets and policies, sound contemporary knowledge must be embraced by broad society. In spite of best efforts, optimal models for exchange of two-way knowledge transfer between academia and industry and within the triangle of academia, industry and policy to enable sustainable blue growth still remain to be found.
- **Human health and wellbeing aspects of blue growth are not considered.** Human health and wellbeing is intrinsically connected to and impacted by the seas. Extreme weather events such as storms and flooding as well as human exposure to marine-borne pathogens and chemical pollution, pose significant threats to human health. At the same time, the seas provide numerous benefits. Understanding and creating human wellbeing from this complexity can only be achieved with an interdisciplinary approach, drawing on expertise across a diverse range of disciplines within natural, social and economic sciences, public health and medicine.

Objectives

■ The ultimate goal of the proposed joint Baltic Sea and North Sea research and innovation programme is to elevate the Northern European regions' research and innovation capacity to a level necessary to achieve a decisive boost in the development of an innovative and sustainable marine and maritime economy. By integrating research and innovation activities into a durable, cooperative, interdisciplinary and focused multinational programme at the scale of regional seas, this joint initiative of several EU member states will effectively contribute to blue growth by focusing on those issues where a collaborative sea-basin approach can bring better, faster and more cost-effective results compared to either the EU and national-level approaches. In particular, the programme will address the challenges associated with sustainably utilising marine ecosystem services, and achieving and maintaining good environmental status of the seas. To this end, the proposed programme will involve all levels of the innovation chain starting from basic research, towards development and demonstration, and employ inclusive and scrupulous stakeholder communication at all stages of the programme development.

The strategic objectives of the programme vital for both the Baltic Sea and the North Sea macro-regional development and in the same time relevant to the objectives of Horizon 2020 and broader Union policy objectives will be:

- **Overcoming fragmentation in research and innovation:** to structure the Baltic Sea and the North Sea EU member states' marine and maritime research and innovation effort in order to enable concerted and efficient responses to the basin-wide challenges across national borders and sectors.
- **Supporting ecosystem based management**: to promote interdisciplinary research and innovation that enables ecosystem-based management of human activities along the land-coast-sea continuum, protects sustainability of different ecosystem services of the Baltic and North Seas and supports the goals of achieving and maintaining good environmental status in these seas and their catchment areas; and to improve the observation, assessment and forecasting capacity of both the natural and societal systems under global change.
- **Fostering sustainability of blue growth:** to deliver new knowledge base for appraising the socio-economic value of different ecosystem services of the Baltic and North Sea areas and to provide innovative tools for comprehensive planning and management of maritime activities and mitigating the trade-offs among different uses; this will serve as an input to integrated coastal management and maritime spatial planning and as a contribution to the EU 2020 strategy towards smart, sustainable and inclusive growth and its implementation in the EU Strategy for the Baltic Sea Region as well the European Commission's Investment Plan for Europe.
- **Transferring knowledge to practice**: to achieve the level of knowledge transfer and collaboration necessary for (a) devising fit-for-purpose regulations, policies, management tools, practices, and incentives and (b) stimulating the development and implementation of innovative technologies of maritime industries that in turn enable sustainable blue growth and enhance human wellbeing without jeopardising good environmental status.
- **Supporting human wellbeing**: to deliver new knowledge base for supporting social sustainability of blue growth and human wellbeing in both genders, including health aspects and fair distribution and inclusive access to the benefits of blue growth among citizens of different regions and states, representatives of different groups of society and people of different occupation.

The regional scope

The Baltic Sea and the North Sea are exceptionally well suited for a joint research and innovation programme (Box 1): they are located in the same latitudes and thus face similar challenges associated with climate and sea level change. Both seas are influenced by runoff from large, densely populated and heavily exploited catchment areas, resulting in excessive loading with nutrients, contaminants and marine litter.

The Baltic and the North Seas are interconnected, forced by the same weather patterns and water exchange with the North Atlantic, and represent extended gradients in physical, chemical, and biological properties of the natural environment. Gradients also exist in the nature, land-use and economic development of catchments, in environmental status, and in regulatory and management frameworks. Importantly, both sea areas exhibit rather homogeneous cultures of and visions for exploiting marine resources and conducting maritime activities, which allows for the countries to benefit from each other´s experience in sustainable management and conservation of marine resources.

BOX 1: EXAMPLES OF THE BENEFITS ARISING FROM A 'TWIN SEAS' APPROACH OF THE PROPOSED PROGRAMME[2]

- The differences and similarities of possible future scenarios between the Baltic Sea and the North Sea, in terms of economic and social actors involved, offer an excellent case for further valuation of ecosystem services and examination of different aspects of ecosystem approach to management. Many human uses are similar between the two systems: there is exceptionally dense and growing sea traffic, intensive fisheries, emerging off-shore renewable energy and developing coastal and maritime tourism and recreation. Some economic activities like offshore oil and gas extraction are specific only for one of the two seas. The diversity of economic development and political organisation among the coastal states and the applied environmental governance systems form a rich knowledge base for further scenario studies and for refinement and development in policy, e.g. joint macro-regional strategy.
- There is an enormous potential of exchanging the best practice in maritime spatial planning in the North Sea and the Baltic Sea: while some of the North Sea states have advanced well with the national-level maritime spatial planning, the Baltic Sea represents an unprecedented example of cross-border cooperation covering the whole sea basin.
- Surrounded by densely populated industrial states, both the Baltic Sea and the North Sea are threatened by various human pressures, although often expressed at different degree, e.g. pollution by hazardous substances, eutrophication and overfishing. Mitigation of these pressures requires similar innovative solutions best delivered in a concerted research and innovation action by all littoral states.
- The Baltic and the North Seas are two neighbouring sea basins where, according to the EU Marine Strategy Framework Directive, good environmental status must be achieved by 2020. In both seas, the basin-wide effort towards good environmental status is strongly coordinated by the regional seas' commissions: HELCOM and OSPARCOM, respectively. The actions by these international bodies are critically dependent on scientific input, making them natural core stakeholders of the proposed research and innovation programme.
- Both the Baltic Sea and the North Sea occupy the same climatic zone with relatively similar projected impacts of climate change. The sea level rise and increase of storminess will require similar measures to protect lowland coasts and infrastructures, warming will affect fish distribution in both seas and changes of precipitation and seasonality will alternate the pattern of river runoff and discharge of contaminants into the seas.
- The mutually interconnected Baltic Sea and North Sea represent a unique test case for studying structure and functioning of marine ecosystem within a broadest gradient of environmental conditions: from an open oceanic system towards a semi-enclosed brackish water system, and from temperate to almost Arctic climate conditions.
- Marine and maritime research depends on complicated and expensive infrastructures. The proposing states operate significant assets in research ships, sophisticated test facilities and unmanned observation, surveillance and other research infrastructures, now predominantly exploited in isolation. The proposed programme will significantly intensify common cross-border use and further development of marine and maritime research infrastructures.

[2] See detailed analysis of similarities and contrasts between the Baltic Sea and the North Sea in part B of the outline document.

Thematic coverage

■ Through advancing marine and maritime research and innovation in the Baltic Sea and the North Sea macro-regions, the proposed programme will contribute to meeting several of the seven key societal challenges highlighted in Horizon 2020 for research and innovation. A particular focus will be on challenges related to food security, sustainable agriculture and bioeconomy, climate action and environment, human health and wellbeing, secure, clean and efficient energy, and smart green and integrated transport.

The programme is based upon recognition of a crucial linkage between the ecosystem state, structure and functioning, the goods and services provided by the northern European regional seas and human lifestyles and wellbeing. This notion will underpin the analysis of the critical trade-offs between utilisation and conservation of ecosystem services. It will also be the premise for analysing the ability of alternative policy instruments and new governance structures for responding to the current and future sustainability challenges.

Recognising that the capacity of the seas to support human wellbeing is in many ways linked with the surrounding land, the proposed programme will stimulate the establishment of seamless governance links between the seas, their coasts and catchment areas. Maritime spatial planning and integrated coastal management are critical enablers of sustainable blue growth and therefore will be in focus of the programme.

The proposed programme will be built taking into account the Earth system science perspective; its specific research and innovation objectives will address the set of grand challenges of global Earth system science[3]: (a) improve forecast capabilities for regional environmental changes, (b) enhance and integrate observational systems, databases, and dissemination structures needed to manage those changes, (c) determine how to best anticipate, recognise, avoid and manage disruptive global environmental change, (d) research what institutional, economic and behavioural reforms are necessary, (e) drive innovation in developing technological, policy and social responses towards sustainability.

Outcomes of research and innovation within different disciplines and their contribution of knowledge and tools towards the general objectives are exemplified in Table 1. Reaching any of these objectives requires an interdisciplinary approach. Moreover, the outcomes under each discipline are expected to serve as sources of information and ideas for research and innovation to be done within other disciplines.

[3] ICSU (2010). Earth System Science for Global Sustainability: The Grand Challenges. International Council for Science, Paris. ISBN: 978-0-930357-73-3

Table 1. Contribution of different research disciplines to the general objectives of the Baltic Sea and North Sea research and innovation programme.

Disciplines / General objectives	Natural sciences	Socio-economic and political sciences	Technological sciences	Cross-cutting innovation outcome
Supporting ecosystem based management	Functioning of and links between the marine ecosystems and drainage basins as well as impacts of stressors are understood. Status and changes are reliably monitored and assessed and future changes are forecasted accurately.	Links of the ecosystem services to human lifestyles and wellbeing are understood and valuated. Societal phenomena can be monitored and societal goals determined.	New sensors, observation tools and data handling technologies are provided.	Scientific, technological and social inventions are transferred into practical solutions, such as maritime spatial planning and integrated management.
Fostering sustainability of the blue growth	Relationships between ecosystem properties and ecosystem services are understood. Understanding of temporal and spatial changes in physical, geographical, chemical and biological nature enables targeted mitigation actions.	Socio-economic values are known based on reliable assessments. New tools (e.g. fit-for-purpose regulations and economic incentives) for ecosystem based management and transnational planning are provided.	New clean tech solutions and information, communication and decision support technologies are provided.	Practical solutions for reduction of pressures, new environmentally friendly exploitation and marketable products/ solutions.
Transferring knowledge to practice	Information on natural ecosystems and impact of human activities is synthesised and communicated in a way that fills knowledge gaps in system understanding and predictive capability.	Information on socio-economic systems is synthesised and communicated in a way that fills the knowledge gaps in policy development. New methods for knowledge transfer and organisation of governance and institutional roles are provided.	New technologies for collaboration and knowledge transfer between scientists, industry, policy developers, management authorities, and other stakeholders are provided.	Reality-tested scientific, technological and social inventions reshape stakeholder activities and are transferred into practical solutions and marketable products through cooperation.
Supporting human wellbeing	Impact of ecosystems' state on human health is understood and consequences in change in ecosystem state on human health can be predicted.	Relationships and development of culture, behaviour and values systems in relation to seas are understood. New methods for inclusive and efficient communication of knowledge are provided.	New technical tools for studying of human health, behaviour, and culture in relation to seas are provided. Enhanced tools for communication of this knowledge are established.	Scientific, technological and social inventions are transferred into practical management solutions, industry decisions and marketable products.

Added value of the action at the European Union level

■ The proposed programme will play an important role in Europe's efforts to design and promote diverse and often conflicting sectors of blue economy and align them with societal goals including good environmental status of our seas. To ensure that expansion of the blue economy truly increases welfare, it must go along with the fundamental principles formulated in the Europe 2020 strategy: growth must be smart, sustainable and inclusive; *smart* with respect to integration of cutting edge science-based, innovative solutions and industrial leadership, *sustainable* in economic, social and ecological terms tackling societal challenges and *inclusive* considering the multitude of coastal, marine and maritime activities and trade-offs between them. Historically, many maritime activities have had detrimental impacts on marine ecosystem structure and functioning; the new blue growth strategy requires mitigation of impacts and restoration of ecosystem resilience, to conserve and increase their ability to provide goods and services also to future generations.

Already today, taken together, the blue economies of the Baltic Sea and the North Sea account for around EUR 50 billion annual turnover, sustain at least 1.5 million[4] work places and possess significant capacity to expand further. This enormous body of economy is directly and critically dependent on quality and extent of the ecosystem services provided by the two regional seas and their coasts. The northern seas of Europe are in many ways at the forefront of a global surge to develop marine and maritime potentials, and it is here where new technologies, new methods of cross sector management and new approaches to transnational governance are often tested.

The programme will foster joint programming within the EU as well as with the international actors involved in the relevant research and innovation arena of regional seas, including funders, academia, industries and public governance institutions. It will also support EU macro-regional and sea-basin strategies and contribute to building the EU marine and maritime research and innovation area. The programme will improve Europe's competitiveness and strengthen nascent or existing structures of supra-national research and innovation in the marine and maritime realms. Specifically, the programme will:

- create knowledge bases for defining maritime economic and marine environmental targets in the Baltic Sea and the North Sea regions
- make the transfer of new knowledge and technology to marine/maritime related policies and regulations as well as maritime industries more efficient and foster harmonisation of mitigation actions through intensive dialogue, collaboration and mutual learning
- strenghten the competitiveness of Europe´s marine and maritime science sectors by further integrating the science communities of two neighbouring European regional seas in order to optimise research structures, improve coherence and exchange, develop common visions, and establish a culture of mutual learning and understanding.

The programme will complement within its geographic and thematic scope some of the key strategic objectives of the Joint Programming Initiative (JPI) 'Healthy and Productive Seas and Oceans', including alignment of the research agendas of both initiatives, among others, through a joint working group already established. This working group will be responsible for aligning the strategic research and innovation agendas of both programmes and developing concrete mechanisms of coordinating their implementation plans, also considering other relevant Joint Programming Initiatives, such as the JPI on Agriculture, Food security and Climate Change and the JPI Water challenges for a changing world.

Activities will also be coordinated with other thematic science programming initiatives, such as other regional initiatives of different formats e.g. PRIMA (partnership for research and innovation in the Mediterranean area) and BLUEMED (initiative for blue growth and jobs in the Mediterranean), the relevant ERA-NETs, as well as technological development fora, such as European Technology Platforms. The proposed programme will seek ways to coordinate and enable synergies and complementarities with

[4] See chapter *Human uses of ecosystem services* for more information.

BOX 2: EXAMPLES OF ADDED VALUE OF THE PROPOSED PROGRAMME TO SEVERAL EU AND GLOBAL LEVEL POLICIES AND PROGRAMMES

EU Marine Strategy Framework Directive: The proposed programme will coincide with the end of the first implementation cycle and beginning of the second cycle. It will deliver information necessary for the member states to assess the outcome of the first cycle as well as review and refine the indicators and targets of good environmental status, renew monitoring and strengthen programmes of measures for the second cycle. In this way the programme will also support objectives and action programmes of the regional seas' conventions – **HELCOM** and **OSPARCOM**.

EU Common Fisheries Policy: The proposed programme will deliver new knowledge and tools for the implementation of the ecosystem approach and the precautionary approach to fisheries management. It will generate new multi-species and multi-fisheries assessment methods and will contribute to the implementation of the maximum sustainable yield concept. The revised Common Fisheries Policy is to be implemented at regional level in an environmentally, economically and socially sustainable manner, requiring a regional approach to technology development and management as outlined by the present programme.

EU Maritime Spatial Planning Directive: The proposed programme will deliver both the background information and new tools for maritime spatial planning. A particular attention will be paid to the issues of cross-border maritime planning both in coastal and offshore regions.

UN Convention on biological diversity: One of the objectives within the CBD (11th Aichi target) requires that by 2020, at least 17 % of terrestrial and inland water areas and 10 % of coastal and marine areas are to be conserved through effectively and equitably managed, ecologically representative, and well-connected systems of protected areas and by other effective area-based conservation measures. The proposed programme will support meeting of this requirement by delivering new spatial data and marine biodiversity mapping and spatial modelling tools as well by testing the effect and optimising the spatial marine biodiversity conservation measures. In this way it will also support the EU biodiversity strategy to 2020.

EU Common Agricultural Policy: Implementation of the renewed agricultural policy, notably, within the broader context of emerging bioeconomy will require adopting new technologies, developing new products, changing production processes, and supporting new patterns of demand. Recognising the crucial role of agriculture as a source of various pollutants into waters and ultimately into seas and taking into account the projected climate change and socioeconomic scenarios, the proposed programme will deliver new knowledge and know-how for emergence of a truly sustainable agriculture policy. In particular it will suggest science-based new governance approaches and management methods allowing to combine economically viable agriculture and minimised environmental impact.

European Structural and Investment Funds (ESIF)[5], e.g. the European Maritime and Fisheries Fund (EMFF) and the INTERREG programme financed by the European Regional Development Fund.

Scientific and technological support will be provided to various EU policies, such as the Integrated Maritime Policy, the Common Fisheries Policy and the Common Agricultural Policy and similarly to relevant EU directives, such as the Marine Strategy Framework Directive and the Directive on Maritime Spatial Planning (Box 2). The proposed programme will help to guide and harmonise (a) the implementation of these policies and directives on member state and regional levels including coastal zone management, (b) linking oceans to human health and wellbeing, (c) defining good environmental status and monitoring maritime activities, (d) enhancing modelling and predicting capacity both with respect to human and natural impact on marine states, e.g. climate change, and (e) providing innovation for food security and safety.

By addressing these, the proposed programme will also deliver to several other global policies and programmes under the International Maritime Organisation (IMO), the United Nations Environment Programme (UNEP) and the World Climate Research Programme (WCRP).

[5] ESIF refers to: ERDF – European Regional Development Fund, Cohesion Fund, ESF - European Social Fund, EAFRD - European Agricultural Fund for Rural Development and EMFF – European Maritime and Fisheries Fund.

Relevance to the objectives of Horizon 2020

■ The European Union 2020 strategy expresses high expectations as regards marine ecosystems capability to provide goods and services for the European citizens. Blue growth is a cross-cutting issue in the EU Framework Programme for Research and Innovation Horizon 2020. The proposed programme is helping to achieve the Horizon 2020 objectives for smart, sustainable and inclusive blue growth and jobs based on the coupling of excellent science and innovation, enhancing cooperation between public and private sectors, stimulating industrial leadership and long-term macro-regional coordination (Box 3).

The Baltic Sea and the North Sea with their coasts and coastal regions make up a substantial part of Europe and are among the most productive regions in terms of fisheries, marine energy and shipping in Europe. The northern location differentiates the natural dynamics of these seas from the southern European seas, while these northern seas share commonalities with one another as regards pressures from human activities and their management as well as environmental protection objectives implemented through the regional commissions.

By being crosscutting in nature, the proposed joint Baltic Sea and the North Sea programme meets several key societal challenges of Horizon 2020: firstly *Food security, sustainable agriculture and forestry, marine, maritime and inland water research and the bioeconomy*; but also *Secure, clean and efficient energy; Smart, green and integrated transport; Climate action, resource efficiency and raw materials* and *Health, demographic change and wellbeing.*

The goal of industrial leadership as stipulated in Horizon 2020, namely *Leadership in enabling and industrial technologies*, *Innovation in small and medium-sized enterprises* is addressed by programme's calls for innovation. Linkages to relevant knowledge and innovation communities (KICs) and European technology platforms (ETPs) will be established.

Also, cross-disciplinarity in addressing the marine and maritime issues in the macroregions surrounding the Baltic Sea and the North Sea as a whole will provide a unique contribution to the Horizon 2020 framework. Focusing on marine and maritime activities, identified to have high potential for sustainable competiveness, innovation and growth, the new programme addresses several key drivers of growth identified in Horizon 2020, such as (a) developing new knowledge and skills, which underpin excellent research and innovation, (b) engagement of industry, including SMEs, (c) addressing the research and innovation divide and (d) supporting strong partnership with member states.

