

**BONUS-169 BALTIC SEA SCIENCE PLAN
AND IMPLEMENTATION STRATEGY**

**Assignment concerning BONUS Task 2.5:
Potential Future Transnational Research Schemes (Coordinator: ICES)**

By

Christopher C.E. Hopkins

International Council for the Exploration of the Sea: chris.hopkins@aquamarine.se

Jan Thulin

International Council for the Exploration of the Sea: jan@ices.dk

Jon G. Sutinen

University of Rhode Island: JSutinen@uri.edu

In Collaboration with:

Kaisa Kononen

Academy of Finland: kaisa.kononen@aka.fi

Pauli Snoeijs

University of Uppsala: pauli.snoeijs@ebc.uu.se

Sif Johansson

Swedish Environmental Protection Agency: sif.johansson@naturvardsverket.se

Hans-Ortwin Nalbach

Germany Federal Ministry of Education & Research: hans-ortwin.nalbach@bmbf.bund.de

Summary:

The Baltic Sea ecosystem is seriously impacted by many naturally and human caused pressures. This has reduced the capacity of the Baltic Sea to sustainably provide the goods and services upon which humans depend directly and indirectly for social, cultural and economic benefits. At the regional seas level in the European Community, the Marine Strategy and the Maritime Policy have recently been introduced to holistically integrate, focus and make more effective a raft of national and international policies, agreements and regulatory instruments for reducing marine pollution, conserving exploitable living resources and biodiversity, and tackling climate change while also ensuring sustainable human socioeconomic development. An important constituent is elaboration and implementation of the 'ecosystem approach to the management of human activities' in the European regional seas, the success of which must be supported by appropriate research and technological development (RTD) across a wide range of scientific disciplines. Currently, the nine Baltic Sea States cooperate to set priorities and carry out concerted actions in international management and regulatory forums concerning the marine environment and living resources. However, there is a lack of corresponding pan-Baltic collaboration for coordinating the funding and the implementation of the RTD that is needed to effectively address the Baltic Sea's transboundary environmental problems.

As result of the above-mentioned considerations, the eight Baltic Sea States of the European Union together with the Russian Federation and the European Commission aim to establish BONUS (Baltic Organizations' Network for Funding Science) to implement a joint programme under Article 169 of the European Community Treaty. The mission of BONUS is to fund and implement a joint Baltic Sea regional research programme, called BONUS-169, thereby establishing durable cooperation of the Member States' research policies and their scientific communities in order to support the sustainable development of the Baltic Sea region. The goal of BONUS-169 is to create a cooperative, interdisciplinary, well integrated and focused transnational research programme in support of the Baltic Sea region's sustainable development, by providing scientific outputs that facilitate the implementation of ecosystem-based management of the Baltic Sea environmental issues. It will enhance our understanding and predictive capacity about the Baltic Sea ecosystem's response to impending changes caused by both naturally and human induced pressures and about linkages between environmental problems and the social and economic dynamics in responding to them. In turn, it will form the basis for prudent management aimed at safeguarding the sustainable use of the ecosystem's goods and services. The specific objectives of BONUS-169 are manifested in the eight interlinked Themes that together form the core of the Science Plan: 1) Linking science and policy; 2) Understanding climate change and geophysical forcing; 3) Combatting eutrophication; 4) Achieving sustainable fisheries; 5) Protecting biodiversity; 6) Preventing pollution; 7) Integrating ecosystem and society; and 8) Strengthening collaboration and use of common resources.

BONUS-169 will act as a regional sea demonstration programme bridging science and policy, underpinning the European Marine Strategy and Maritime Policy. Lessons learnt and best practices will be exchanged with other European regional seas and regional seas elsewhere. The programme will also promote activities to foster the whole Baltic Sea Research Area—including four new Member States and the Russian Federation—through the formation of a Baltic Sea Research Council, and to cross the national borders of basic research towards application and dissemination of knowledge to wider society and users.

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1 BACKGROUND

Within the European Research Area (ERA), the European Community's (EC) Sixth Framework Programme (FP6) for Research and Technological Development (RTD) aims *inter alia* at better coordination of research activities and the convergence of research and innovation policies at national and Community levels, leading eventually towards formation of a 'common market' for RTD goods and services. The ERA-NET *BONUS for the Baltic Sea – Network of Funding Agencies* has been funded by FP6 from 2004 – 2007 to 'form a network and partnership of key agencies funding research with the aim to deepen the understanding of conditions for science-based management of environmental issues in the Baltic Sea'. BONUS has worked vigorously to strengthen cooperation between these funding agencies and create conditions for a joint Baltic Sea research and researcher training programme—called BONUS-169—under Article 169 of the EC Treaty, involving the eight EC Member States¹ together with the Russian Federation and the European Commission.

Invoking Article 169² of the Treaty is a potentially powerful, but rarely used, tool for integrating national and EC research policies. In BONUS-169, the eight EC Baltic Sea States propose to act, as members, together with the Russian Federation as an associate member, but with *de facto* full rights, to establish a 'common structure' set out as a European Economic Interest Grouping (EEIG). Accordingly, the Russian Federation has equal rights and obligations as set out in the EEIG Statutes, including a special association agreement with 'as-if-treatment', *i.e.* as if Russia were an EU Member State. Russian participation in BONUS-169 meets the objectives of the Common European Research Space between Russia and the EU as depicted by the EU – Russia Summit Meeting in May 2005. Under BONUS-169, planned to run from 2008 - 2012, the nine Baltic Sea States envisage establishing a virtual 'common pot' for integrated funding of openly competed, peer-reviewed research and analysis. Research needs may arise from science but with clear relevance for redressing the environmental problems in the Baltic Sea area. Under Article 169, besides the Member States, the Community will contribute to this integration by funding the joint research programme. With reference to the year 2004, for example, it has been shown that 71 per cent of the Baltic Sea projects were funded at national level, 25 per cent were financed by the EC, and a further three per cent were Nordic cooperation projects. The total funding from all three sources was EUR 52 million³.

As a BONUS ERA-NET product, a *Framework Proposal for the BONUS-169 Baltic Sea Science Plan* was published and circulated in August 2005 for extensive consultation and feedback. In developing a science plan for the future, it is extremely important for the success of the plan that top-down planning (*e.g.* environmental problem orientated) and bottom-up input (*e.g.* question-driven priorities of scientists and research organizations) are effectively coupled. Accordingly, between September 2005 and September 2006, the nine Baltic Sea States individually arranged and reported on consultations concerning the Plan—involving over 800 active scientists and stakeholders in the region—with a view to identifying priorities and gaps. The feedback from these consultations helped focus the scope and substance of the *BONUS-169 Science Plan*, as well as firming up the issues and topics constituting the Plan's thematic basis. The process for developing the Science Plan is shown in **Annex 1**.

BONUS-169 aims to create a cooperative, interdisciplinary research programme in support of the Baltic Sea region's sustainable development by developing scientific knowledge to facilitate the transnational ecosystem-based management of the Baltic Sea environmental issues. It will improve our understanding and predictive capacity about the Baltic Sea ecosystem's response to impending changes caused by both naturally and human induced pressures. It will also reveal linkages between environmental problems and the social and economic dynamics in responding to them. Thus, BONUS-169 provides a regional contribution to addressing key global challenges: climate change, the impact of increasing encroachment of human activities

¹ Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden.

² For further information see <http://www.cordis.lu/coordination/art169.htm>. The main objective is to go beyond mere coordination of national programmes to achieve an integration of the different national and regional programmes in a single joint one. The basic selection criteria are: 1) involvement of enough Member States to obtain a significant structuring effect and critical mass; 2) the topic is of great interest to the Community and fits with the thematic properties of the Framework Programme; 3) the principles of co-funding by Member States and Community, and of additionality are respected; 4) there is sufficient European value-added; and 5) Article 169 is the only way the project/programme could be implemented.