By applying Horizon 2020 principles in evaluation, and supporting the common use and development of research infrastructures, the programme also addresses the goals of excellence in science, collaboration and optimal use of infrastructure.

BOX 3: EXAMPLES OF RESPONSES OF THE PROPOSED PROGRAMME TO SOCIETAL CHALLENGES HIGHLIGHTED IN HORIZON 2020

1) Health, demographic change and wellbeing: The programme will address ecosystem services that are critical determinants of human health and wellbeing, including such as regulating detoxification of hazardous substances, provisioning healthy food, cultural and amenity recreation, tourism and aesthetic experience.

2) Food security, sustainable agriculture and forestry, marine and maritime and inland water research and bioeconomy: Marine and maritime research will be in the core of the programme. It will apply an Earth system approach to link the Baltic and the North Seas' ecosystems with their coasts and catchments. It will generate new knowledge and innovation in support of sustainable and competitive bio-based industries including minimising plant nutrient leakages from agriculture.

3) Secure, clean and efficient energy: The strategic research and innovation agenda of the programme will incorporate long-term sustainability and minimise environmental impact of the offshore energy activities in the Baltic and the North Seas. It will test approaches towards combined use of the sea space, for e.g. wind farms and mariculture and biodiversity protection zones.

4) Smart, green and integrated transport: The programme will generate new knowledge and innovation necessary for conversion to environmentally friendly maritime transportation in European waters. It will maintain strong focus on improving maritime safety by e.g. developing e-navigation tools for cruising and port maneuvers, human factor in maritime safety as well as the ice navigation safety.

5) Climate action, environment, resource efficiency and raw materials: The programme will stimulate refining of the regional climate models and improve understanding of effects of climate change on biological productivity. It will focus on the less understood aspects of co-action of climate change with other pressures on the ecosystem. Its interdisciplinary approach will allow developing principally more reliable scenarios of future sustainable land management, taking into account the effects of climate and socioeconomic changes on coastal ecosystem functions and services.

Efficiency of Article 185 TFEU as the most appropriate means

The Treaty of Functioning of the European Union Article 185 initiative offers a powerful tool for research governance in support of achieving sustainability of the regional seas, their coasts and adjacent catchments. It is the highest level of integration of research coordination in the EU context. This enables to address complex areas, which require close interdisciplinary cooperation across member states, such as marine and maritime research. Without any doubt, ecosystem-based marine management will only be effective if developed and implemented in a coordinated manner, including all involved countries. In this sense the proposed programme clearly represents the critical mass of the involved states.

Achieving the European Union's policy objectives regarding vigorous development of sustainable blue economy in Northern Europe's sea basins requires a massive and enduring structuring effect on different levels of research and innovation: (a) a regional focus (joint developing and implementation of an agreed sea-basin research and innovation agenda by all littoral states of the respective sea), (b) alignment between regional seas (in this case the Baltic and the North Sea) and (c) bridging between marine research and innovation underpinning maritime activities. This ambitious goal can be best, if not only, achieved by a TFEU Article 185 activity initiated by highly committed member states and supported by the European Union.

Actions at national level, even by the economically strongest member states, do not reach the needed critical mass in terms of financing, manpower and mobilised infrastructure. Moreover, such national programmes do not ensure the optimal exploitation of the research and innovation results by all sea-basin states and lack the coordinating effect with respect to common implementation of policies and directives.

In turn, the proposed programme is expected to have a strong structuring effect on national level. As evidenced by the preceding BONUS programme, previously isolated research and innovation effort by several research and innovation funders supporting interests of different sectors becomes much more impactful when structured under a durable joint programme.

Various ERA-NET actions, including ERA-NET Plus and COFUND, have proved to be efficient kick-starter of collaboration among the national research and innovation funding institutions in many mutually important areas. They do not, however, guarantee collaboration between all relevant actors in a region, and an enduring structuring effect; that can only be achieved by a state government-level commitment to jointly implement a multi-year, transnational programme addressing all relevant challenges in a highly integrated and interdisciplinary fashion.

Joint programming initiatives based on the variable geometry principle are an effective tool to provide an overarching network for strategic alignment and ensuring synergies between national activities. They can invigorate research and innovation progress in targeted areas prioritised by few or several member states, but cannot guarantee a concerted research and innovation pursuit in areas where involvement of all relevant member states is necessary, e.g. meeting the sea-basin challenges. Neither there is a guarantee that a joint programming initiative, being a largely member state-driven action, will respond efficiently to the European Union policy priorities, nor provide a region-wide network or regionally coordinated actions required for integrated policy development and sea basin management as will be achieved by an Article 185 activity.

The experience of BONUS witnesses the importance of a strategic approach in building a targeted transnational research and innovation programme (Box 4). Such strategic approach requires adequate continuity and endurance of the programme over several years of implementation, which can be best achieved through an activity pursuant TFEU Article 185. Moreover, (a) mobilising the involved national research and innovation funders, (b) creation of the necessary level of scientific cooperation among the participating states, (c) developing the necessary levels of financial and management integration and, very importantly, (d) establishing the necessary level of visibility and respect within the stakeholder community critically depends on an enduring effort that can only be provided by an activity pursuant TFEU Article 185.

The leverage effect in terms of the critical mass is ensured by high level of commitment to integration at scientific, management and financial levels by the participating countries, i.e. the coastal states surrounding the Baltic Sea and the North Sea and their catchments (Belgium, Denmark, Estonia, Finland, France, Germany, Latvia, Lithuania, The Netherlands, Poland, and Sweden). Commitment is under negotiation with the United Kingdom. Research funding and implementing institutions of Norway are invited to collaborate and join the initiative at a later stage. Republic of Ireland has expressed interest to become observer of the proposed programme. Russian funders are participating in the calls of the current BONUS programme on *ad hoc* basis. A similar mechanism for cooperation with Russian research and innovation funders will be applied in the proposed programme.

The calls and projects implemented during 2007-2014 within BONUS demonstrate that the science and technology communities applying funding from the Baltic Sea related calls comprise up to 900 entities, each involving on average 2-4 researchers. Similar data based on already implemented joint calls is not available from the North Sea region. However, on estimate by the national funding institutions, the total involvement of research and innovation community will roughly amount to approximately 10 thousand active scientists. Generation of such volume of involvement is important in order to reach to goals of the proposed programme.

Finally, but not the least, the proposed initiative envisages achieving an ambitious level of scientific, management and financial integration. It will handle systematic calls for transnational research and innovation proposals in accordance with commonly adopted strategic agenda and rules and manage the resulting transnational projects through a coherent financial and scientific framework. This level of integration is only achievable by involving a dedicated implementation structure (DIS) mandated to handle the pooled national and community funds.

The experience gained during BONUS, the Article 185 Joint Baltic Sea research and development programme, demonstrates a strong defragmentation and structuring effect generated by a TFEU Article 185 instrument (Box 5).

BOX 4: ACHIEVEMENTS OF BONUS

- Through a successive evolution from an ERA-NET to an ERA-NET+ project, and then to an Article 185 programme, BONUS has built a unique, macroregional collaboration of research and innovation funding institutions that supports sustainable development of the Baltic Sea ecosystem services through research and innovation. BONUS is considered an EU-wide pioneer in creating a macroregional governance framework for research and innovation. BONUS contributes significantly to the increase of scientific excellence, level of interdisciplinarity and joint use of research infrastructures. Due to its very targeted focus, BONUS also contributes directly to the improvement of the Baltic Sea environment, to policy development and to the sustainable development of the region.
- Major progress has taken place as regards scientific, management and financial integration since the initiation of BONUS as an ERA-NET in 2003, when Baltic Sea research was based on national, un-coordinated, partly thematic, partly non-thematic calls. Today all participating states have suspended their national Baltic Sea programmes and all programmatic funding for Baltic Sea research is funnelled through BONUS.
- BONUS is an important contributor of new scientific knowledge which is critical for successful implementation of the EU Strategy for the Baltic Sea Region, EU Marine Strategy Framework Directive in the Baltic Sea marine region, the EU Directive on Maritime Spatial Planning, and the HELCOM Baltic Sea Action Plan – this is evidenced by statistics of already implemented BONUS projects' contributions to policy developments and the programme summary published in AMBIO early 2014.
- BONUS has its origin within funding co-operation between basic science oriented funders. During its operation BONUS has, however, attracted innovation funders, broadened its funding base and included innovation component into its strategic research agenda. Thus BONUS has become a pioneering funding structure in support of blue growth and sustainable development of the Baltic Sea region.
- BONUS has implemented already three calls, BONUS+ call 2007 within the ERA-NET+, and calls 2012 and 2014 within Article 185. At present, 15 research projects and 13 innovation projects have been selected and implemented with total funding of EUR 49.3 million. Based on the evaluations of the calls 2012 and 2014 by independent observer the call management was 'highly positive'. The third call with funding at least EUR 30 million was opened on 9 November 2015.
- BONUS has improved the quality of science and increased international research collaboration. Comparison based on a bibliometric study of international publication of Baltic Sea science 2002-2006 and the scientific articles published by the BONUS+ during 2008 – 2015 (BONUS Publication No. 9 2008) reveals that the median impact factor of the all publications increased with almost 2 units and the average percentage of publications by multinational groups changed from 32 % to 53 %.
- BONUS has established broad stakeholder consultation platforms while developing its strategic research agenda. It collaborates closely and systematically with the most important regional conventions and organisations such as HELCOM, VASAB, CBSS and ICES.
- In terms of the financial integration, BONUS has created a unique procedure of co-financing its actions through real money funding by the participating countries and the EU.
- For the management of a complex financial structure involving multitude of different funders BONUS has built an efficiently functioning dedicated implementing structure (the BONUS EEIG) which is governed by the participating countries and operated by the BONUS Secretariat. After a rigorous assessment by the European Commission (EC), the BONUS EEIG has signed a delegation agreement with the EC in order to receive and distribute the Union contribution to the BONUS-185 programme.
- By establishing bilateral agreements with Russian funding institutions allowing participation of Russian scientists in BONUS projects, BONUS has created a bridge between and for the European and Russian scientific communities.

BOX 5: SELECTED QUOTATIONS FROM THE INTERIM ASSESSMENT OF BONUS IN 2014

…it is clear to the Panel that the potential outputs and outcomes that can be achieved through the strategic approach developed under Article 185 of the Treaty of the Functioning of the EU will lead to significant advances in knowledge of importance and direct application to end-users.

…

the support of the EU in the BONUS programme has helped to engage the effective participation of non-EU Member States that will help address the development challenges for the Baltic Sea as a whole.

…

The transnational collaboration facilitated by BONUS has also supported enhancement of the research capacity of smaller, less research intensive Baltic Sea States and enabled them to make very positive and valuable contributions to ensure the knowledge necessary to address the challenges facing the Baltic Sea.

…

…the robust strategic framework of BONUS and the collaboration achieved between Member States is a valuable model that could be applied to other European sea areas.

…

Overall, the Evaluation Panel is very impressed by BONUS's achievements founded upon the development of transnational and trans-disciplinary cooperation, of human and institutional capacities, of information sharing and the trust in the integrity of all actors within the management of successive phases of the programme. The Evaluation Panel is confident that there will be further major advances in policies and management actions to enhance the sustainable use of the Baltic Sea ecosystem resulting from the outcomes of BONUS that would not have been achieved without this integrated approach.

Full document available at:
http://ec.europa.eu/smart-regulation/evaluation/search/download.do?documentId=12453881

Implementation

The implementation of the joint Baltic Sea and North Sea programme builds on the structures and procedures developed in implementing BONUS, the joint Baltic Sea research and development programme, implemented under Article 185 of the TFEU during 2010-2017.

The proposed new programme is expected to become operational in late 2017 and continue for six years, with the first call opening in early 2018 and the last one in 2021. The main implementation methods are presented in Table 2.

Table 2. Strategic objectives and means to achieve the objectives.

Strategic objective	Means to achieve the objective
Overcoming fragmentation in research and innovation	developing joint strategic research and innovation agenda (SRIA), pooling of financial resources, opening joint calls, performing joint evaluation process, supporting researcher mobility, establishing joint stakeholder platforms
Supporting ecosystem based management	defining objectives, priorities and research & innovation themes based on comprehensive policy framework analyses, requiring true interdisciplinarity in proposal preparation
Fostering sustainability of blue growth	supporting specific innovation projects led by enterprises, developing a model of joint actions involving the entire innovation chain from new ideas to market development
Transferring knowledge to practice	involving end-users in SRIA development, proposals, projects, and evaluation of projects' outcomes
Supporting human wellbeing	delivering research and innovation outcomes which enable ecologically, socially and ethically sustainable way of living

Scientific integration

The main programmatic document of the programme – its strategic research and innovation agenda (SRIA) will set and justify the strategic directions and at the same time outline the planned implementation and identify the work programme. Such a coherent, single-document approach allows streamlining the structure of the programme, in particular towards its potential beneficiaries and stakeholders, while making systematic updates based on stakeholder consultations, programme reviews and project outcomes fast and easy.

The programme's SRIA will be based on the initial research and innovation needs identified in part B of this document and intensive stakeholder consultations during 2016-2017 and thereafter updated in an iterative process (1-2 times during the implementation period). The SRIA will underpin the policy- and industry-driven character of the whole programme. A broad and inclusive consultation with the academic communities and enterprises of the participating states and the relevant transnational research and innovation initiatives and frameworks (e.g. ICES, European Marine Board, relevant ERA-NETs, Joint Technology Initiatives and Joint Programming Initiatives) as well as a profound and wide-reaching engagement of key stakeholders and end-users will secure programme's far-reaching ambition and capacity to boost swift progress beyond the current state-of-the-art.

Transnational collaborative research and innovation projects will be the main instrument for implementation of the proposed programme. In its calls for proposals, the programme will prioritise to a high degree the demand for research integrating natural, technological and social sciences and addressing multi-sector marine governance issues.

To facilitate innovation, collaboration between actors along the entire value chain is necessary. Therefore, the proposed programme will implement actions that stimulate this collaboration, e.g. by enabling common tackling of challenges and exploitation of opportunities, thus realising the maximum innovative potential. Innovation projects led by enterprises are specifically encouraged and supported. A new model of joint actions will be developed, involving different parts of the innovation chain. The aim of the model is to create new knowledge and solve specific challenges towards commercializing of the potential solutions via proof of concept, leading to commercial endeavors and feedback into the experimental phase.

The general structure of the joint Baltic Sea and the North Sea programme will follow a nested approach incorporating the objectives and themes of global importance as well as more specific themes addressing particular challenges to be met either in the Baltic Sea

or the North Sea region. Broad and inclusive stakeholder consultation during development of the SRIA will secure the optimal balance between the policy-driven, industry-driven, and bottom-up science driven strands of the programme.

Management integration

The ambitious goals of scientific, management and financial integration will only be possible to reach if a dedicated implementation structure (DIS) is established. The legal form of the DIS will be decided jointly by the participating states.

BONUS EEIG (European Economic Interest Grouping), established in 2007 by eight EU member states (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden) for the management of the BONUS programme (2011-2017) and developed for the purpose of implementing the programme under Article 185, is used as the coordinating body for the necessary preparatory work. However, an optimal legal form of DIS for implementing the proposed programme is under consideration by the participating states, and may, or may not, resolve to another implementation form than the one used in the current BONUS programme (2011-2017).

The governance of the DIS will include:

- Steering Committee (or Board/General Assembly depending on the legal form) as the highest authority of the DIS, forming its decision-making body
- Joint Secretariat, headed by an Executive Director, to implement the decisions of the Steering Committee
- Advisory Board to assist the Steering Committee and the Secretariat on strategic issues
- Forum of representatives from ministries and other key stakeholders
- Forum of Project Coordinators to provide a platform for coordination of activities across projects and exchange of best practice in project coordination and communication of achievements

The **Steering Committee** is the highest authority of the DIS, forming its decision-making body and board governing its Secretariat. The Steering Committee is composed of senior officers representing research funding and management institutions appointed by the members of the DIS. It is presided by the Chairperson, a position that is rotated annually among the DIS members. The previous, current and future chairpersons form the Executive Committee that supports the Secretariat in matters of strategic importance. The Steering Committee decides on the strategic orientation of programme, including the decisions on defining and updating the programme, the planning of calls for proposals, the budget profile, the eligibility and selection criteria, the pool of evaluators, the approval of the ranking list of the projects to be funded, the monitoring of progress of the funded projects and the supervision of the adequate and orderly work of the Secretariat in relation to the programme. In principle, all decisions are based on consensus, otherwise each participating state has an equal vote in decisions. The Steering Committee may establish additional internal bodies for the management of e.g. geographically or otherwise limited matters. In order to mutually coordinate activities and share the expertise, the Steering Committee may allow observers from non-participating member states.

The joint **Secretariat** is headed by the Executive Director, who implements the decisions of the Steering Committee and acts as the principal representative of the programme to both the Commission and the various national funding institutions. The composition of the Secretariat staff will ensure sufficient expertise on matters related to both the Baltic Sea and the North Sea. The Secretariat is responsible for the overall coordination and monitoring of activities of the programme, the publication, evaluation and outcome of the calls for proposals, monitoring of the funded projects both from the contractual as well as scientific point of view, for reporting on progress to the Steering Committee and the European Commission and programme level communication and dissemination to ensure high visibility. It is also responsible for the planning and organisation of consultations with stakeholders and the Advisory Board and their subsequent integration and streamlining into the strategic research and innovation agenda and the promotion of effective science-policy interfaces.

The **Advisory Board** assists the Steering Committee and Secretariat. It is composed of scientists of high international standing, representatives of relevant stakeholders, including for example, tourism, renewable energies, fisheries and aquaculture, maritime transport, biotechnology and technology providers and including both industry and civil society organisations with an interest in those sectors, other related integrated programmes and other European regional seas. It provides independent advice, guidance and recommendations regarding scientific and policy-related issues, including advice on the objectives, priorities and direction, ways of strengthening the performance and delivery and the quality of research outputs, capacity building, networking, and the relevance of the work to achieving the objectives of the programme. It also assists in the use and dissemination of the results of the programme.

The **Stakeholder Forum** brings together representatives from ministries, industries and other key

stakeholders dealing with the Baltic Sea and the North Sea blue economy, governance, sustainability as well as research and innovation matters. The Forum convenes in alternating venues to cover the regions of the Baltic Sea and the North Sea. Its aim is to support the programme by discussing its planning, outcomes and emerging research needs from the decision-making perspective.

The **Forum of Project Coordinators** is composed of coordinators of projects funded through the programme. It assists the Secretariat in matters dealing with the scientific coordination and the integration and synthesis of the research results of the programme. The Forum of Project Coordinators serves as a main platform facilitating cross-project collaboration and promoting clustering among projects.

The proposed programme will open joint calls based on the strategic research and innovation agenda (SRIA) with a minimum of eight participating states in common calls covering both the Baltic Sea and the North Sea issues. For launching calls on sea basin-specific topics, participation of the majority of the respective littoral states will be conditional. Other EU member states and associated countries may participate with a reduced amount of EU funding up to 25 % to their beneficiaries. Third countries may participate through bilateral agreements with the DIS without EU funding.