³ BONUS 2005. Baltic Sea research and R&D funding in 2004. BONUS Publication No. 3. 96 pp.

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on coastal and offshore areas, and the consequences of these pressures on ecosystem structure and function. In turn, BONUS-169 will form the scientific foundation for prudent management, through integration and transfer of knowledge to wider society and users, aimed at safeguarding the sustainable use of the ecosystem's goods and services.

Since the 1970s, pressing needs to limit marine pollution and conserve exploitable living resources resulted in the proliferation of international management and regulatory Conventions, and other instruments, in the European regional seas, *e.g.* North-East Atlantic, North Sea, Baltic Sea, Mediterranean Sea, and Black Sea. The *ecosystem approach to management* (EAM) has been adopted during the last decade as a fundamental tool for achieving sustainable development, and has been integrated into the Conventions and the workplans of the implementing international Commissions. The EAM was defined, at the First Joint Meeting of the Helsinki and OSPAR Commissions (25-26 June 2003, Bremen, Germany), as: *'the comprehensive integrated management of human activities based on the best available scientific knowledge about the ecosystem and its dynamics, in order to identify and take action on influences which are critical to the health of marine ecosystems, thereby achieving sustainable use of ecosystem goods and services and maintenance of ecosystem integrity'*. The 2005 European Thematic Strategy on the Protection and Conservation of the Marine Environment ('Marine Strategy') and the accompanying Marine Strategy Directive—forming the environmental pillar of the emerging 'Maritime Policy' (*c.f.* 2006 Maritime Green Paper: Towards a Future Maritime Policy for the Union: A European Vision for the Oceans and Seas)—aim *to promote sustainable use of the seas and to conserve marine ecosystems* and requires Member States to cooperate wherever possible at the level of existing Regional Seas Conventions. To gain a solid basis for well-informed, successful and cost-efficient decision-making, it is essential that we increase our knowledge of the oceans and seas, through research and technological development (RTD).^{4 5}

Implementation of BONUS-169 under FP7 will achieve the formation of a Baltic Sea Research Area that is funded and supported by a Baltic Sea Research Council. In so doing, it will amplify the critical mass and combat fragmentation in the marine sciences, including bringing together closer collaboration between the basic and applied research communities across many disciplines. Furthermore, BONUS-169 will substantially advance coordination and complementarity among the Baltic Sea States. It will establish cohesive scientific priorities and activities, whereby excellence in marine research, technology and innovation, complemented novel approaches in social and economic sciences actively support the Marine Strategy and Maritime Policy. BONUS-169 acts as a demonstration programme, bridging science and policy, whereby lessons learnt and best practices will be exchanged with the other European regional seas and regional seas elsewhere.

2 THE BALTIC SEA ECOSYSTEM

2.1 Intensifying human encroachment and environmental consequences.

The Baltic Sea is a semi-enclosed European inland sea forming one of the world's largest brackish water bodies. It is surrounded by nine Baltic Sea coastal States: Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russian Federation, and Sweden. However, the drainage basin emptying into the Baltic Sea has a population of about 95 million people, from 14 States, situated in a catchment area that is about four times larger than the area of the sea. About 33% of this population lives within 50 km of the coast. Since formation of the Baltic Sea about 8 000 years BP, the region has been a major focus of human habitation attracted by the natural beauty and rich resources of the coastal and offshore areas. These resources have historically provided the basis for food security and trade within the region and with other regions, as well as many other socioeconomic benefits.

Particularly since the industrial revolution, and manifestly so today, human populations and their activities⁶ have not only benefited from but also increasingly exerted pressures on the Baltic Sea ecosystem. These

⁴ Speech by Commissioner Joe Borg 'How can marine research contribute to the Maritime Policy?' at the European Parliament Conference on the Future of European Marine Scientific Research, Brussels, Belgium, 17 October 2005.

⁵ Speech by State Secretary Stefan Wallin, Ministry of the Environment, Finland, at EU Maritime Policy Conference in Turku, Finland, 19-21 July 2006.

⁶ Examples are coastal engineering and land reclamation, and industries such as agriculture and forestry including pulp and paper production, the production of iron and steel, chemicals and petrochemicals including oil and gas exploration

pressures have caused the intensive and unsustainable exploitation of many fish stocks and other resources, pollution from harmful and hazardous substances (*e.g.* heavy metals, persistent organic pollutants, radioactivity, and oil spills), excessive inputs of nutrients and organic material leading to the effects of advanced eutrophication, introductions of alien organisms, and other diverse forms of ecological disturbances. This has resulted in serious depletion of vulnerable species and the degradation of sensitive habitats, some of which are in danger of local extinction, as well as causing changes in environmental quality, and the structure, function and integrity of the ecosystem. Contaminants, such as persistent organic pollutants (*e.g.* DDT, PCBs and dioxins) and heavy metals, have accumulated via the food web causing health problems in several biota (*e.g.* benthos, birds and marine mammals), and levels of some pollutants in seafood (*e.g.* fatty fish and shellfish) constitute a health risk for humans in some areas. These degradations in ecosystem health have resulted in associated detrimental human socioeconomic impacts. Additionally, the impacts of human induced climate change and global warming on the Baltic Sea ecosystem is of major concern and is anticipated to have substantial impacts on human communities.

The Baltic Sea ecosystem is characterized by fluctuations in the natural environment connected with infrequent and sporadic flushing of the deeper basins with more oxygenated water from outside, followed by stagnation periods frequently lasting many years with declining levels of oxygen. The delicate status of the Baltic Sea ecosystem is particularly susceptible to the effects of climatic and oceanographic variation and change, including the frequency and magnitude of saltwater intrusions causing flushing and increased oxygenation in the deeper basins, as well as by the volume and quality of run-off connected with the effects of leaching and dispersal of nutrients and pollutants. Additionally, the low biodiversity of the Baltic Sea ecosystem—associated with the brackish water being too salty for most freshwater species and too fresh for most marine species—and the short ecological history of the Baltic, places many plant and animal species near the periphery of their physiological and ecological tolerance, making them particularly vulnerable to human-caused stresses.

2.2 Changing environmental and geopolitical perspectives: The case for a transnational Baltic Sea research programme.

Numerous international conventions, agreements and other instruments contribute to the protection of coastal and offshore environment and biodiversity, and fisheries conservation, of the Baltic Sea (**Annex 2**). In 2004, a major geopolitical development occurred in the Baltic Sea region when Estonia, Latvia, Lithuania, and Poland acceded to the European Union, joining Denmark, Finland, Germany and Sweden – thereby leaving the Russian Federation as the sole non-EU coastal Baltic State. Accordingly, many EC strategies, policies and directives (**Annex 3**) apply to the marine environment, and living marine resources including fisheries and biodiversity, in the Community waters of the Baltic Sea. Within its Exclusive Economic Zone, a body of national legislative and administrative instruments regulates the fisheries and environmental management systems in the Russian Federation.

In particular, the inherent key feature of the Marine Strategy and the Maritime Policy is the interlinkage of science, policy and management of the European regional seas (*e.g.* the Baltic Sea, North Sea and the Mediterranean Sea). The Strategy and its associated Directive are designed to play a central role in promoting sustainable development, by aiming to achieve good environmental status of the Community's marine waters by 2021 and to protect the resource base upon which marine-related economic and social activities depend.

A key element of the Marine Strategy and Directive is implementation of the integrated ecosystem approach to management to achieve 'good environmental status. This will be achieved through cooperation between Member States cooperating at the regional sea level within the framework of existing regional seas Conventions (*e.g.* the new Baltic Sea Action Plan of HELCOM, the Baltic Marine Environment Protection Commission). Synergies exist with other Community policies such as the Maritime Policy Green Paper and relevant water legislation (*e.g.* Water Framework Directive), and continued efforts to improve integration and cooperation with third parties beyond the Community (*e.g.* Russian Federation). Thus, the 2004 enlargement of the Community in the Baltic Sea region has significant implications on the land, coastal and

and production, power generation, as well as mining and mineral and aggregate extraction, dredging and dumping of materials including garbage and litter, fisheries and aquaculture, shipping, and tourism and recreation.