The proposed programme will publish common guidance for applicants, evaluators and beneficiaries. Submission of applications, evaluations and reports will be made centrally through the thoroughly tested electronic proposal submission system (EPSS) of the programme. The Secretariat with the help of the programme managers from the national funding institutions will arrange the joint evaluation of the proposals respecting the principles of excellence, transparency, fairness and impartiality, confidentiality, efficiency and speed as well as ethical considerations. Avoidance of conflict of interest will particularly be taken care of.

The decisions about projects to be funded will be made by the Steering Committee following strictly the ranking list resulting from the joint evaluation. The Secretariat will follow and monitor project implementation, national funding, EU funding, in kind provisions and reporting as well as report to the European Commission and the national funding institutions.

Furthermore, based on the BONUS model, the proposed programme will support wide programme-level cooperation actions such as workshops, conferences, training courses, synthesis work as well as dissemination and specific stakeholder events. A particular emphasis is put also into the training and other activities for young scientists, the leaders of tomorrow. Key communications and dissemination tools and means such as strong online and social media presence, publications, promotional material and partner collaboration are used to their full potential in efforts supporting the realisation of the new programme's ambitious aims.

Financial integration

The total indicative commitment of national resources by the participating states amounts to at least EUR 100 million during the whole duration of the programme. Of this amount, at least EUR 66.7 million will be covered by cash contribution (Table 3).

The United Kingdom's Natural Environment Research Council (NERC) has expressed interest (subject to the UK's ongoing 5-year spending review) to collaborate with the proposed programme on a call by call basis contributing funds to future calls for proposals where they deliver NERC's priorities. NERC has in recent years worked closely with the marine programmes of DEFRA and Marine Scotland, and their involvement in shaping calls for proposals could provide a strong basis for NERC future collaboration with them and the proposed programme.

Table 3. Indicative cash contributions and total in-kind contribution by the participating states to the programme.

Committing state	National funding institutions involved	Indicative cash contribution (€)
Belgium	Government of Flanders	3 000 000
Denmark	Innovation Fund Denmark	11 432 143
Estonia	Estonian Research Council, Estonian Ministry of Agriculture,	1 125 000
Finland	Academy of Finland	5 000 000
France	French National Agency for Research (ANR)	6 000 000
Germany	Bundesministerium fur Bildung und Forschung	20 000 000
Latvia	Ministry of Education and Science of the Republic of Latvia	700 000
Lithuania	Research Council of Lithuania	600 000
The Netherlands	The Netherlands Organisation for Scientific Research (NWO)	5 000 000
Poland	National Centre for Research and Development	1 912 500
Sweden	Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS), Swedish Environmental Protection Agency (SEPA)/ Swedish Agency for Marine and Water Management (SWAM),	9 500 000
	Funders expected to participate on call by call basis, e.g. Estonia's Environment and Investment Centre (KIK), Finland's Ministry of Agriculture and Forestry and Britain's Natural Environment Research Council (NERC)	2 397 023
Total cash		66 666 666
Total in-kind		33 333 333
		100 000 000

While partners of the proposed programme will be national-level research funding institutions, other resources, critically important for fulfilment of the programme's objectives, e.g. significant research infrastructures and other in kind financing, such as labour costs of senior research staff are covered from other national sources. Therefore, national allocations to the programme will include both cash and in kind contributions. On the programme level, the percentage of total in kind contribution will constitute up to 33.3 % (one third) of the total contribution of the participating member states. Readiness to provide significant in kind contribution to the programme has already been expressed by a number the national funding institutions as well as national research performing institutions.

In kind contribution will be provided in a form of free of charge access to the significant national research infrastructures, such as research vessels and field stations, supercomputers and other high-tech. equipment, as well as by covering extra personnel and other costs. In kind contribution by the participating member states will be linked directly to the tasks of the programme's projects, be accountable and auditable. In order to procure the necessary in kind contribution to the programme, the dedicated implementation structure will conclude dedicated agreements with the competent national providers. By mutual agreement by the participating states the EU matching funding generated by the in kind contributions may also be used as a buffer resource in case of a mismatch occurring between committed funds and the consumption capacity by particular states.

The national and EU funding will be administered within a 'post evaluation common pot' scheme according to which the amount of national funding decided for respective beneficiaries is transferred to the DIS, and thereafter a single grant agreement covering both national and EU funds is concluded with those beneficiaries applying the Horizon 2020 funding rules. In those cases when transfer of national funds to the DIS is not possible due national regulations, the national funding to the beneficiaries will be administered by the national funding institutions and the EU funding to the beneficiaries will be administered by the DIS both adhering to the Horizon 2020 rules.

The participating states will contribute to the programme running costs in the level of 5 %.

Challenges and opportunities

The gains and advantages that arise from the different elements of the new programme itself are considered as strengths and those dependent on external stakeholders as opportunities. Similarly, the potential deficiencies that arise from failures within the proposed programme are considered as weaknesses and those potentially caused by external factors – as threats.

Strengths

- Cultivating scientific and innovation excellence, promoting transnational cooperation and smart specialisation among the participating countries
- Fostering complementarity and reducing duplication by merging national programmes
- Contributing to the specific objectives of Horizon 2020
- Contributing to implementation of the related European Union policies, namely Integrated Maritime Policy, the Marine Strategy Framework Directive, Water Framework Directive, Maritime Spatial Planning Framework Directive, Biodiversity Strategy 2020, Climate Change Adaptation Strategy and the Common Fisheries Policy
- Contributing to implementation of the EU Strategy for the Baltic Sea Region
- Contribution to the implementation of the EU blue growth strategy
- Testing new approaches to management and financial integration of member states' investment to research, technology, development and innovation
- Strengthening the links between academia and industries
- Supporting take-up of new knowledge in policy and industry, and ensuring the applicability of generated knowledge
- Supporting systematically inter- and transdisciplinarity in research and innovation (including social innovation) aiming at meeting the major societal challenges
- Using existing, tested structures and processes of programme management, stakeholder engagement, dissemination, communications and implementation (e.g. EPSS)

Opportunities

- Developing a model of forging synergies and avoiding duplication of effort between the research and innovation funding sources and the regional development funds
- Strengthening the science and innovation contribution to implementation of the European regional seas' conventions
- Stimulating collaboration between actors along the entire value chain, e.g. by enabling common tackling of challenges and exploitation of opportunities, thus realising the maximum innovative potential
- Encouraging and supporting specific innovation projects led by enterprises
- Developing a new model of joint actions involving the entire innovation chain starting from proof of principle and proof of concept leading to commercial endeavors and feedback into the experimental phase
- Developing a model of involving the non-EU states into macro-regional research governance networks
- Further developing a nested model of macroregionally structured EU research and innovation area to address societal challenges

Potential weaknesses (risks)

- Reduction of the programme to a mere funding instrument, with disregard to its potential to become a macroregional research governance structure. Specific efforts to follow up and secure uptake of the research outputs after completion of projects funded will be taken
- Widening the disparity with other European macroregions. This risk is disputed by the fact that several participant states border also to other sea basins such as the Arctic, Northeast Atlantic and the Mediterranean to which the best practices might be transferred. Therefore the programme will act as a test case in creating such networks
- The available financial resources do not match the programme´s ambition of covering a multitude of research and innovation needs. This potential weakness will be reduced by careful prioritisation

while developing the programme's research and innovation agenda in close consultation with the stakeholders from the Baltic Sea and the North Sea regions
- The involvement of industries, particularly the innovative small and medium sized enterprises remains insufficiently low. Specific measures will be taken to create participation rules and incentives promoting involvement, and where appropriate, stimulate project leadership by innovative enterprises
- Inability of science to deliver the needed advice. This weakness will be reduced by careful definition of the expected outcomes while developing the programme's research and innovation agenda

Threats

- The impact on the relevant policies remains insufficient due to unwillingness of governments and industries to adopt science-based advice. To avoid this, the new programme will produce model-based scenarios on future development under different policy options. The programme will benefit from BONUS's extensive experience of working on research and policy interface
- Norway does not join the programme. While subsequent Norwegian membership is envisaged, in the initial phase, Norway will be treated as a non-participant member state or associated country: its beneficaries are entitled to receive up to 25% of the requested funds from the 'common pot' of the programme
- Collaborative links with the regional conventions remain weak. This threat is minimal because close cooperation has already been achieved between BONUS and HELCOM, and a mutual agreement of collaboration signed with OSPARCOM

The programme will develop an efficient risk management strategy including preventive measures related to the potential weaknesses and threats. Also, a strong and strategic communications and stakeholder engagement work will support the realisation of opportunities as well as avoidance of threats to the programme.

Progress indicators and reporting

■ The programme's progress towards its objectives will be monitored periodically against six broader criteria. 'Input indicators' are those determining the level of effort invested towards achieving different objectives, and the 'output indicators' those, assessing directly the effect of programme's effort. The list below in Table 4 mainly represents the set of indicators tested within the BONUS programme. Additional indicators allowing to assess its ultimate input on meeting the key societal challenges will be defined later in consultation with the European Commission.

Table 4. Progress indicators within the BONUS programme 2011–2017.

Progress indicator	Input/ output
Support to development and implementation of Union policies	
Number of times the participants involved in projects contributed significantly to the development and implementation of policies and management practices at international, European, macro-regional or national level, e.g. to EU Integrated maritime policy, EU MSFD, EU WFD, EU Common Fisheries Policy, EU macro-regional strategies, HELCOM, OSPAR	o
Number of times the participants working in the projects serve as members or advisers in various policy-related committees, e.g. Commission's services, HELCOM, VASAB, ICES working groups etc.	o
Number of international, national and regional stakeholder events organised to promote knowledge-based implementation of various policies.	i
Number of joint events/co-operation activities/partnerships arranged in cooperation with the INTERREG programmes	i
Strengthening the innovation capacity	
Number of successfully commercialised new products or technologies as outputs of projects	o
Number of innovations brought to the demonstrator phase through programme's effort	o
Number of patents applied for as an output of projects	o
Number of innovation projects led by a SME	i
Number of innovation funding institutions participating in the programme	i
Number of cross-border innovation clusters created with programme's support	i
Number of academia – industry collaborations created with programme's support	i
Number of public-private co-publications	o
Co-financing by SMEs (cash and in-kind)	i
Scientific integration	
Number of peer-reviewed publications arising from the programme's research involving authors from at least two different participating states	o
Number of comparative studies addressing both the Baltic Sea and the North Sea issues	o
Number of review-, knowledge synthesis- and foresight articles produced by the programme's participants and published in high impact international media	o
Number of joint events/co-operation activities/partnerships involving actors from outside the Baltic and the North Sea regions and other European marine basins	i
Number of persons and working days spent by foreign participants using major research facilities (including research vessels)	o
Number of entries to existing openly accessible common databases and data products	o
Number of transnational post graduate courses organised within the programme	o
Number of mobility activities (persons, visit days) by scientists of one participating state to another participating state	o
Total number of PhD students and post-docs affiliated to the programme	o

Progress indicator	Input/ output
Number of popular science papers, media interviews, multi-media products, TV episodes, cases of engaging with social media etc. by the programme's participants	o
Management integration	
Number of member states participating in the joint research and innovation programme (i.e. adhering to joint implementation rules)	o
Number of joint transnational calls	o
Number of infrastructure providers supporting implementation of projects by providing free-of-charge use of infrastructures	o
Financial integration	
Programme's total budget	o
Percentage of funding to national research programmes in the relevant areas of research and innovation that is integrated into one macro-regional programme.	i
Percentage of programme's funding that is managed through a 'post selection common pot'	o
EU-level added value to the ERA process	
Number of times the programme has advised development of other Article 185 initiatives, emerging macro-regional research networks, ERA-NETs and been involved in the ERA-learn process	o
Number of transnational research and innovation networks addressing European regional seas	o
Number of research and innovation calls arranged in collaboration with other European seas programmes and/or JP initiatives	o

Part B:

Similarities and contrasts between the Baltic Sea and the North Sea

Ecosystems

The structure and functioning of the marine ecosystems of the Baltic Sea and the North Sea have been studied systematically for over a century from physical, geochemical and biological perspectives - the overall characteristics of the ecosystems of both seas are generally well known. The two systems are located in the same climate and biogeographical zones; they share a number of important species and processes, while they differ strongly in other respects.

The water residence time is very different between the two systems. The North Sea is relatively open to oceanic influences, both in the north and through the Channel in the south. The general circulation is counterclockwise and the residence time is in the order of one year. In contrast, the Baltic Sea has very limited water exchange with the North Sea. In both systems the intensity of water exchange fluctuates depending on the weather. The long residence time of the Baltic Sea, and relatively high inflow of river water, explains the salinity gradient towards very low values in the north. It also explains the permanent salinity-based stratification in the system that effectively closes off the deeper basins from exchange of oxygen, unless water renewal takes place after exchange events with the North Sea.

The long residence time also increases the relative importance of internal transformations in nutrient cycles and has a major impact in terms of the fate of loading from land. Consequently, eutrophication is one of the most serious problems in the Baltic Sea as this basin has to cope with increased nutrient loadings entirely with internal processes. In the North Sea eutrophication problem is more restricted to coastal and inshore areas especially close to river estuaries.

Species diversity in the Baltic Sea is much lower than in the North Sea, and it decreases with decreasing salinity. As a consequence, food webs tend to be shorter in the Baltic Sea, with stronger links between the (relatively few) nodes and less redundancy. Lower species diversity may increase the vulnerability of the ecosystem for invasions by alien species. In recent years, the Baltic Sea has seen a relative high degree of invasion, either by sea transport or through freshwater connections with eastern basins. Human alteration of connectivity has affected this system strongly, especially when compared to the relatively low level of natural connectivity. Invasions and range extensions of species have also affected the North Sea ecosystem

Table 5. Similarities and contrasts in the natural settings of the Baltic Sea and the North Sea.

	Baltic Sea	North Sea	Relevance
Physical characteristics			
Sea surface area km²	415 000	750 000	Scale of marine ecosystems and space for exploiting of their services by humans
Catchment area km²	1 700 000	850 000	Inflow of freshwater, nutrients' and contaminants' load
Volume km³	21 760	94 000	Heat conservation, ecosystem resilience, dilution of contaminants
Exchange of water with adjoining systems	Very limited	Open to Atlantic in north and exchange through Channel in south	Hydrological and biological connectivity and species' movements - invasive species, climate, tidal regime etc.
Morphometry	Multitude of sub-basins with often contrasting environmental conditions	A relatively compact basin with a shallower SE and much deeper NW parts	Gradients in environmental conditions
Water residence time	Approximately 23 years	1-2 years	Salinity, hydrology and dilution of contaminants
Salinity	Low. Remarkable N-S salinity gradient 0 – 6.5 psu	Nearly ocean level, 35 psu	Depth of mixing, species distribution
Temperature range	Wider temperature range. Seasonal ice in north of the Baltic. Temperature rising with climate change	Narrower temperature range. No ice. Temperature rising with climate change	Depth and seasonality of mixing
Depths: **average** **maximum**	 52 m 460 m	 130 m south 50 m south & west coast 300 – 700 m	Diversity of habitats, support of bottom water to production
Oxygen minima	Widespread. Probable increase.	Very limited. Possible increase.	Benthic production. Internal loading of nutrients
Water circulation	Determined by salinity and seasonal temperature stratification	Governed by water inflow from the Northeast Atlantic Ocean across the open boundaries with increasing admixtures of river contributions along the southern and southeastern rim	Determines horizontal gradients in physico-chemical properties, water stratification, advection of water masses across the sea basin
Sea level	Rising. In NE parts compensated by land uplift.	Rising.	Inundation risk of lowland coasts. Increasing need of coastal protection.
Biota and biodiversity			
Annual primary production	118 g C m^{-2}	In central part and northern parts - 70-100 g C m^{-2} ; in south-eastern coastal waters - 430 g C m^{-2}	Productivity of ecosystems provides a unique test case for comparative ecosystem functioning and food-web studies
Species richness	Low	High	Ecosystem resilience provides a unique test case for comparative studies on e.g. community structuring and evolutionary biology, biodiversity conservation
Benthic/pelagic production.	Pelagic production dominates in much of the Baltic	Greater role benthic production	Living biological resources
Food web	Tightly coupled	Diffuse	A tightly coupled system is subject to greater risk of sharp cascading food web effects

Seas and societies

Throughout history, seas have served humankind as a means of traveling and transporting goods from one place to another. Fish stocks, sea mammals and birds, marine vegetation, and salt provided important contribution to human nourishment. Living in coastal areas with maritime resources at hand and ship routes available has been one of the most important sources of wealth and culture. In particular, thanks to their outward-looking geography, the sea and the coastal ports and societies have been important drivers of the societies. Over time the utilisation of maritime resources has widened to cover resources below the water (sand and gravel, oil and gas), to energy resources (wind, tidal, wave and ocean thermal energy) and modern biotechnology - not to mention the ever increasing recreational functions of the seas. Development of science and technology is expected to further deepen and widen the use of maritime resources.

Seas shape societies and their mutual interaction: regional economic areas and zones emerge through trade and other social activities, and at the same time seas allow for connections to nations and people all over the world. This holds especially true for the Baltic Sea and the North Sea. As an almost closed sea, the Baltic Sea has historically created a distinct economic region within its littoral countries and multiple smaller regional economic zones. For the North Sea, good examples are provided by the historically intensive interaction between England and France along the English Channel, and between Norway and Northern Britain. While the North Sea is an integral part of the Atlantic Ocean with open trade routes, access via the Danish Straits to the open oceans has been of vital importance for countries in the rims of the Baltic Sea to export and import goods for production and consumption. The high welfare of the Baltic Sea countries would not have been possible without these open trading routes.

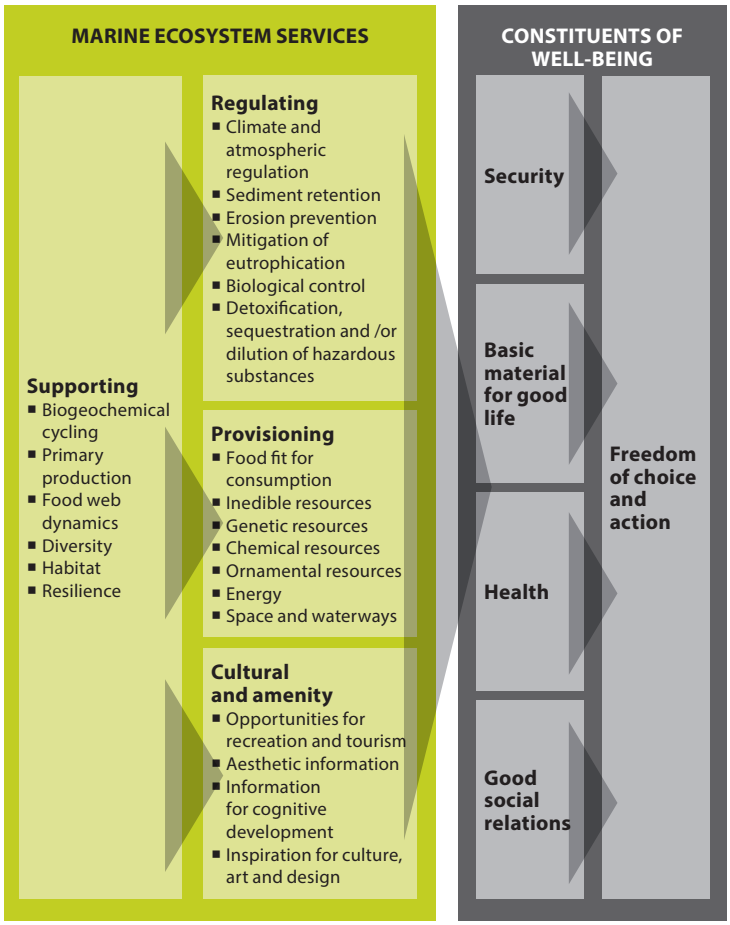


Figure 1. Schematic presentation of the relation of four categories of marine ecosystem services with human well-being. Lists of the ecosystem services are not exclusive; obtained from BONUS Publication No. 14 (2014), based on Millennium Ecosystem Assessment, 2005; Garpe, 2008 and de Groot et al., 2010. Alternative systems have been presented e.g. by Haines-Young and Potschin, 2010, and Meas et al., 2013

The concept of ecosystem services

The ecosystem services concept captures benefits that humans directly or indirectly derive from the sea. They include goods with economic value such as fish and other marine produce and services like waste assimilation. Marine ecosystem services can be divided into provisioning, supporting, regulating and cultural services (Figure 1).