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marine policies of the Baltic Sea States, especially regarding the application of various strategies, policies and instruments concerning agriculture, transport, environment, fisheries, water resources and scientific research. The Community must face the challenge of developing and applying a more proactive strategy for collaboration with the Russian Federation in research, assessment and management to achieve improved conservation and restoration of the environment and the living resources of the Baltic Sea, and to ensure the sustainable development of the region.

Although the Baltic Sea is one of the most scientifically investigated sea areas in the world, research traditions and capability vary substantially among coastal States, and also with respect to the breadth and depth, as well as degree of development, of the various relevant science disciplines. The amount of data and literature concerning the chemistry, hydrography, and fauna and flora of the Baltic Sea is abundant but often nationally scattered in numerous languages. Thus, studies synthesizing and combining the data and information sources across and between sub-regions of the Baltic Sea are generally scarce. A thorough exploitation of the existing knowledge is the foundation of new research. Furthermore, each State has tended to develop its own particular funding priorities and activities in basic and applied research independently of the other States. Thus, at an overarching level, there is a limited awareness of each other's research portfolio and how and why it is deployed. In turn, there is a lack of Baltic-wide transboundary research consultation, planning, coordination and concerted action necessary to provide the scientific knowledge and predictive capacity to effectively tackle the environmental challenges facing the Baltic Sea ecosystem. The Baltic Sea States cooperate to set priorities and carry out concerted actions in international management and regulatory forums concerning the marine environment and living resources. However, the Baltic Sea research situation contributes to fragmentation, restricts complementarity and limits achieving of critical mass, and not least hinders the dissemination of best practices and lessons learnt.

Professional networks are a necessary precondition for collaboration in the modern scientific world. The networking of marine scientists in the Baltic Sea region has a long history starting in the early 20th century, through the establishment in 1902 of the International Council for the Exploration of the Sea (ICES), organizing Conferences of Baltic Hydrographers from the 1920s onwards and establishment of three scientific associations: the Baltic Marine Biologists (BMB), the Conference of Baltic Oceanographers (CBO) and Baltic Sea Geologists (BSG) in the 1960s and thereafter. Following its foundation in 1974, HELCOM has established a system of scientific working groups. Starting in the 1990s, several EU-funded projects have provided new platforms for the networking of scientists within and outside the Baltic Sea region⁷. An important existing regional networking forum is the biennial Baltic Sea Science Conference. However, an obvious gap in the Baltic Sea science networking is the lack of a platform for wider interdisciplinary communication which would give scientists from the natural, social, economic and other fields an opportunity to learn from each other and consider Baltic Sea environmental issues in multi-, inter- and transdisciplinary ways.

There is no cause for complacency regarding the environmental threats facing the Baltic Sea region: existing problems and emerging issues need to be actively addressed and resolved. In order to be successful, there is a pressing need to build, mobilize and further integrate 'core science' capabilities on a pan-Baltic scale in order to underpin the sustainable development of the Baltic Sea with regard to ecosystem-based management. In this context, many States will benefit from collaboration in capacity building, in terms of knowledge, human expertise and facilities. To this end, research institutions should be encouraged to further coordinate their use of infrastructure, network building and collaboration with a view to enhancing capacity development and interchange in the region.

3 BONUS-169 JOINT BALTIC SEA REGIONAL PROGRAMME

As result of the above-mentioned considerations, the eight Baltic Sea States of the European Union together with the Russian Federation and the European Commission aim to establish BONUS (Baltic Organizations' Network for Funding Science) to implement a joint programme under Article 169 of the European Community Treaty. ***The mission of BONUS is to fund and implement a joint Baltic Sea regional research programme, called BONUS-169, thereby establishing durable cooperation of the Member States' research***

⁷ See BONUS 2005. Baltic Sea Research and R&D Funding in 2004. BONUS Publication No. 3.

policies and their scientific communities in order to support the sustainable development of the Baltic Sea region.