The concept of ecosystem services is pivotal in linking the existence, the proper functioning and the integrity of marine ecosystems to human welfare, and thus in providing the basis for an ecosystem-based management of the seas. Despite this important principal, actual valuation of ecosystem services in monetary terms is fraught with methodological and conceptual difficulties. Human demand of goods and services, changes with the state of the ecosystem and is influenced by processes of global change. It is equally influenced by changes in the economic and social

organisation of societies, which determines the value given to certain goods and services at a particular time and place. Therefore, even for marketable goods and services the value evolves. Moreover, the value of non-marketable goods and services is particularly difficult to estimate. Finally, there is neither consensus about the delimitation of the list of relevant goods and services, nor about the list of suitable indicators to be used to estimate their status or value.

At present, no comprehensive valuations of marine goods and services at the basin scale are available for the Baltic Sea or the North Sea, although several studies are underway and some estimates are made at national or sub-regional scales. A project carried out by the Swedish government in 2009 identified 24 marine ecosystem services provided by the Baltic Sea. They include food, energy, space and waterways, primary production, biogeochemical cycles, biodiversity, resilience, removal of nutrients, recreation and aesthetic value among others. The estimated annual monetary value of these services is more than EUR 5 billion. Only ten out of these 24 services are currently operating properly, while seven are under severe threat. Among those under severe threat are food webs, biodiversity, habitats and most importantly, the resilience of the Baltic Sea, i.e. its capacity to resist and recover from disturbances.

In the North Sea, within the EU Vectors project, valuations of ecosystem services for the Doggerbank area were made as a pilot study. The study explores various methodological aspects, and besides monetary valuation also illustrates the use of ecosystem services in evaluation of scenarios. In this approach, the relative change in ecosystem services under different management options, rather than the absolute values, is the central focus. Another case study in the same project focuses on the willingness of tourists in the Wadden area to pay for avoiding climate change effects on the ecosystem. It shows that the yearly non-market marginal benefit of maintaining biodiversity and landscape values is substantial and should be taken into account in policy making.

Human uses of ecosystem services

It is a common practice to refer to blue economy when highlighting the current and future economic importance of maritime sectors. The notion of blue economy emerged as a further development of green growth stressing the important role of blue oceans. Blue economy and blue growth refer to an increasing appreciation that the world's oceans and seas, requiring a more systematic and coordinated actions for maintaining and improving the sustainable use of maritime resources. The European Union stresses the long term strategy to support sustainable growth in the marine and maritime sectors as a whole and sees that seas and oceans can be important drivers for the European economy with great potential for innovation and growth.

The individual sectors of the blue economy are interdependent (Box 6). They rely on common skills and shared infrastructure such as ports and electricity distribution networks. While maritime sectors are interlinked with many value added chains, the most important sectors may be condensed to a few key functions. ECORYS recently condensed them to the following five: maritime trade and transport; energy and raw materials; living, working and leisure in coastal regions and at sea; coastal protection and nature development; and maritime security. The EU Commission estimates that accounting for all economic activities that depend on the sea, the EU's blue economy creates 5.4 million jobs and a gross added value of almost EUR 500 billion per year. Shipping has a special role among maritime activities, as 75 % of Europe's external trade and 37 % of trade within the EU takes place via marine transport.

What holds for the EU and Europe, holds true for the Baltic Sea and the North Sea. The recent working document by the EU Commission characterises the economic importance of blue economy for the Baltic Sea countries as follows: "The Baltic Sea region has all the necessary elements for successful development of an innovative and sustainable maritime economy. Compared to other EU regions, it enjoys lower unemployment, higher growth rates and lower government debt ratios." Table 6 illustrates the current role of the main maritime economic activities for the Baltic Sea countries in terms of employment and gross value added.

Table 6. The blue economy in the Baltic Sea: main maritime sectors, number of jobs and gross value added. Sources: EU Commission 2014 and STECF 2013.

Maritime Economic Activity	Employment (working years)	Gross value added (billion euro)
Coastal tourism	127 000	3.1
Fish for human consumption[1]	117 000	3.8
Shipbuilding	51 000	2.0
Short sea shipping[2]	39 000	5.7
Passenger ferry services	26 000	2.0
Aquaculture	1 300	0.1

[1] More than 70 % of jobs and value added takes place in fish processing and retail.
[2] Short sea shipping refers roughly to shipping that takes place within Europe.

In terms of employment, the most important sectors in the Baltic Sea are coastal tourism and fishing for

human consumption, while short sea shipping creates the greatest gross value added. Fisheries (without fish processing and retail) creates value-added about EUR 1.0 billion and provides 9 400 jobs. The role of aquaculture is small: the number of jobs is close to 1300 and value added EUR 0.1 billion. Sand and gravel extraction is small and there is no oil and gas production in the Baltic Sea. Quite recently many countries have started energy production by constructing offshore wind mills. While their economic role is still small, it can be expected to increase in the future. In 2008-2010, offshore wind farming increased by 20 %, cruise tourism by 11 % and marine aquaculture by 13 % in the Baltic Sea region.

Table 7. The blue economy in the North Sea Area II: main maritime sectors, number of jobs and gross value added. Source: OSPAR, 2013.

Maritime Economic Activity	Employment (working years)	Gross value added (billion euro)
Recreation and tourism	299 000	21
Commercial Sea Fisheries	117 000	2
Shipping and port	305 000	47
Oil and gas production	716 000	6
Renewable energy	14 100	0.16
Aquaculture	3 100	0.2

The main maritime activities in the North Sea differ both in size and composition from those in the Baltic Sea. This reflects the fact that the North Sea has long since been an important site in European shipping lanes and it belongs to the most important fishery areas in the word. Furthermore, and in contrast to the Baltic Sea, offshore oil and gas production and renewable energy have a great role in the North Sea. A recent compilation by OSPAR estimated the most prominent commercial activities related to maritime economy for the North Sea to be about EUR 27.5 billion in gross value-added, and employment related to these activities to equal 1.34 million jobs. Table 7 illustrates the biggest sectors in the North Sea (OSPAR Area II). These figures are indicative, as the background information in the compilation is not entirely complete.

In terms of gross value added, shipping and port industry dominates in the North Sea. While oil and gas production entail the highest number of jobs in production of raw material, its value added is quite low. Oil and gas belong to exhaustible resources and new depositions must be invented. Currently, oil and gas exploration concentrates in the southern sector for gas and the Central Graben sector of the northern North Sea. Renewable energy (wind generators) and aquaculture still play a minor role. Recreation and tourism entails higher employment than traditional fisheries. Despite its relatively small size compared to other sectors, aquaculture has a more important role in the North Sea than it has in the Baltic Sea. Although extraction of sand and gravel has a long history especially in the UK coasts of the English Channel and more recently along the French coasts, its economic role is small.

The fact that the sectors of blue economy have high economic values in terms of both value-added and employment, partly provides market-based economic grounds for ensuring that the use of marine resources is made more sustainable, as this is the precondition of commercial production in the long run. Marine resources also have an economic value much greater than those measured by the market. The tangible and nontangible goods and services impact peoples' welfare directly and give a strong emphasis on sustainable use of all marine resources including preservation of pristine marine environment. This stresses the need to include environmental protection more tightly in the key economic activities. Reconciling economic activities within the confines of good quality of marine

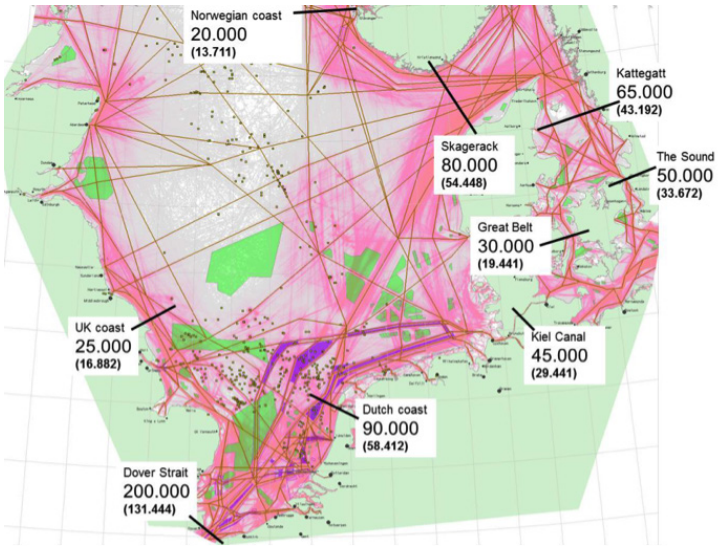


Figure 2. The North Sea traffic density map in 2020+. Labels indicate projected ship density for 2020+ (2012 numbers in brackets). The dark brown lines are the projected network of shipping lanes based on present day traffic patterns. The transparent green polygons are depicting the planned windmill areas and the small dark spots are oil and gas platforms in 2012. In some places they will pass straight through the planned wind mill areas. In those cases shipping lanes will either have to be relocated, or corridors have to be made through the wind mill parks. Note that the busiest branch of the North Sea traffic goes through Skagerrak, Kattegat and the Danish straits into the Baltic Sea. Thus, the North Sea and the Baltic Sea in effect are parts of a single exceptionally busy and globally important maritime transportation corridor. Source: ACCSEAS Baseline and Priorities Report v.3.0., 2014. www.accseas.eu

BOX 6: SECTORS OF BLUE ECONOMY

Shipping of goods and products has been, and still is, the most important single industry utilising maritime resources from an economic angle. Shipping depends directly on the physical properties of seas (such as water depth, sea currents, tidal features, and ice conditions) and indirectly on the ecosystem services that coastal ports make use of. Quality of ship construction, environmental impacts of shipping and organisation of the increasing sea traffic determine largely how greatly this industry impacts the seas. Marine traffic accident risks increase with the traffic frequency. The English Channel in the North Sea is a hot spot of maritime transport. Coming from around the globe, and leaving in the direction of Asia, Africa and America, nearly 500 ships of over 300 tons enter and leave the Channel every day, equaling one craft every 3 minutes. Perpendicular to this traffic, 90-120 daily rotations are operated by ferries between the continent and the British Isles, transporting 17 million passengers per annum. In the Baltic Sea, the narrow international passage of the Gulf of Finland provides another example of an area with heavy ship traffic, including larger oil tankers, toward the Danish Straits and in winter time under demanding ice conditions.

Environmental impacts of maritime traffic are related to air pollution, water pollution and biodiversity. The most important emissions to the air are sulphur, nitrogen and carbon oxides, which all can be reduced by improving energy efficiency and taking a determinate abatement effort. Water pollution shows up mostly in chemical forms due to oil spills, discharge of oil and ballast waters and pollution by toxic anti-fouling ingredients. Impacts on biodiversity takes place especially in coastal areas. Ballast waters have a crucial role in spreading invasive alien species to both seas. Tightening regulation on airborne emissions and water pollution and improving infrastructure in ports to support clean shipping will decrease the negative impacts of pollution. Increasing safety on ships' actions and introducing international marine traffic control systems is imperative in areas with dense traffic, such as the English Channel or the Gulf of Finland to decrease accident risks, especially risk of oil spills.

Offshore drilling of oil and gas provide another type of maritime resource utilised in the North Sea. Offshore drilling of oil and gas from the seafloor relies on the use of sea bottom geological properties and the physical properties of the sea (such as sea depth, waves). The economic importance of this activity in terms of jobs is considerable but the associated environmental risk may be considerable as well. Drilling and pumping infrastructure changes sea bottom only locally but the production itself entails releasing of oil and produced water, and chemicals to the sea, especially through discharges of produced water and partly from drill cuttings. Furthermore, accidental oil spills may arise from different sources during operations and cause disastrous effects especially in surrounding sea areas. Precaution, safety, tight environmental regulation and adequate protection equipment in case of serious oil spills are needed in order to improve water quality and biodiversity in offshore drilling areas.

Extraction of sea sand and gravel means taking sea bottom material for terrestrial uses. Extraction changes radically living conditions at the sea bottom and impacts directly sea grass, bottom fauna and spawning conditions of fish species; biodiversity impacts are evident. Furthermore, in previously contaminated areas, extraction releases contaminants to sea water. Careful targeting of sites and reducing the extent of extraction decreases damages caused by extraction. While extraction has been quite low in the Baltic Sea, it has had a greater role over time in some parts of the North Sea, especially along the UK coasts of the English Channel and more recently along the French coasts. In 2007, 5.5 Mt of marine aggregates were extracted from several tens of km^2 in the UK southern coastal waters and 1 Mt from less than 10 km^2 along French coasts. Recently, this activity moved further offshore to areas also trawled by French fishermen. Several hundred km^2 are presently prospected by French companies both in the eastern and central Channel. All these activities have, in isolation or in combination, long been recognised to be major vectors of change for the ecosystem structure and functioning, and also for related economic maritime sectors in the Channel.

Commercial fisheries utilise the complex nutrient chains of seas, thus, depending on the biological and ecological functions of the seas. The value chain of fisheries is profitable and growing, as demand for fish is increasing. This creates an increasing pressure on fish species and a risk of overfishing. This risk is reinforced by the development of modern fishing technologies and overinvestments in fishing vessels both leading to more efficient fishing. Therefore, the fishing industry is rather tightly regulated and must remain so in the future. The Common Fisheries Policy (CFP) of the EU is the regulatory framework for nearly all countries in the Baltic Sea and the North Sea. This policy relies much on Total Allowable Catch (TAC) approach that is rooted in the principle of sustainability of fishing. While this principle is well understood, whether the annual catches are sustainable or not, is a frequently debated issue. The state of fish stocks, such as herring and cod, has varied over time. In the Baltic Sea, especially the cod stocks are currently dangerously low thanks to overfishing and low salt content of the sea causing spawning problems. Aquaculture is generally thought to provide the needed increase in fish supply and save wild fish stocks. Large salmon production in the North exemplifies the profits and productivity of fish farming. The problems of fish farming are also well-known: feeding fish stocks with food produced elsewhere increases nutrients in sea water causing local eutrophication. Improving feeding efficiency and growing pools is needed to reduce the detrimental effects on water quality in seas.

Recreation and coastal tourism is an expanding industry that is based on use and non-use values people derive from the marine environment. Recreation depends more directly on the biological and ecological portions of coastal and marine ecosystems than any other maritime sector, and it basically requires healthy seas to be viable. Just like other maritime industries, recreational use of marine environment is consumptive and causes negative impacts in the marine environment, albeit in a much smaller scale than the sectors presented above. The key means of sustainable recreation are well planned coastal construction, avoidance on littering and clean marine transportation.

New maritime industries are expected to expand quite rapidly along with current dominant industries. The numbers of offshore structures related to wind energy is ramping up quickly, and ambitious plans for the development of wind farms in the exclusive economic zone exist in most riparian countries in the Baltic Sea and the North Sea. Other energy related infrastructures, such as gas pipelines (Baltic Sea) or electricity transmission lines will increase in both seas in the future. Currently, much effort is devoted to develop marine biotechnology applications and to improve safety of maritime transportation. The emergence of new sectors will create competition with traditional sectors on the uses of sea floor space and other marine resources. While some intervention may be needed to reconcile antagonistic interests, markets will do much of the adaptation, because the relative profitability of each industry ultimately determines the market allocation of maritime resources between industries. These issues of emerging industries will be discussed at length later.

Table 8. Similarities and contrasts between human uses of the Baltic Sea and the North Sea ecosystem services.

	Baltic Sea	North Sea	Relevance
Human uses of the ecosystem services			
Recreation and tourism	142 K jobs EUR 4 679 million value	147 K jobs[x] EUR 5 478 million valuex	Reciprocal dependence on environmental quality, blue growth priority
Commercial fisheries	120 K jobs EUR 3 984 million value	98 K jobs[x] EUR 2 426 million value[x]	Reciprocal dependence on ecosystem health, huge new knowledge need for development of the common fisheries policy
Maritime transportation	75 K jobs EUR 9 094 million value	98 K jobs[x] EUR 13 032 million value[x]	Largest element of current blue economy, source of significant pressures on ecosystems, massive driver of innovation
Shipbuilding and ship repair	65 K jobs EUR 3 211 million value	30 K jobs[x] EUR 2 386 million value[x]	Traditionally large economy in some Baltic Sea and North Sea countries, massive driver of innovation
Offshore oil and gas	negligible	716 K jobs[o] EUR 6 000 million value[o]	Important economy in some North Sea countries, source of accidental pollution risk
Aquaculture	0.7 K jobs* EUR 24 million value*	3 K jobs[o] EUR 200 million value[o]	Promising blue economy, development hampered because of uncertainty with environmental impact, potentially strong driver of innovation
Offshore wind	1.8 K jobs* EUR 192 million value*	14 K jobs[o] EUR 160 million value[o]	One of the most promising future blue economies, main driver of marine spatial planning, opportunities for combined use of space, significant knowledge needs

[x] data from DG MARE inforgraphic, only DE, NL, BE (NO can be added from ECORYS fact sheet)
[o] OSPAR data
[*] Numbers obtained by summing up from the ECORYS national fact sheets of the Baltic Sea states

environment lies at the heart of the EU's strategy of blue growth.

The above account shows that societies exploit marine ecosystem services in multiple and increasing ways. Maritime industries, built on the exploitation of marine resources, are profitable and expanding over time. At the same time, in the absence of well-planned environmental policies, they also cause air and water pollution and deteriorate marine biodiversity. While there are a lot of possibilities to reduce these impacts and preserve pristine marine nature, the knowledge base for designing comprehensive cost-efficient policies is still vague. To sustain blue economy in the future, and to combine a number of cross-sectorial interests and a proper utilisation of the marine resources, special knowledge and know-how on cross-border maritime spatial planning and regulatory instruments are needed. These can be developed drawing on analysis of human uses and pressures on marine environment and on the measures and instruments to mitigate the pressures.

The differences and similarities between the Baltic Sea and the North Sea, in terms of economic and social actors involved, of current environmental problems and of possible future scenarios can offer an excellent case for further exploring the conceptual and methodological aspects of ecosystem service valuation. Use of information from both of these seas in policy orientation and in scenario studies is a promising aspect, both from the viewpoint of developing the approach and from the viewpoint of feeding into policy development.

Most aspects of human use are similar between the two systems, although there are relative differences in the types of economic use. For instance, in relative terms, ship traffic and harbour activity are both more important for the densely populated North Sea states, where some of the world's largest harbours are situated, than for the Baltic Sea states. Also, exploiting offshore oil and gas resources and sea bottom drilling are economic activities of importance to the North Sea while negligible in the Baltic Sea. Economic development and political organisation are variable among the coastal states of both systems and the environmental governance systems also vary accordingly. The diversity present in these two systems can form a rich knowledge base for further refinement and development, especially when compared to the natural system and evaluated with respect to effectiveness.
The exploitation of offshore wind energy, maritime security, blue technology, fish for human consumption, shipping and tourism/recreation are expected to continue. To sustain blue economy in the future, and to combine a number of cross-sectorial interests and a proper utilisation of the marine resources, new methods, tools, knowledge and know-how on cross-border maritime spatial planning are needed.