3.1 Programme goal and objectives

The goal of BONUS-169 is to create a cooperative, interdisciplinary, well integrated and focused transnational research programme in support of the Baltic Sea region's sustainable development, by providing scientific outputs that facilitate the implementation of ecosystem-based management of the Baltic Sea environmental issues. It will enhance our understanding and predictive capacity about the Baltic Sea ecosystem's response to impending changes caused by both naturally and human induced pressures and about linkages between environmental problems and the social and economic dynamics in responding to them. In turn, it will form the basis for prudent management aimed at safeguarding the sustainable use of the ecosystem's goods and services.

BONUS-169 will represent an interdisciplinary scientific model-system for the European regional seas by linking science and management that is inherent in the European Marine Strategy and Marine Policy. It will provide a regional contribution to addressing key global challenges: Climate change, the impact of increasing encroachment of human activities on coastal and offshore areas, and the consequences of these pressures on ecosystem structure and function.

BONUS-169 is a fully fledged framework programme for regionally focused research. Besides its main activity, *i.e.* publishing Calls for specific projects aimed at a series of topics within its strategy, BONUS-169 will also promote activities to foster the whole Baltic Sea Research Area and associated Baltic Sea Research Council – including four new Member States and the Russian Federation - and to cross the national borders of basic research towards wider application and dissemination of knowledge. **The goal is achieved by application of five specified instruments:**

1. RTD activities linked directly to creating prudent, long-term, holistic interdisciplinary solutions involving sustainable use of the Baltic Sea, by:
 - a) Understanding and quantifying the role of climate change and variability, and its implications for the dynamics of the region's ecosystems and associated impacts on human communities;
 - b) Understanding the physical, chemical and biological functioning of marine ecosystems, and understanding and quantifying human impacts (*e.g.* pollution including eutrophication, unsustainable fisheries and aquaculture, and degradation of habitats and ecosystems) on the Baltic Sea environment and its biodiversity and human well-being;
 - c) Developing the scientific basis for sustainable use and protection of the Baltic Sea ecosystem and its associated biodiversity, recognizing the essential benefits arising from socioeconomic development while also realizing the responsibility to conserve, and where appropriate restore, ecosystem health and the production potential of natural capital.

These research activities will be initiated by Calls to the scientific community that will each refer to specified topics originating strategically from the BONUS-169 Science Plan.

2. Activities (including workshops and conferences) linked to networking and coordinating the region's nationally funded research by more closely promoting, planning, funding, implementing, and publicizing pan-Baltic research. A high priority will be given to developing mechanisms to jointly use scientific infrastructure and facilities, including the existing data of universities and research institutions in different countries.
3. Activities linked to bridging the gap between science and users by ensuring that the initiatives and outputs of the region's scientific community better reflect the research needs connected with sustainable development of the Baltic Sea, while also better synthesizing and disseminating research outcomes for improved receptivity and utilization in policy and decision-making. To reach these goals, social, economic and political sciences will be integrated into the RTD-based Calls.
4. Activities linked to educating and training new generations of young scientists to apply novel concepts and technologies for the above-mentioned purposes. BONUS-169 views it as a key task to facilitate integration of the new Member States and the Russian Federation into the European

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Research Area by *inter alia* vigorously involving early stage researchers (ESRs) in all relevant programme-related activities. The programme encourages participation of ESRs in the responses to the topic-related Calls, as well as by application of a wide range of EC instruments related to furthering ESR mobility, secondments, exchanges and Research and Training Networks (RTN).