Pressures from human uses

Ecosystems of the Baltic Sea and the North Sea have undergone noticeable changes during the past hundred years due to excessive use of ecosystem services and poor or insufficient management of human activities that have an impact on the marine environment and ecosystem. Abrupt and rapid shifts in food web and community structure - so called "regime shifts" - took place in the Baltic Sea and North Sea in the end of the

1980's. In such changes, multiple drivers often interact in undermining ecosystem resilience, causing the crossing of a tipping point and an abrupt change in the system. In the northern European seas the changes were coupled to the larger scale climatological phenomena, as well as direct human causes such as overfishing and, especially in the Baltic Sea, eutrophication.

Eutrophication

The effects of nutrient enrichment (eutrophication) are arguably the most significant threat to the marine environment of the Baltic Sea. The nutrient regime in the Baltic Sea is today in an undesirable state with low oxygen conditions and risk of unmanageable internal loads of phosphorus.

In light of unsustainable agricultural practices (e.g. massive increase in biofuel crops' cultivation) and expected increased precipitation and coupled nutrient imports from the catchment, its future evolution is uncertain. In the year 2010, total water- and airborne nutrient inputs of reactive nitrogen and phosphorus into the Baltic Sea were estimated to be 980,000 and 38,000 tonnes, respectively, and significantly exceeded the natural background loads and the targets set in the HELCOM Baltic Sea Action Plan.

The large sedimentary pools of phosphate deposited over decades in muddy sediments of the large basins are expected to contribute significantly to future nutrient loads when hypoxic or anoxic conditions continue to develop at the sediment-water interface. The imbalance in the ratio between reactive nitrogen and phosphorus from external and internal sources stimulates nitrogen fixation and increases the flux of organic matter from the sea surface into the deep basins, where remineralisation further depletes oxygen levels. Although this is a natural process, increased nutrient inputs accelerate the depletion of oxygen in deep water during periods of rare inflow events of heavier North Sea surface water which would fill the deep basins with oxygenated water.

Direct discharges account for 75 % of nitrogen and 95 % of phosphorus inputs to the Baltic Sea, the remaining 25 % (N) and 1-5% (P) are from atmospheric inputs. Recent attempts to curb eutrophication have led to decreasing phosphorus loads in waterborne inputs since 1994. The nitrogen input has also decreased, but the trend is not statistically significant and strongly depends on runoff. To attain 'good environmental status' in the Baltic Sea, nutrient reduction targets have been set in the HELCOM Baltic Sea Action Plan (i.e. 600,000 t N/a and 21,000 t P/a).

In the North Sea, the nutrient pools of winter months determine the level of primary productivity and are governed mainly by variable imports from the Atlantic Ocean via the northern boundary. The ratio of essential plant nutrients, nitrogen and phosphorus, in of these imports is close to the proportion in which these elements are required for algal production. A second significant nutrient source is atmospheric deposition of reactive nitrogen that is deposited at high rates in the southern North Sea and gradually decreases with distance to sources on land. At peak atmospheric concentrations in 1990, the mass of N deposited from the atmosphere has been estimated at 547.000 t N/a for the North Sea. The estimate of atmospheric N deposition in 2004 was 457.000 t/a and may reflect the improvement of air quality on land. On the downside, deposition of inorganic nitrogen from ship emissions has increased by 20 % in summer and by 10% in winter since the reference year 2000, and an estimated 17 % of atmospheric nitrogen deposition today originates from ships, with a tendency to rise.

A third significant and more localised source of nutrients reaching the North Sea are river loads of more than 1 million tonnes of inorganic nitrogen and 50.000 tonnes of phosphorus in the early 1990´s. Environmental legislation and the political upheavals in

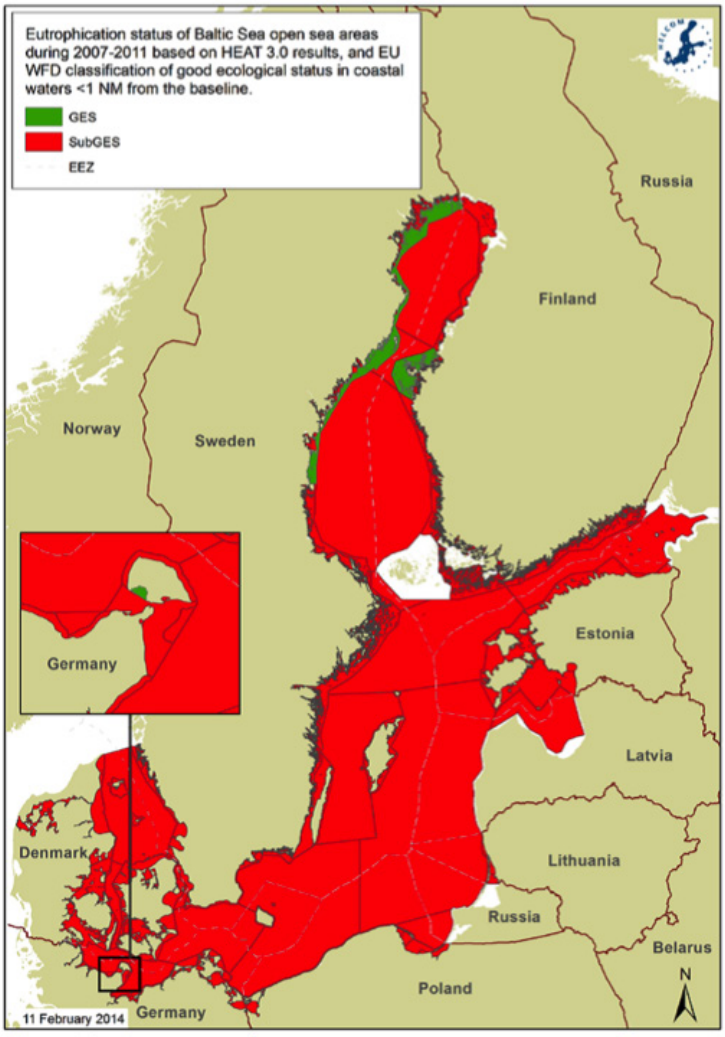


Figure 3. Eurtophication status in the Baltic Sea (2007-2011). Red colour indicates areas where environmental status is below good. Source: HELCOM, 2014.

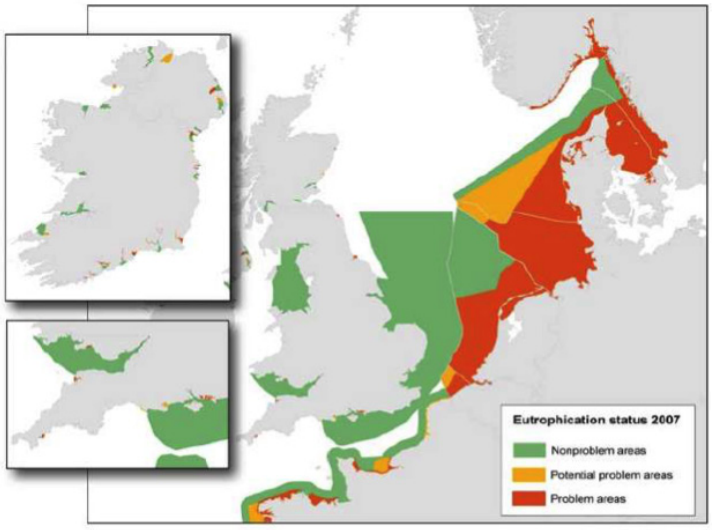


Figure 4. Eutrophication status of the OSPAR maritime area. Source: Second OSPAR integrated report, OSPAR Commission 2009, Publication number 327.

eastern Europe led to a significant decline of phosphate loads of continental rivers (2011: estimated at 9.000 t P/a), whereas discharges of inorganic nitrogen declined more gradually by about 50 % (300.000-400.000 t N/a). The latter are coupled to river water discharge because of the large storage of reactive nitrogen in soils and aquifers of the river catchments.

The human-induced sources contribute nutrient cocktails that differ from the Atlantic source in the stoichiometric balance, and a predominance of reactive nitrogen in coastal waters of the southern North Sea may have fostered blooms of undesired plankton during peak eutrophication. Environmental conditions in many of the tidal estuaries, which in the 1980´s were choked with nutrients, massively eutrophied and often suboxic, have improved. In spite of their poor environmental conditions, they were effective nutrient filters during peak eutrophication. Ongoing waterway managements have eradicated the functional basis for the estuarine filter, and today many of the large navigated and managed estuaries have turned from being nutrient sinks to being nutrient sources. Thus, although not so severe and widespread as in the Baltic Sea, eutrophication remains a problem in certain inshore parts of the North Sea (Figure 4).

Hazardous substances

Hazardous substances are those naturally occurring or artificial substances that are persistent, prone to accumulate in organisms and have adverse/toxic effects on biota. Examples are certain inorganic substances ("heavy metals", radioactive substances) that are concentrated by humans and subsequently discharged to the environment, and a range of chemicals (e.g., organometals, organohalogens, pesticides, pharmaceuticals, plastic debris, nanomaterials etc.) not occurring in nature, made by humans for specific purposes, and finding their ways into and accumulating in food chains (xenobiotic substances). The lists of priority substances in the EU legislations are being continuously updated while the effects of 'cocktails' of different hazardous substances are still greatly unknown.

Hazardous substances are emitted and discharged from a variety of sources around the two seas. The Baltic Sea and the North Sea are the final recipients of discharges into water and air by 270 million people, their households, industrial activities, traffic, agricultural activities and transport.

A recent assessment by HELCOM states that "during 1999-2007 the Baltic Sea was an area with high contamination by hazardous substances". Currently, 137 out of 144 areas, amongst them all open-sea areas of the Baltic Sea except the northwestern Kattegat, have been classified as being disturbed and the most contaminated areas include Northern Baltic Proper, Western and Eastern Gotland Basins and certain parts of Kiel and Mecklenburg Bights. A variety of hazardous substances are the leading cause of contamination, including PCBs and benz[a]anthracene in open sea areas, and TBT, mercury, DDE, lead, HCH, PAH metabolites and dioxins in coastal sites of the Kiel and Mecklenburg Bights. At many locations, water around larger cities has a moderate or poor ecological status. An overall assessment of the health of Baltic Sea wildlife demonstrates that status of predatory birds and seals are improving, while fish and lower trophic levels are impacted by hazardous substances. Fish populations in coastal areas suffer more from pollution than in open-sea sites.

Intergovernmental monitoring cooperation and regulation in the North Sea since the 1980´s has been shown to have had an effect over the last decades. In recent assessments the pollution status of the North Sea significantly improved and inputs continue to decline with respect to cadmium, mercury and lead, as well as classical pesticides, polychlorinated biphenyls and organotin. However, the environmental targets have not been met in all compounds and compound classes, and the Greater North Sea region is considered a problem area. The hot spots remain in the coastal regions, particularly in large estuaries (e.g. Seine, Thames, Rhine), and sediments often carry legacy of previous discharges. Whereas the pollution caused by heavy metals and classical hydrophobic and lipophilic compounds has decreased, new compounds are being developed and applied continuously, some substituting the ones that have been banned. These new substances of concern (including brominated flame retardants, pharmaceuticals and personal care products) are often more polar and persistent than the classical organic contaminants, have higher concentrations in the water

than in sediments, and are more difficult to analyse. In addition, rapidly increasing application of engineered nanoparticles raises concern that an elevated long term exposure to nanomaterials may result in significant adverse effects for both human health and the aquatic and marine environment. The relevance of many of these new substances for the ecosystem health remains largely unassessed, and OSPAR calls for continued efforts to monitor effects on biota.

Risk of accidental pollution

Accidental marine pollution may originate from shipping, but also from offshore and coastal installations (e.g. oil platforms, industrial facilities, nuclear power plants etc.).

In the Baltic Sea, shipping has steadily increased during the last decade, reflecting intensifying international co-operation and economic growth. Both the numbers and the sizes of ships have grown and this trend is expected to continue. According to HELCOM, there are about 2,000 ships in the Baltic marine area at any given moment, and each month around 3,500–5,000 ships ply the waters of the Baltic. This already high and ever increasing intensity of marine transportation has significantly raised the risk of large oil spills in the Baltic marine area.

In 2011, altogether 121 ship accidents happened in the HELCOM area. Based on data from 2002-2011, 7% of the reported accidents caused some kind of pollution. All incidents with pollution in 2011 occurred during fuel transfer except for one which was caused due to machinery damage. Half of the accidents were caused by human factor. Special characteristics such as low salinity, small water volume, restricted connection to the ocean, seasonality and the ice cover during winter make the Baltic Sea highly vulnerable to the effects of oil spills. The recovery rate of the spilled oil in the Baltic Sea is generally much higher than the global average and can reach as much as 50% as proven in some earlier major pollution accidents.

In the North Sea, the Channel is one of the busiest shipping routes in the world, with some 250 vessels passing through it every day. Heavy maritime traffic moves towards the ports of Ostend, Zeebruges, Ghent

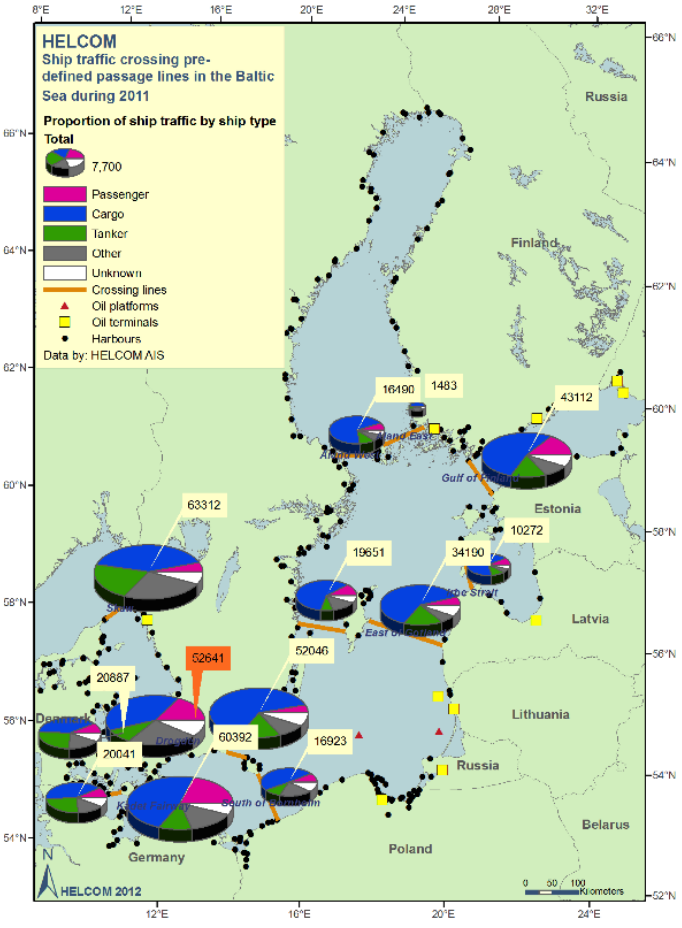


Figure 5. Number of ships crossing AIS fixed lines in the Baltic Sea in 2011 according to the type of vessels. The figure for Drogden (the red comment box in figure) is approximately 30% higher than the number of ships verified by the Danish Maritime Authority (DMA) through i.a. visual methods. The discrepancy between the HELCOM AIS statistics and the manual statistics in the Drogden area is being investigated. Source: HELCOM BSEP 123, 2010.

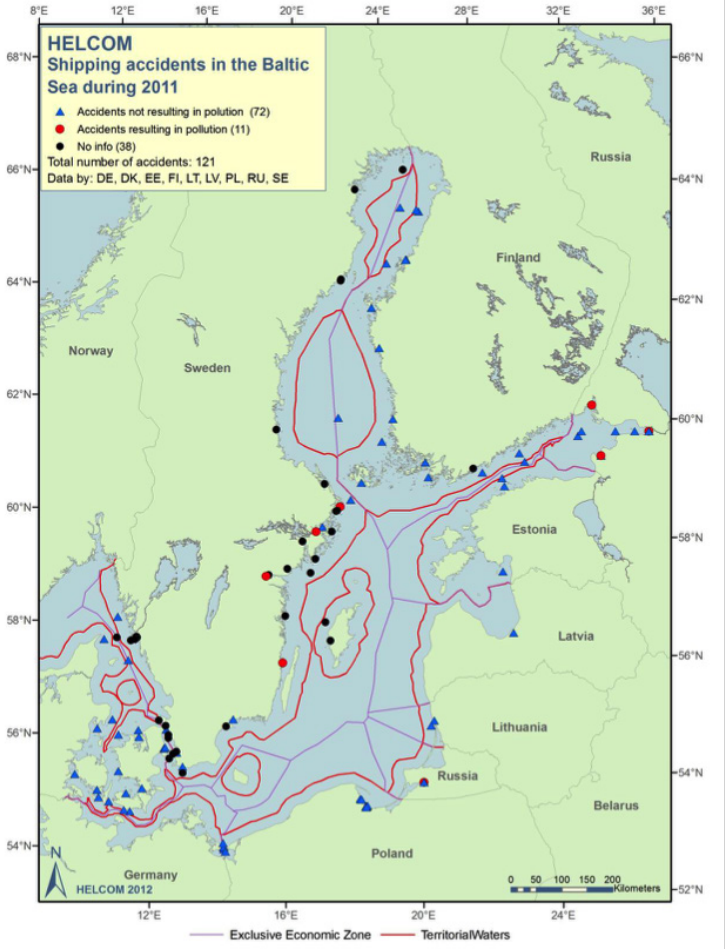


Figure 6. A map of accidents involving tankers in 2002-2011. Source: HELCOM BSEP 123, 2010

and Antwerp, or to other large European harbours such as Rotterdam or Hamburg. This explains why the approaches to the Channel represent the highest occurrence of accidental spills. The most frequently spilt products are various Intermediate fuel oil (IFO) grade fuels and crude oils (e.g. 41 and 27 % accordingly in 2007). Three significant spills of chemicals were recorded, involving respectively sulphur, methyl methacrylate and several types of plant fertiliser.

Another huge concern in the North Sea is allegedly deliberate illegal dumping of oily refuse from the vessels. Although the individual volume of each such spill can be comparatively small, together they may account for as much as 500,000 litres of oil damped into the sea annually (Figure 7).

An additional growing concern about accidental marine pollution is related to accidental loss of containers at sea. Although containers predominantly carry non-toxic substances such as bulk goods, container shipping, which already accounts for approximately half of the world's shipping tonnage, is growing fast. In the North Sea alone, the container port capacity is forecasted to more than triple over the next five years. According to the World Shipping Council (WSC), worldwide, on average 1700 containers are lost each year at sea. Notwithstanding the Bonn Agreement framework, the danger of accidents and pollution remains – mainly due to bigger and faster ships, growing volumes of cargo and the dangerous nature of many goods that are being carried.

The North Sea area has around 50 000 km of pipelines transporting oil and gas products from over 1300 installations (Figure 8). In 2007, around 60% of all operational installations reported air emissions and discharges to the sea as a result of oil and gas extraction. Eighteen per cent of the offshore gas wells are reported being leaking by the Norwegian Petroleum Safety Authority. The main causes for accidental spills include drilling accidents, usually associated with unexpected blowouts of hydrocarbons from the well (e.g. the Elgin accident in 2012), underwater pipeline damage, due to material defects and pipe corrosion (e.g. the Gannet Alpha accident in 2011), ground erosion, tectonic movements on the bottom, and ship anchors and bottom trawls. Over the period of 2000-2011, 4123 separate spills were recorded by oil companies operating in the North Sea. In total, 1,226 tonnes of oil were spilt into the North Sea during the same period, in addition to an unknown quantity of methane. In addition, chemicals such as methanol, calcium bromide brine, or triethylene glycol can be released and their decommissioning operations can be a threat.

Also radioactive substances reach the North Sea. Both natural and artificial substances are likely to be

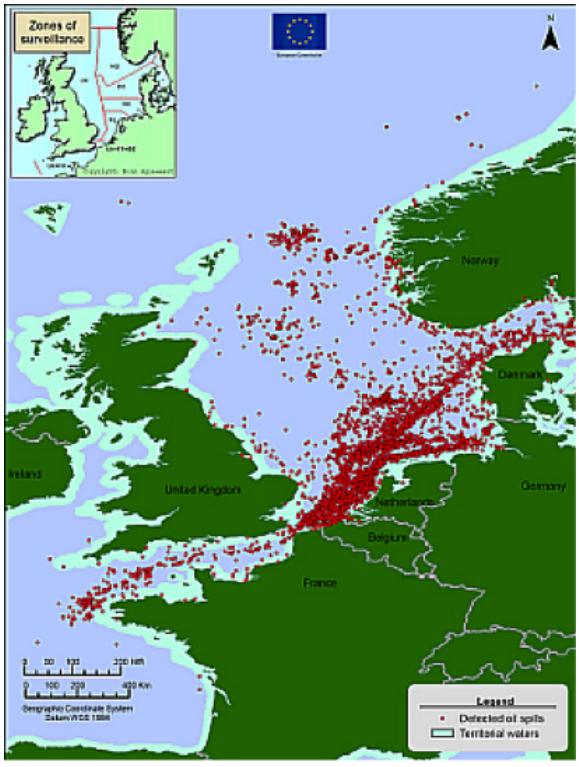


Figure 7. Detected cases of illegal oil damping in the North Sea, 1992–2011.
Source: www.spill-international.com

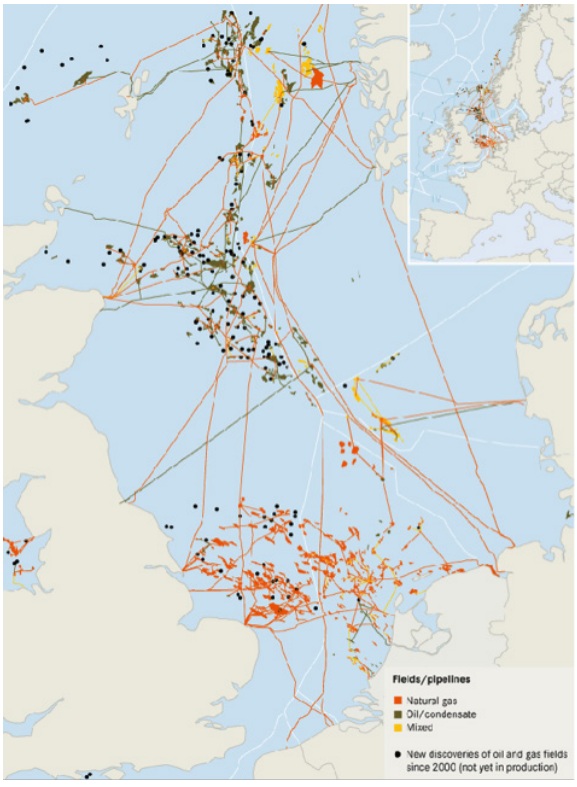


Figure 8. Offshore oil and gas fields under exploitation, new discoveries not yet in production and pipelines in 2009. Source: OSPAR, 2010. Quality Status Report 2010, OSPAR Commission. London. 176pp.

discharged, particularly from nuclear power plants, but also from installations for the reprocessing of used fuel and certain medical or research laboratories. Since the mid-eighties, the inputs of beta activity arise from nuclear reprocessing installations like Cap de la Hague. As far as alpha activity is concerned, the sources are dominated by the phosphate industry and the exploitation of oil and gas in the North Sea. The exposure of the population has declined considerably from the 1960's to the 1990's.

Since the competition for space is growing year on year in the North Sea area, the potential risk for accidental pollutions arises accordingly. This calls for an increased monitoring effort and further development and update of hazard identification and risk modelling.

Fishing effects

The main fishing effects in the sea ecosystems can be categorised as effects on target species, including genetic effects, effects on sensitive non-target species that may be taken as bycatch, food web mediated effects on communities and direct destructive effects on benthic fauna and benthic habitats. Bottom trawling and dredging cause mortality of many species because they are crushed directly by the gear or get caught and have died by the time they are taken on deck and discarded to the sea. Within and among species, mortality is often size dependent so that habitat complexity is reduced and smaller free-living species and individuals become relatively more abundant in heavily fished habitats. Overall, the bottom trawling effect on benthic biota and habitats seems considerably more severe in the North Sea than in the Baltic Sea, where its occurrence is patchier.

As regards the Baltic Sea**,** there is substantial uncertainty about both the direct impact of fisheries on targeted fish stocks and about the food web consequences of the top-down influence of fisheries relative to bottom-up effects of e.g. eutrophication. The Baltic Sea constitutes a highly variable environment where both productivity of fish stocks and catchability by the fisheries vary in dependence of hydrographic, chemical and biological conditions. In addition to the natural variability of the ecosystems, several parameters may exhibit directional change, though overlaid by high inter-annual variability. Recruitment of fish stocks success is altered under the influence of climatic warming and growth and maturation processes are affected by both climatic conditions and fisheries induced evolution. These changes in productivity affect not only the maximum sustainable yield (MSY) of the species but also the fishing mortality at which this yield is obtained.

In the Baltic Sea dramatic changes (i.e. regime shifts) related to climate variability and fisheries have been observed during the last 3 decades. The shift in the functioning of the central Baltic ecosystem was initiated by the collapse of the cod stock with effects on lower trophic levels and the entire pelagic food web. The cod stock decline was caused by a combination of climate-related unfavourable reproduction conditions and unsustainable fishing pressure. Trophic cascading has contributed not only to regime shifts, but also to newly established species interactions that prevent recovery of desired food web configurations.

Regime shifts have also been observed in other sub-systems, including coastal areas. Cascading effects similar to the open sea have been also observed, eventually affecting bloom-forming macroalgae. These coastal changes seem to be related to the decline in local predatory fish, potentially a result of the open sea changes.

In the North Sea the fishing mortality rates peaked in the 1990's but have been falling since. The reductions in effort that have contributed to the reductions in mortality have also led to reductions in the spatial footprint of fishing and in rates of discarding in most fisheries where they are recorded. Reductions in fishing mortality are starting to lead to reversal of some of the fishing impacts that were reported in the 1990s, but the system remains highly modified by fishing.

For a large part of the southern and central North Sea in the early 2000s, it was estimated that the effects of bottom trawling reduced benthic biomass and production by 56% and 21%, respectively, compared with an unfished situation. More recently, a comparison of fishing and natural disturbance for a large area of the western North Sea showed that disturbance attributable to demersal fishing exceeded natural disturbance. The imbalance between natural and fishing disturbance was greatest in muddy substrates and deep circalittoral habitats. The dynamic sea beds subject to high natural disturbance in the southern North Sea were generally less sensitive to given impacts than more benign environments. Although fishing effort appears to be very widespread when studied at large scales, efforts at local scales can be very patchy, with some areas of seabed fished many times and others not fished at all. Consequently the overall impacts of fishing in the North Sea habitats are less than would be assumed if the effort were more uniform in space and time.

Fishing has modified the structure and function of the North Sea food webs. The abundance of small fish of all species as well as the abundance of species with a low maximum size has increased over large parts of the North Sea since the early 1980s. This has led to reductions in the mean size and mean maximum size of the community as well as the proportion of large fish, these are the metrics widely used to describe the effects of fishing in the North Sea today. The community response has been attributed to reductions in

the abundance of larger and more sensitive species in the community, but the response also reflects the prey-release of their smaller prey species. More recently, climate change has also been implicated as a contributor to changes in size structure, with warmer sea temperatures favouring smaller body-sized species and smaller body sizes within species.

When fishing effort and mortality rates were at historical highs in the North Sea, discard rates were also very high. Material not consumed by birds predominantly sink to the seabed, providing a feeding windfall for benthic scavengers. The ecological consequences of discarding for seabirds and benthic scavengers are, however, different. The seabirds can locate the source of food by following fishing boats, while the arrival of discards at the seabed cannot be predicted by the animals foraging there and thus the food supply is not dependable. Locally, energy provided by discards has made an important contribution to the diet of scavengers. One study in the North Sea suggested that seabed scavengers obtained 37 % of their energy requirements from discards during the fishing season. This level of contribution was probably sufficient to allow larger populations of these scavenging species to exist than would otherwise be possible.

Climate change

In the course of the 21st century, anthropogenic CO_2 emissions and atmospheric concentrations will continue to rise. The accompanying climate change will affect sea level, ecosystems and biogeochemical cycles worldwide and regionally.

In the Baltic Sea catchment, precipitation is expected to increase between 4 and 22 % by the end of this century and temperature to rise by 2-4 °C. Direct consequences are increased river run-off during winter, decreased and shortened ice seasons (by 1-2 months in the northern Baltic Sea and by 2-3 months in the central parts), lower salinity in the surface mixed layer, and enhanced density stratification. Indirect consequences are increased nutrient loads from the catchment area, lower oxygen concentrations and enhanced phosphate reflux from sediments, and significantly enhanced primary production. The expected changes in salinity, in concurrence with increasing temperature, are likely to cause changes in biota. Depending on their sensitivity to salinity and temperature, respectively, species are expected to be pushed south and west, while others will move north. Most likely there will be also consequences at the genetic level, if populations are more, or less, isolated than before, and if effective population sizes decrease due to migration or partial extinction.

Model experiments suggest a similar regional warming (2-3 °C) for the North Sea by the end of the 21st century that diminishes the water-mass exchange with the North Atlantic and decreases nutrient import from the ocean, decrease surface salinity and increase stratification, and – in contrast to projections for the Baltic Sea - reduce primary production in the North Sea by 30 %. Responses to warming have already been observed in the majority of the more abundant North Sea fishes, with three times more species increasing in abundance than declining. The North Sea winter bottom temperature has increased by 1.6 °C over 25 years and during this period the mean depth occupied by the bottom dwelling fish community has increased by ~3.6 m per decade.

The sea level is globally rising at a mean rate estimated at 1.7 mm/a, chiefly from warming surface and intermediate water masses of the global Ocean. In the North Sea and the Baltic Sea realm, relative (isostatic) sea level is regionally variable, because the NW continental margin is still adjusting differentially to the unloading of glacial ice sheets from some 10.000 years ago. This creates a mosaic of relative sea level dynamic, in the North Sea ranging from a drop of 0.1 mm/a in the northern Denmark to a marked increase of 8 mm/a in the Bothnian Bay. The underlying vertical land movement obscures global (eustatic) sea level variations, but average mean sea level trends in the North Sea are broadly consistent with the global sea level rise over the 20th century. When compared to earlier decades, no obvious acceleration of sea level rise since the 1950´s can be inferred. Changes in the sea level around half a meter is expected by 2100 in the western parts of the Baltic Sea, but are suspected to be offset by land uplift in the eastern/northern parts.

Inter-annual and decadal variations in sea level, storm surge and wave climate are closely linked and reflect the corresponding changes in atmospheric storm activity. Over the North Sea, the latter has undergone considerable variations on time scales of years and decades with relatively high values around 1995 and at the beginning of the 20th century, whereas relatively low storm activity was observed around 1960 and over the most recent years. Scenaric model projections on possible developments until the end of the 21st century suggest that combined sea level rise and changed wind climate may lead to an increase in maximum storm surge height of 1.1 m in the inner German Bight, an area particularly vulnerable due to low elevation coastlines.

The CO_2 invasion into the sea surface from rising atmospheric concentrations causes increases in the acid concentration of sea water. This decreases the supersaturation of calcite, restricts calcification and creates stress for calcifying organisms. The pH of the North Sea water appears to have decreased from 8.08 to close to 8.00 over the last 36 years due to warming, corresponding to a

17 % increase in acidity. In a regional climate scenario model experiment, the uptake capacity for CO_2 in the North Sea is expected to decline until the end of the 21st century, mainly due to warming.

The pH of the Baltic Sea surface water varies widely between 7.85 in winter and 8.6 in summer, when waters are warm and biological processes are active. The mean annual pH has been estimated to 8.19 at pre-industrial CO_2 levels in the atmosphere and to 8.07 at today´s levels, and a doubling of atmospheric CO_2 concentrations is expected to further depress the average pH to 7.91. A corresponding trend is not clearly evident in monitoring time series, but they may be too short.

Other threats to ecosystem resilience

Destroying and fragmenting habitats; disrupting migratory pathways

As described above, at the habitat level, vulnerable benthic habitats are damaged or wiped out by intrusive fishing methods such as beam trawling, leading to a change in benthic community structure and a loss of vulnerable species. Especially the exploitation or destruction of habitat-forming species, such as oyster reefs or seagrass beds, has far-reaching effects on the composition of the rest of the ecosystem. Sand and gravel extraction can locally alter benthic habitats. Furthermore, placing large hard structures, e.g. oil and gas rigs or windmills into the sea, alters benthic communities and may provide stepping stones for the migration of invasions that otherwise would be restricted by the lack of a hard substrate. Habitat degradation is of particular concern at the coast, where (historic or present) land reclamation results in loss of valuable and productive coastal wetlands, and coastal constructions further aggravate this trend. These constructions are related to diverse economic activities, in particular harbours, industrial complexes, housing and tourism. Increasing rates of sea level rise will alternate coastal dynamics that may lead to further hardening of the coast and 'coastal squeeze', leading to the loss of intertidal and transitional habitats between open water and land. Dredging of waterways, especially in estuarine harbours, contribute to a further hardening of the coast. Strategies for 'soft' coastal defense and construction, preserving habitats while maintaining coastal protection, are urgently called for.

Many marine and coastal species depend on more than one habitat during their life cycle. Breeding or spawning, nursery, and adult life may need different habitats. Migratory birds or amphidromous fish are extreme examples, but many more populations are affected. This stresses the importance of connectivity between habitats, as well as the need for well-equilibrated conservation measures affecting all important habitats in a species' life cycle.

Introduction of alien species

About 120 non-native, alien species have been recorded in the Baltic Sea and some of these pose additional threats to the entire ecosystem including changes in the structure and dynamics of the ecosystems at local, regional and basin-wide scales. At present, the most unwanted alien invaders include fishery disrupters, fouling organisms and boring species. In addition to the threatened species, all marine and coastal biotopes in the Baltic Sea and the North Sea are to some degree threatened, which again contribute to the threats on the species.

Similarities and contrasts in pressures from the human uses

Similarities and contrasts in pressures on ecosystems originating from the human uses of the Baltic Sea and the North Sea are outlined in Table 9.

Table 9. Pressures from the human uses of the Baltic Sea and North Sea ecosystem services.

	Baltic Sea	North Sea	Effect
Pressures from the human uses			
Eutrophication	The whole sea, except the northernmost sub-basin is eutrophicated	Eutrophication confined to the southern inshore areas close to river estuaries	Oxygen depletion, reduced water clarity, blooms of harmful organisms, beach foam (North Sea)
Risk of accidental pollution	High; caused by shipping	High; caused by shipping and oil and gas production. Considerable issue of illegal discharge by ships	Multiple damaging effects on marine and coastal biota; need to enhance prevention and combating operations and their coordination among the states
Fisheries impacts	Several fish stocks heavily overfished causing cascading effects in the ecosystem	Fishery-induced phenotypic change in some fish populations; bottom trawling impact on benthic biota; significant role of fisheries discards in feeding of birds and benthic invertebrates	Direct effect on abundance of the targeted species and bycatch; damage to benthic biodiversity by bottom trawling, indirect effect through the food webs on whole community
Climate change	Change in salinity, water temperature regime and shortening of ice season; escalated eutrophication effects	Significant increase of wind surge risk threatening the lowland coasts; reduction of primary production; effects of water acidification more expresses than in the Baltic Sea	Multiple effects on ecosystems and their services to humans
Other threats	Invasive non-native species; destruction of habitats; disrupting of migratory pathways of some marine animals	Destruction of habitats; disrupting of migratory pathways of some marine animals	Threats to biodiversity and biological resources

Threats to long-term sustainability of ecosystem services

The sustainable provision of marine ecosystem services on the long term depends on the structural and functional integrity of the ecosystem components, as well as on the boundary conditions of the ecosystem (e.g. climate, pH, nutrient and sediment run-off from land, exchange with the ocean). If certain thresholds of pressures on ecosystems are exceeded their natural resilience capacity is compromised and an ecosystem providing services in a desired quality and quantity becomes impossible even if the adverse human pressures are mitigated. On a global scale these are known as planetary boundaries[7] .

At the level of populations, overexploitation is a direct threat to the long-term provisioning services. Overfishing has been shown to endanger the maintenance of stocks, resulting in the loss of breeding populations and thus of genetic diversity, but also in new selection pressures leading to changed life history strategies. In some well-documented cases, overexploitation of fish to very low population levels has led to fundamental changes in the ecosystem, preventing the recovery of the stocks even after release from fishing pressure.

The potential loss of genetic diversity in marine populations is related to the loss of habitats and populations. Its significance in terms of potential gains from 'blue biotechnology' is still difficult to estimate, but as the sector develops the value of preserved genetic diversity is estimated to increase.

Maintenance of biodiversity strongly contributes to the preservation of non-use values in ecosystem services. These values are of prime importance for tourism, even if the tourism industry itself is more often than not the cause of habitat degradation.

With respect to the regulating ecosystem services, such as biogeochemical regulation, water purification, production regulation or climate regulation, all activities leading to pollution or eutrophication of the marine system endanger the continued provision of the services (see Figure 1 for more on the linkages among the ecosystem services and constituents of human well-being). Despite the capacity of marine systems to buffer loadings and inputs, too high pressures tend to lead to non-linear and sometimes dramatic changes in the system and loss of its resilience. The ability to determine the location of tipping points and estimate maximal allowable pressures is of great importance for the long-term sustainable use of marine systems. Many pollution and eutrophication sources are located on land and regulated through land run-off. However, also purely maritime activities, such as shipping and exploiting the off-shore oil and gas resources, may have considerable pollution impact on the marine system via emissions into water and air, waste production or accidental spills.

Of particular importance, in case of regional seas which are a shared responsibility of many countries, is the cross-border governance of sustainable use and management of marine ecosystems. This has legal, but also cultural, social and political aspects. In this context comparison between the Baltic Sea and the North Sea, especially with respect to the latter aspects, may be particularly instructive.

Linking the seas and societies

Conceptual framework of linking the seas and societies

Links between society and the marine environment, and back to society through regulation and policies, can be described through a framework of driving forces (D), pressures (P), states (S), impacts (I) and responses (R) (DPSIR) (Figure 9). The case of the Baltic Sea eutrophication may serve as an example where agricultural farming and use of chemical fertilizers acts as a driver causing a pressure on marine environment through increased level of loading of nutrients, phosphorus and nitrogen to the sea. The increased loading results in higher concentrations of nutrients in the sea water. This in turn causes increased primary productivity resulting in undesired structural changes in communities, anoxia in deep waters and ultimately, resulting from eutrophication, loss of economic value of ecosystem services such as recreational value or value of coastal properties. The societal response to this unwanted impact could trigger a change in agricultural policy that restricts e.g. the use of fertilisers.

The DPSIR framework represents a system's analysis view. It can encourage and support decision making by pointing out clear steps in the causal chain where interventions could take place to reach a goal agreed by the society. The DPSIR framework, although often presented as a linear chain or a circle, in reality represents a very complex web of many interacting factors some of which may induce highly non-linear relationships. Certain measures for controlling human activities to reduce pressures may have impacts on not just one but several aspects of the ecosystem state. Such impacts can be cumulative or synergistic, and amplify the sought-after positive impacts and extend these over to various descriptors of the ecosystem state. The impacts from measures may also be antagonistic, implying that there are trade-offs between different desired states depending on the measures chosen.

[7] See e.g. www.stockholmresilience.org/21/research/research-programmes/planetary-boundaries.html

The drafting of the Marine Strategy Framework Directive's programme of measures, that are due in 2015, include gap analyses of existing measures as well as impact analyses of proposed new measures. Those analyses require thinking of DPSIR type of systems. So far the work has revealed that for many features of the marine environment and ecosystem services there is still a lack of quantitative understanding on the linkages between the factors of the DPSIR chain, i.e. systematic application of the DPSIR framework can potentially serve as a vigorous tool for identifying the critical knowledge needs. In the Baltic Sea region this quality of the DPSIR approach has already been very successfully used in formulating content of the BONUS strategic research agenda. Nevertheless, our capacity is still underdeveloped to address cumulative, synergistic or antagonistic impacts on marine ecosystems created by human pressures. Level of integration of socio-economic valuations in such analyses and models is still insufficient.

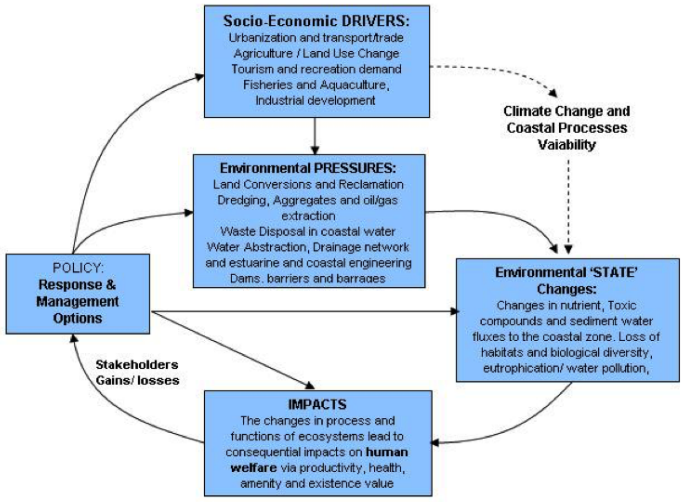


Figure 9. The Driving forces-Pressure-State-Impact-Response framework used in Integrated Coastal Zone Management (ICZM). Source: Modified from Turner et. al. (1998).

Future driving forces, pressures and societal responses

Neither Europe nor the countries in the Baltic Sea and North Sea are isolated from key global trends and challenges. Climate change is probably the greatest challenge that humankind has faced and there is an urgent need to reduce global carbon emissions. Secondly, the growth of world population still continues and will reach 9 billion by 2050. Thirdly, both increasing population and climate change challenge our ability to produce food for the increasing population. Finally, the need to eradicate poverty continues to be urgent requiring both political reforms and economic growth in less developed countries. It has been estimated that providing the western standard of living to the entire world population would increase resource use and pollution to entirely unsustainable levels. This stresses the need for fundamental changes in production and consumption patterns and technologies.

The European Union strives currently to expedite the current slow economic growth and at the same time adjust to the needs for stringent climate mitigation policies. The economic strategy, as advocated by the United Nations, is to rely on green growth that sharply reduces carbon emissions, increases the use of renewable energy and other renewable resources together with a determinate stress on research and development and innovations to reduce costs and expand sustainable product space. The blue economy can have important role in this transformation.

The European Union is a forerunner in developing climate mitigation policies and striving at the international agreement to curb greenhouse gas emissions. The EU has decided to reduce its CO_2 emissions by 80-90% relative to the 1990 level by 2050. The climate and energy policies of the EU have many implications to maritime industries and the marine environment. To match the mandatory renewable energy targets, the member states have and will increase the production of offshore wind power. In the Baltic Sea and the North Sea this increases the use of maritime space for energy production, and also energy-related infrastructure in the nearby bottom areas. Consequently, competition increases with fisheries, recreation and other industries on maritime space. Another immediate implication of climate and energy policies is the current building of liquefied natural gas terminals and consequent increases in maritime transportation of energy. Expectedly, both the EU and its member states will increase their self-sufficiency in energy. Besides increasing renewable energy production some EU member states are currently inspecting possibilities to utilise shale gas using fracking technology, which increases water pollution and release of harmful substances to both the Baltic Sea and the North Sea.

Growing population and the observed increasing trend in meat consumption in developing countries implies greater global demand for food, which may lead to permanently higher prices of agricultural products. This will intensify agricultural production and use of fertilisers in Europe. Furthermore, higher temperatures and increasing droughts will weaken agricultural growing conditions in Southern Europe and improve agriculture in the Northern Europe. As competitiveness of the northern agriculture increases, agricultural production increases (even more than in the presence of higher food prices alone) in the riparian areas of the Baltic Sea and North Sea. Furthermore, unless new environmentally friendly cultivation practices are developed, nutrient loads will also increase along with the

increasing intensification of agriculture. The expected detrimental impacts on water quality may further be reinforced by increased precipitation, extreme weather conditions and resulting floods. Finally, increasing food prices also increase profitability of fisheries and aquaculture. According to some estimates even now, fish consumption exceeds fish catches in both the Baltic Sea and the North Sea by a considerable amount: 8 million tons annually. This gap and the increasing future demand for fish could be met best by increasing aquaculture so that sustainability of wild fish stocks will not be jeopardised.

Countries in the Baltic Sea and North Sea are at the forefront of innovations and technological progress. They belong to the first ones to make use of the rapid technological progress in working offshore and in ever deeper waters. Robots, video-surveillance and submersible technology are creating huge opportunities to utilise resources below the sea bottoms. Offshore industries in the North Sea are increasing employing new technologies and they have been introduced to the Baltic Sea as well. Consequently, one may expect that the use of current offshore resources will be intensified and new resources introduced. In the future, both seas will serve increasingly as a resource base to rim countries. As an important part of this development, increasing investments in grid connections and transmission capacity, gas and oil pipelines are to be expected. Planning, construction and monitoring sea bottom infrastructure will become increasingly important for both seas and especially for the North Sea.

Institutions and policy measures

There are a number of policy institutions functioning in the northern seas region that engage in marine and maritime policy.

The EU with its integrated maritime policy and extensive environmental legislation is the most significant cooperation platform and policy institution. Most of the states in the northern region are members of the EU. The only country in the drainage basin of the Baltic Sea that is not a member is the Russian Federation. In the North Sea drainage basin, Norway, although being a non-EU state, is a member of the European Economic Area (EEA) and implements EU legislation within the EEA's framework.

The EU member states have an aim to achieve or maintain good environmental status of their marine environments by the year 2020. This objective stems from Directive 2008/56/EC establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive, MSFD). The member states are to establish marine strategies that consist of initial assessments, determination of good environmental status and establishment of environmental targets that were due by 2012, monitoring programmes in 2014 and programmes of measures by 2015. The second implementation cycle of the directive will start in 2018. For the purposes of the MSFD, the Baltic Sea has been designated as a marine region and the North Sea, including the Kattegat and English Channel, is a subdivision of the North East Atlantic Ocean region.

In July 2014, a directive establishing a framework for maritime spatial planning (MSP) was adopted by the EU. It is aimed at contributing to sustainable growth of maritime economies and the sustainable development of marine areas. The MSP directive requires member states to establish maritime spatial plans, requires certain planning to be carried out and asks the member states to update their plans every ten years.

The EU Strategy for the Baltic Sea Region (EUSBSR) was the first comprehensive EU strategy to target a 'macro-region'. It includes a number of priority areas to save the sea, connect the region and increase prosperity – each accompanied by concrete flagship projects as well as by clearly identified targets and indicators. The Strategy helps to mobilise EU funding and policies and coordinate the actions of the European Union, EU countries, regions, pan-Baltic organisations, financing institutions and non-governmental bodies to promote a more balanced development of the Baltic Sea Region. Priority area 'Save the sea' is very much connected to the work carried out under HELCOM.

Of all the Baltic Sea organisations, the one that is most relevant for the protection of the marine environments is HELCOM which stands for Baltic Sea Marine Environment Protection Commission. HELCOM was established first in 1974 and recreated with the updated Convention on the Protection of the Marine Environment of the Baltic Sea Area in 1992. All coastal states and the EU are contracting parties of HELCOM. HELCOM is a policy organisation that compiles data and assessments on the marine environment and human pressures, and uses this information as a basis for recommendations and strategies. The HELCOM Baltic Sea Action Plan was adopted in 2007 and focusses the work of HELCOM on four priority areas: environmentally friendly maritime activities, protection of biodiversity, combatting of eutrophication and reduction of pollution by hazardous substances. The HELCOM Baltic Sea Action Plan is regarded as a mechanism for implementation of the EU Marine Strategy Framework Directive (MSFD) in the region.

VASAB is an intergovernmental, multilateral co-operation of 11 countries of the Baltic Sea region in spatial planning and development. The joint HELCOM-VASAB Working Group on Maritime Spatial Planning has since 2009 ensured cooperation among

the Baltic Sea countries for coherent regional maritime spatial planning processes in the Baltic Sea.

The Council of the Baltic Sea States (CBSS) is an overall political forum for regional inter-governmental cooperation. The members of the Council are the eleven states of the Baltic Sea region as well as the European Commission. The CBSS has three long term goals that were adopted in July 2014: 1) to foster a Baltic Sea region identity and intensify contacts supporting its further development, 2) to develop the Baltic Sea region as a model region of sustainable societies able to manage and use resources efficiently, to tap the economic, technological, ecological and social innovation potential of the region in order to ensure its prosperity, environmental protection and social cohesion, and 3) to enhance societal security and safety in the Baltic Sea region.

The Baltic Sea Parliamentary Conference (BSPC) is a forum for political dialogue between parliamentarians from the Baltic Sea region. The BSPC gathers parliamentarians from 11 national parliaments, 11 regional parliaments and 5 parliamentary organisations around the Baltic Sea. The BSPC thus constitutes a parliamentary bridge between the EU- and non-EU countries of the Baltic Sea region. The BSPC aims at raising awareness on issues of current political interest and relevance for the Baltic Sea region and have addressed issues of relevance for the marine environment as well.

In the North Sea, OSPAR is the mechanism by which fifteen governments of the western coasts and catchments of Europe, together with the European Union, cooperate to protect the marine environment of the North-East Atlantic including the Greater North Sea (OSPAR Area II). It started in 1972 with the Oslo Convention against dumping and was broadened to cover land-based sources and the offshore industry by the Paris Convention of 1974. These two conventions were unified, updated and extended by the 1992 OSPAR Convention. The new annex on biodiversity and ecosystems was adopted in 1998 to cover non-polluting human activities that can adversely affect the sea.

The fifteen OSPAR contracting parties are Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. Finland is not on the western coasts of Europe, but some of its rivers flow to the Barents Sea, and historically it was involved in the efforts to control the dumping of hazardous waste in the Atlantic and the North Sea. Luxembourg and Switzerland are contracting parties due to their location within the catchments of the River Rhine.

The 40-year track record of OSPAR includes comprehensive monitoring of substances, significant reduction in phosphorus and heavy metal inputs; a radical reduction of discharges from nuclear plants since 1989; regulation for offshore oil and gas activity; bans on dumping of waste and offshore platforms; ecological quality objectives for a healthy North Sea; and a growing network of OSPAR Marine Protected Areas. The current focus of OSPAR is in particular the cumulative impacts and emerging pressures that have to be considered within the ecosystem approach. The work of OSPAR is based on collaboration and consensus, paying strong attention to sharing and understanding, concerns and successes with the stakeholders.

The OSPAR publications provide an authoritative record of these achievements. Particularly notable is the comprehensive OSPAR Quality Status Report published in 2010 (referred to in several parts of this programme outline document). This report was prepared for the OSPAR Ministerial Meeting which assembled in the same year and adopted the North-East Atlantic Environment Strategy. OSPAR has set and is implementing a dedicated Regional Implementation Framework for the EU Marine Strategy Framework Directive (MSFD Roadmap).

In 1983 in Bonn, the eight North Sea bordering countries and the EU signed an agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances from maritime disasters and chronic pollution from ships and offshore installations as well as to carry out surveillance as an aid to detecting and combating illegal and accidental pollution at sea. In 2001, the so-called Bonn Agreement was joined by Ireland. A major purpose of the Bonn Agreement is to facilitate cooperation between the contracting parties in response to large maritime disasters and other emergencies. The responsibilities of the parties of the Bonn Agreement include keeping their zones of responsibility under surveillance for threats of marine pollution, including coordinating aerial and satellite surveillance, alerting each other to such threats, adopting common operational approaches, supporting each other in response operations when requested, sharing research and development, and carrying out joint exercises.

In 2014, the Bonn Agreement produced a risk assessment of marine pollution in the Greater North Sea. The OSPAR Commission and the Bonn Agreement are cooperating closely on many cross-cutting issues and the OSPAR Secretariat also fulfils the secretarial function for the Bonn Agreement.

Twenty five years ago the North Sea Commission was established as an informal cooperation platform for regions around the North Sea. Its mission is to further partnerships between regional authorities which face the challenges and opportunities presented by the North Sea. The main objectives of the North Sea

Commission are: (1) to promote and create awareness of the North Sea region as a major economic entity within Europe. (2) to be a platform for developing and obtaining funding for joint development initiatives, (3) to lobby for a better North Sea region. The strategic focus for the North Sea Commission is the North Sea Region 2020 strategy paper. The vision of the North Sea Region 2020 strategy is to realise macro-region's potential to act as an engine for growth in Europe and as a centre of excellence for wider EU issues through developing existing cooperation efforts, improving policy efficiency and value for public money. Its aims are:

- Help the North Sea region remain and improve the performance as a competitive, attractive and sustainable area of Europe
- More efficiently address common transnational challenges and exploit opportunities related to sustainable economic growth, climate, energy, accessibility and management of the maritime space
- Ensure a better governed region through cross-sectorial coordination and multi-level governance
- Provide a potential pilot for a different kind of macro-regional strategy than the EU strategies for the Baltic Sea and Danube areas

The North Sea Commission's strategy paper is its contribution towards the implementation of the Europe 2020 strategy for smart, sustainable and inclusive growth. The strategic priorities of North Sea region 2020 are: (1) managing maritime space, (2) increasing accessibility and clean transport, (3) tackling climate change, (4) attractive and sustainable communities, (5) promoting innovation, excellence and sustainability. The North Sea regions from Scotland, England, France, Belgium, the Netherlands, Germany, Denmark, Sweden and Norway may become members of the North Sea Commission.

The following Table 10 provides a summary of the most relevant institutions and policy measures functioning in the Baltic Sea and the North Sea regions.

Table 10. Summary of the institutions and policy measures functioning in the Baltic Sea and the North Sea regions.

	Baltic Sea	North Sea	Effect
Institutions and policy measures			
EU Integrated Marine Policy	Yes, but it does not apply to the Russian Federation	Yes	Coordination of policy in sectors dependent of or affecting quality and quantity of marine ecosystem services
EU macro regional strategy	EU Strategy for the Baltic Sea Region, but it does not apply to the Russian Federation	No	For the time being only the Baltic Sea has such a Strategy but the EU strives for such regional strategies
EU thematic directives: MSFD, WFD,MSP	Yes, but it does not apply to the Russian Federation	Yes	All but a very few states implement the EU directives in both sea regions.
EU Common Fisheries Policy (CFP)	Yes, but it does not apply to the Russian Federation	Yes, in consultation with Norway	The CFP aims to guarantee the sustainability of living aquatic resources and environmental protection through sustainable fishing whose management is based upon an ecosystem approach to management
Regional seas' conventions	HELCOM, all coastal states and the EU are contracting parties	OSPARCOM	HELCOM and OSPAR have adopted largely similar active approach to the protection of the two sea areas and EU directives, especially the MSFD
Other intergovernmental and regional networks	CBSS, VASAB, Baltic Parliamentary Conference, European Parliament Baltic Intergroup	Trilateral Wadden Sea Cooperation between Denmark, Germany and The Netherlands, North Sea Commission	These organisations and networks facilitate coordination of various thematic policies across the national borders at macroregional or sub-regional scale. Their actors represent national or regional public governance. Several of these networks have potential to become core stakeholders of the new programme.
Non-governmental organisations	Coalition Clean Baltic, Oceana, WWF	Oceana, WWF	NGOs are active and participate e.g. regional seas conventions' work as observers in [at least] the Baltic Sea

Potential for sustainable blue growth

The blue growth strategy

In its 2012 communication titled "Blue Growth, Opportunities for marine and maritime sustainable growth", the EU Commission has sketched the societal and economic reasons for renewed emphasis on growth in the marine and maritime sectors. Rapid technological evolution enabling exploration and exploitation of marine resources hitherto unreachable, increased demand on marine living resources for sustaining humankind and increased demand on ocean energy as a replacement for the use of fossil energy sources and need to reduce the greenhouse gas emissions are the major drivers for a renewed attention to 'blue' economy. The aim of the blue growth strategy is to harness the untapped potential of Europe's oceans, seas and coasts for jobs and growth through facilitating appropriate investments and research. It can contribute to the EU's international competitiveness, resource efficiency, job creation and new sources of growth whilst safeguarding biodiversity and protecting the marine environment, thus preserving the services that healthy and resilient marine and coastal ecosystems provide.

Employment and current activity in the blue economy are shown in Figure 10. However, growth potential differs between sectors. The most promising areas of growth appear in the following five areas:

- **Blue energy**, where offshore oil and gas are traditional sectors, wind energy production is quickly maturing, and other forms of ocean energy (tidal, wave or thermal energy) could be further developed, provided that the technological and environmental challenges can be met
- **Marine aquaculture**, which is a fast growing sector world-wide that lags behind in European waters. The Commission proposes to enhance growth in this sector by improving legislative and administrative environment, incorporating aquaculture into novel multi-use platforms, technological developments and exchange of best (sustainable) practices
- **Maritime, coastal and cruise tourism**, which is the largest maritime economic sector and one that at the same time exerts strong pressure on (coastal) ecosystems, but also depends heavily on the natural quality and beauty of these systems. Organisational and educational measures are foreseen; R&D may mostly be needed in the realm of sustainability of these activities
- **Extraction of marine mineral resources**, currently a small sector with nevertheless a high promise of growth, provided that the major technological and environmental problems can be solved. This is, therefore, a sector in need of strong R&D efforts
- **Blue biotechnology**, a sector with a strong growth rate, focusing on diverse application areas: food and energy production (in particular through culturing algae), human health products (pharmaceuticals, personal care products), industrial products and processes (enzymes, biomaterials) and environmental processes (bioremediation). This sector is in need of strong R&D investment, requiring on the one hand extensive exploration of biodiversity resources, and on the other hand technological means of deriving industrial products from these resources

In its report to the Commission, ECORYS evaluates Europe's capacities to take opportunities for blue growth and profit from the high-level scientific and technological knowledge of oceans and seas. They stress the importance of a long-term strategy oriented towards sustainability of marine practices (Box 7).

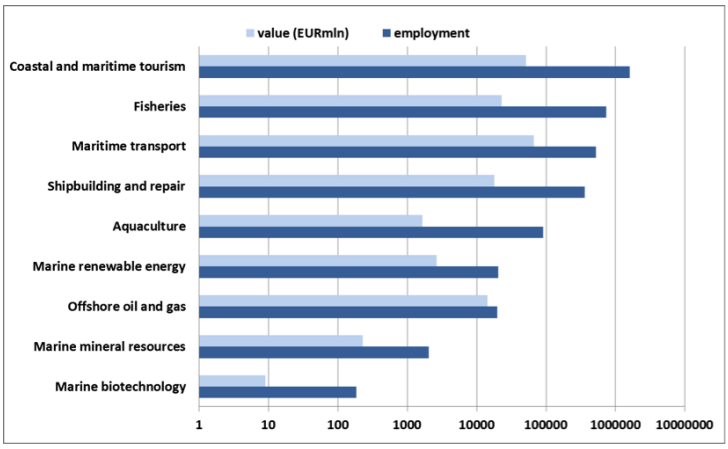


Figure 10. Economic size and employment of several marine and maritime economic activities in EU states. Note the logarithmic scale. Source: European Commission, 2014

BOX 7: SELECTED QUOTATIONS FROM THE ECORYS REPORT

"Europe is well placed to lead on the transformation of traditional maritime economic activities, e.g. green shipping, sustainable tourism, sustainable aquaculture, but even promoting more sustainable forms of business within oil and gas or marine mineral mining. Playing out the card of sustainable maritime innovations is likely to produce growth and jobs in a world which is increasingly aware of sustainability. This card is however less likely to succeed in a world which is short-term oriented and where Europe moves from crisis to crisis.

The EU's future success in the maritime economy will therefore largely depend on its own technological as well as strategic response capacity, and its ability to bring promising and sustainable maritime innovations fast and decisively, adapted to a rapidly evolving global context."

From: Blue Growth: Scenarios and drivers for Sustainable Growth from the Oceans, Seas and Coasts, Final Report, ECORYS, August 2012

Sustainability is also the major theme in the response of ocean environmental groups on the blue growth strategy. They point to the importance of the ecosystem approach and the precautionary principle and plea for careful growth and thorough maritime spatial planning. Although differences in emphasis exist, these stakeholder positions are not principally opposed to the positions taken by the Commission. Together they point to sustainable innovation as the major goal of this operation. A strong urge for scientific, technological, social and political action preserving healthy seas as a background for sustainable development is also the major theme of the 'declaration of HOPE' ensuing from the European conference for the marine environment in Brussels, March 2014.

All 'blue growth' economic sectors have a strong basis and tradition in the North Sea – Baltic Sea region, either as activities within the seas, or as activities undertaken from the important large harbours and maritime centers in the region. Most 'blue growth' activities cannot be restricted to member states' exclusive economic zones, or are already subject to existing European policies, such as the fisheries policy. Major advantages are to be gained in bringing together parties that do not always reside in the same country (e.g. pharmaceutical companies and biotechnology laboratories). The issue of marine spatial planning has strong basin-wide aspects, as well as strong links between the North Sea and the Baltic Sea with respect to shipping, pipelines and other infrastructure. Basin-wide technological developments, e.g. electric grids or storage systems for wind energy, will also need cooperation on a European level. With respect to R&D, the North Sea and the Baltic Sea can serve as a laboratory where many technological and environmental aspects of blue growth can be tested and exported to the rest of the EU.

It is important to highlight the significant challenges i.e. insufficiency of existing knowledge, research–policy and research–industry gaps as well as weakness of transdisciplinary research cooperation across national borders.

Prospects for marine and maritime research and innovation

For the coming decades the focus of marine research and innovation effort will remain, no doubt, on meeting the grand societal challenges: harnessing in full the potential of the 'blue economies', securing long-term sustainability of the marine ecosystem services by achieving and maintaining sufficient environmental quality and adapting to the impacts caused by the climate change. Filling our knowledge gaps and finding new technological, management and governance solutions will necessitate more and more emphasis on interdisciplinarity. Combination of the traditional marine science disciplines with the latest advances in areas such as information and communication technologies, material science, nano-technologies, omics and societal sciences will become a norm. Meeting the future maritime development needs will require radical refurbishing of the whole global system of collecting, handling and unrestricted close-to-real-time distribution of all kinds of marine information, a trend that is already ongoing.

The recent analysis "Navigating the Future IV" by the European Marine Board identifies 10 large bodies of research that will become even more pivotal during the coming decades:

- Understanding marine ecosystems and their societal benefits
- Changing oceans in a changing Earth system
- Safe and sustainable use of marine and coastal space
- Sustainable harvest from the sea
- The oceans and human health
- Energy and raw materials from the seas and oceans
- Sustainable use of the deep sea resources
- Polar ocean science
- Blue technologies: Innovation hotspots for the European marine sector
- An integrated and sustained European Ocean Observing System (EOOS).

Of particular relevance to the new Baltic Sea and North Sea programme are such directions of future research and innovation as e.g.: defining the controls and limits of ecosystem resilience; including predictive capacities and regime shifts and adaptation in the context of

global change; functional and dynamic definition of ecosystem health which conforms to scientific understanding in relevant policy context; connecting changing oceans to human well-being; finding improved methods to reduce uncertainty in climate change projections; developing and implementing interdisciplinary approach to maritime spatial planning and ecosystem-based management of human activities; developing fisheries and aquaculture in a full ecosystem context; better understanding the potential health benefits from marine and coastal ecosystems; science and innovation in support of developing renewable marine energy; development of nano- biotechnologies and nature-inspired design; and development of automated in-situ observation technologies in combination with the advanced remote techniques. Enhancement of knowledge transfer and the science-policy interface will remain as critically important as it is nowadays[8].

Training and careers of the next generation of marine experts will remain a task of an utmost importance. "The "new 21st century" scientist will need to possess both a cross and trans-disciplinary perspective. The new generation of marine scientists will not be scientists who know little bit about all disciplines, but deep knowledge in one discipline and basic "fluency" in two to three others."

In unison with the above, the recent early gap analysis performed by the coordination and support action "Healthy and productive seas and oceans" revealed a number of open questions related to climate changing the ocean, healthy oceans, seas and coasts and sustainable blue economy. In order to address these questions, and in addition to lot of specific innovation, a range of new cross-cutting technologies, such as new physical and bio-sensors, omics, robotics, autonomous platforms, information transmission technologies and corrosion-resistant and antifouling materials will have to be developed. This in turn, may catalyse in the future the marine and maritime research and development in particular to become a strong driver of generic innovation in many fields.

These ambitious tasks can only be fulfilled if a radically new transnational and cross-sectoral model of cooperation and integration in research and innovation governance, usage and development of infrastructures and data sharing is built.

[8] This account of the identified future research and innovation lines is far from exhaustive and represents a voluntary selection by the authors of this programme outline document.

Research and innovation competence

The data in Eurostat reveals that the EU member states behind this proposal are in the forefront of forward-looking research and innovation effort. Seven out of eleven countries involved in the proposal (in decreasing order FI, SE, DK, DE, FR, BE, NL) are within eight top member states as regards percentage of gross domestic expenditure on research and development. Also, all of these countries have higher proportion than the EU-28 average of research and development personnel. Although the remaining four 'new' EU member countries (EE, LT, LV, PL) are behind the EU averages as regards the above indicators, the already implemented research collaboration within the BONUS projects as well as stakeholder communication in these countries has had, and will continue to have, a positive impact in the field of marine/maritime research, development and innovation.

Since the beginning of systematic scientific study of the oceans and the seas in the 19th century, the Northern European seas have been at the forefront of the advanced enquiry about the role of the marine ecosystems for the planet and the society. The body of scientific literature accumulated since that time is enormous and it continues to grow both in absolute volume as well as in relative proportion compared to other parts of the World Ocean. An extraction from the Web of Science for the years 2009-2013 (Table 11) gives a convincing evidence of the level of scientific activity addressing the three marine areas covered by the proposed Northern European regional seas' research and innovation programme: Channel, the North Sea and the Baltic Sea. While the amount of scientific literature reflects directly the level of the previous research effort dedicated to these areas, it

Table 11. Number of the peer-reviewed scientific papers in different thematic areas of marine and maritime research addressing the Greater North Sea and the Baltic Sea, 2009-2013. Extract from the Web of Science, August 2014 .

Thematic area	Channel	North Sea	Baltic Sea	Total
Physical oceanography, climate interactions	377	2226	1568	3796
Geology and geophysics	249	1910	1115	3051
Biodiversity, ecosystems, ecology	378	1760	1577	3353
Fisheries, aquaculture, marine biotechnologies	230	1604	1260	2786
Geochemistry, hydrology	59	337	355	696
Pollution, contaminants, toxic effects	109	925	1012	1895
Engineering, offshore activities, oil and gas	91	611	305	948
Sociology, economy, policy	4	42	36	78
Total	813	5274	4121	9421

Table 12. Similarities and contrasts in the Baltic Sea and the North Sea research, development and innovation cooperation

	Baltic Sea	North Sea	Effect
Cross-border marine and maritime R&I cooperation			
JPI OCEANS	Yes	Yes	The joint programme will provide a vigorous funding instrument supporting in the regional seas scale the objectives of this JPI
Article 185	Yes	The joint Northern European regional seas research and innovation programme in preparation	The joint programme has potential to integrate activities that support policy implementation and development of the regions overall
ICES	Yes	Yes	ICES provides scientific advice and has capacity to assist in harmonising approaches to e.g. assessments in both regions
Cooperation with the third countries	Russia: BONUS, The Gulf of Finland Year 2014	N/A	
EU regional development fund's programmes (INTERREG A, B, C)	Baltic Sea Region Programme, South Baltic Programme, Central Baltic Programme	North Sea Region Programme, 2Seas programme	These programmes promote regional development through transnational cooperation. Partners of projects are state and local government bodies, academia and enterprises. In 2015 the regional development fund's programmes start new funding period with reviewed operational plans. In several aspects these plans are compatible with the thematic scope of the joint Baltic Sea and the North Sea programme. BONUS and the Baltic Sea Region Programme already cooperate to strengthen synergies and avoid duplication.
Cooperation of the innovation funders	BSR Stars programme, StarDust project	**?**	Promote competitiveness of innovative enterprises; create territorial clusters of innovators
Ongoing thematic ERANETS	COFASP: fisheries and aquaculture resources and seafood chain MARTEC II: maritime technologies ERA-MBT: marine biotechnology OCEANERA-NET: ocean energy NEWA: European wind atlas ECO-INNOVERA: eco-innovation	COFASP MARTEC II ERA-MBT OCEANERA NEWA ECO-INNOVERA	ERA-NETs are collaborations among the national research and innovation funders aiming at boosting cooperation in a specific thematic area. Most typically ERA-NETs culminate in one or several joint calls by the participating states. There are at least six thematically relevant ongoing ERA-NETS with participation of both the Baltic Sea and the North Sea states: Denmark – 6, Belgium, France, Germany, Sweden – 5, Netherlands, United Kingdom – 4, Norway – 3, Finland, Poland – 2, Estonia, Latvia, Lithuania – 1. These ERA-NETS effectively supplement the thematic scope of the proposed the joint Baltic Sea and the North Sea programme, especially in such areas as the core technologies of renewable energy and maritime transportation as well as food processing.
FP 7 marine and maritime projects: data from Marine Knowledge Gate 2.0	Denmark* - 63 Germany* - 88 Sweden* - 50 Poland – 36 Finland – 32 Estonia – 13 Lithuania – 9 Latvia - 5	UK – 124 Norway – 92 France – 89 the Netherlands - 81	Altogether there are 156 cooperative research projects involving both (80% cases) or either the Baltic Sea and/or the North Sea scientists and innovators. The most well covered thematic areas correspond to the the joint Baltic Sea and the North Sea programme Strategic Research and Innovation Agenda segments: *"Sustainable use of ecosystem services"* – 78 projects; *"Coasts and catchments"* – 26 projects; *"Structure and functioning of marine ecosystems"* – 20 projects; *"Observation and monitoring tools"* – 19 projects; *"Societal responses"* – 12 projects
Other continuous cross-border initiatives	Baltic Earth (ex BALTEX): climate Baltic Stern: costs and benefits of combating eutrophication ECORD: consortium of deep-sea drilling for research	ECORD	Usually bottom-up initiatives by research organisations; facilitate development of research on specific issues; often catalyse preparation of strong research project proposals, promote synthesis of research results

* Denmark, Germany and Sweden may be considered as both the Baltic Sea and the North Sea states

also gives a bold message about the level of the societal interest devoted to their protection and exploitation of their resources.

Note that the same research article often addresses more than one thematic area.

The Table 12 below summarises and compares several features of networking and cooperation in marine and maritime research and innovation across the Baltic Sea and the North Sea macroregions.

What is now urgently needed to boost further development and successful implementation of all facets of the EU integrated maritime policy, as well as the blue growth strategy and ultimately reaching the headline targets of the Europe 2020 Strategy, is achieving more coordination in the use of the massive research and innovation assets across the national borders of the countries surrounding the Northern European regional seas. If this is succeeded, Europe will have, in addition to the enormous immediate benefit in the two maritime macroregions inhabited by 270 million people, an example and a test-bed of new approaches towards building what would be called a pan-EU marine and maritime research and innovation area.

It is obvious that integration and coordination across the national borders bring such benefits as avoiding duplication (not only among the member states, but also between the member states and the EU research and innovation framework), more efficient use of the existing research infrastructures and development of the new ones, more competition leading to enhanced quality and smart specialisation, larger critical mass to tackle the most ambitious objectives, and a joint market place for growing and optimal dislocation of the human capacity. At the same time, there are a number of hindrances that slow the progress and challenges that will need to be overcome while building marine and maritime ERA.

Glossary

ACCSEAS – Accessibility for Shipping, Efficiency Advantages and Sustainability

AIS – Automatic Identification System, a HELCOM expert working group

Article 185 of the Treaty on the Functioning of the European Union – Enables the EU to participate in research programmes undertaken jointly by several Member States, including participation in the structures created for the execution of national programmes.

BALTEX – The Baltic Sea Experiment

Baltic Stern – Baltic Systems Tools and Ecological-economic evaluation- a Research Network.

BSR Stars – A programme within the EU Strategy for the Baltic Sea Region

Bonn Agreement – A mechanism by which the North Sea States, and the European Union (the Contracting Parties), work together to help each other in combating pollution in the North Sea Area from maritime disasters and chronic pollution from ships and offshore installations

BONUS EEIG – Baltic Organisations' Network for Funding Science, European Economic Interest Grouping

BSEP – Baltic Sea Environment Proceedings, publication series of HELCOM

BSPC – Baltic Sea Parliamentary Conference

CBSS – Council of the Baltic Sea States

CFP – Common Fisheries Policy

COFASP – Cooperation in Fisheries, Aquaculture and Seafood Processing ERA-NET

DDE – Dichlorodiphenyldichloroethylene

DG MARE – Directorate-General for Maritime Affairs and Fisheries

Directive 2008/56/EC – The Marine Strategy Framework Directive

DPSIR – The causal framework for describing the interactions between society and the environment adopted by the European Environment Agency: driving forces, pressures, states, impacts and responses.

ECO-INNOVERA – ERANET project focusing on the support of eco-innovation in research and development.

ECORD – European Consortium for Ocean Research Drilling

ECORYS – A research and consulting company

EEA – European Economic Area

ERA – European Research Area

ERA-NET – EUs funding scheme for cooperation and coordination of research activities

ERA-NET PLUS – EUs funding scheme for topping up joint multinational calls for research, development and innovation projects

ERA-MBT – The Marine Biotechnology ERA-NET

EU – European Union

Europe 2020 Strategy – EU's growth strategy for the coming decade

HCH – Hexachlorocyclohexane

HELCOM – Baltic Sea Environment Protection Commission

Horizon 2020 – European Union's Framework Programme for Research and Innovation launched in 2014

ICES – International Council for the Exploration of the Sea

JPI OCEANS – Joint Programming Initiative "Healthy and Productive Seas and Oceans"

MARTEC II – Maritime Technologies as an ERA-NET

MSFD – Marine Strategy Framework Directive

MSP – Maritime Spatial Planning

NEWA – New European Wind Atlas ERA-NET PLUS

OCEANERA – Ocean Energy ERA-NET

OSPAR – Convention for the Protection of the Marine Environment of the North-East Atlantic

PAHs – Polycyclic aromatic hydrocarbons

PCBs – Polychlorinated biphenyls

STECF – Scientific, Technical and Economic Committee for Fisheries

t N/a – Tonnes of Nitrogen per annum

t P/a – Tonnes of Phosphorus per annum

TBT – Tributyltin

VASAB – Visions and Strategies around the Baltic Sea

WFD – Water Framework Directive

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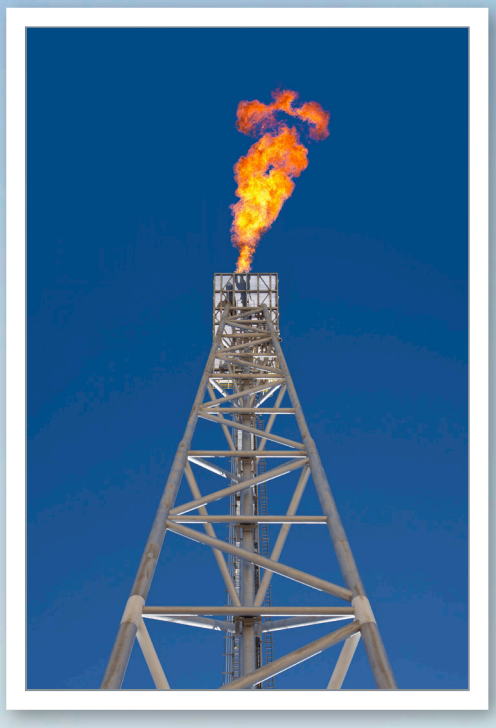

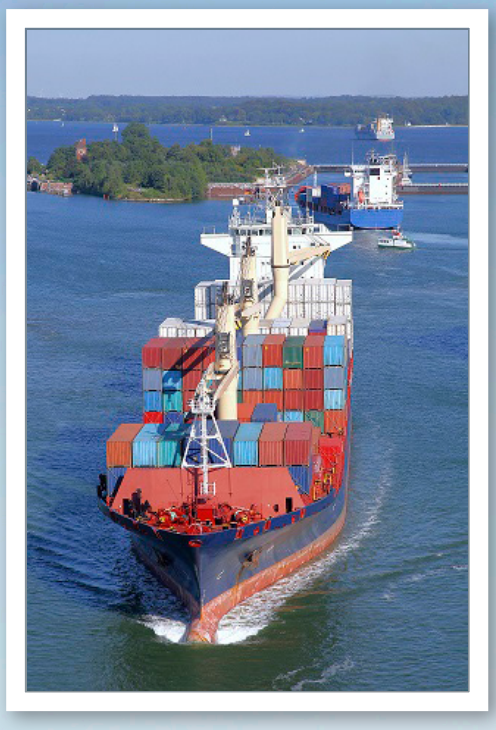

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