5. Activities linked to ensuring the development, visibility and sustainability of the joint Baltic Sea Research Programme and to promoting transfer of its achievement to other European regional seas.
 - a) Activities promoting the joint Baltic Sea Research Programme to ensure a high profile in European and international levels;
 - b) Regular reporting the implementation of the joint Baltic Sea Research Programme with special emphasis on its public-interest value;
 - c) Establishing regular channels for exchanging information, lessons learnt and best practices with regulatory bodies of European regional seas (*e.g.* HELCOM, OSPAR, Black Sea Commission, Mediterranean Commission on Sustainable Development).

Such activities will include workshops, conferences, joining regional events with exhibitions, open-days involving research institutes and vessels for the public (*e.g.* schools), journalist seminars, utilization of internet and printed information and contributions to TV.

The BONUS-169 programme will combine relevant fundamental research aimed at improving our understanding of the Baltic Sea ecosystem with highly focused strategic research aimed at solving specific problems of high societal priority. BONUS-169 will, in the long term, produce a wide range of science-based deliverables progressing the state-of-the-art, best practice and lessons-learnt connected with the topics addressed by the eight Themes forming the core of the programme

The specific objectives of BONUS-169 are manifested in the titles and content of eight interlinked Themes (Fig. 1) that are further elaborated in Section 3.4.

3.2 Deliverables expected from the implementation of BONUS-169

Beyond the publication of scientific papers in the peer-reviewed literature, prominence will be given to transferring the results to various stakeholders and to raising wider public awareness and understanding of the need to practice effective stewardship of the Baltic Sea ecosystem. BONUS-169 will provide the scientific basis for improved management and regulation with respect to improved implementation of Community Policy according to the European Marine Strategy and the Maritime Policy, and pertinent associated Directives and instruments.

The deliverables will focus on substantially enhancing scientific knowledge, understanding, and capacity including training and education. This will be facilitated by developing and applying dedicated data-sets and databases on a Baltic-wide basis, from field and laboratory studies, innovative methodology, and analyses including scenarios and models. Improved software and hardware/equipment production for common use is encouraged. Information and presentational material will be produced and made available on a dedicated website including newsletters, videos, reports and breaking-news. Workshops, conferences and exhibitions will be arranged and associated reports produced. Emphasis is placed on actions and measures to increase interdisciplinary collaboration and redress scientific fragmentation.

Climate change, eutrophication, pollution, unsustainable fisheries including aquaculture, degradation of biodiversity, and increasing human encroachment represent major threats to the status of the Baltic Sea environment and ecosystem⁸⁹¹⁰¹¹. Accordingly, these threats and their human socioeconomic consequences

⁸ HELCOM 2003. The Baltic marine environment 1999 – 2002. Baltic Sea Environment Proceedings No. 87. 48 pp.

⁹ ICES 2003. Environmental Status of the European Seas. A Quality Status Report Prepared by the International Council for the Exploration of the Sea for the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. 75 pp.

¹⁰ UNEP 2005. Lääne A., E. Kraav & G. Titova. Baltic Sea, GIWA Regional Assessment No. 17. University of Kalmar, Sweden.

¹¹ BALTEX - HELCOM 2006. Climate change in the Baltic Sea area. Draft HELCOM Thematic Assessment in 2006. HELCOM Stakeholder Conference on the Baltic Sea Action Plan. Helsinki, Finland.

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form the focus of the BONUS-169 research, in which the importance of closer linking science and policy, and strengthening collaboration and use of common resources at the pan-Baltic level, are emphasized as important constituents for programme success. With this in mind, the main deliverables anticipated to be provided by BONUS-169 are listed in **Table 1**. As the precise nature of the actual deliverables is highly dependent on the response manifested by the science community to the Call for project proposals, the list below is limited to the broad-spectrum level. More specific details, of greater interest to the research community, are provided under Section 3.4 Research Themes.

Table 1. *The main BONUS-169 deliverables¹² sorted by principal areas of programme focus.*

No.	Linking science and policy
1	Better capacity to detect, predict and mitigate environmental problems and risks in a coherent and holistic manner. It will increase the usability of research products from the Baltic Sea science community for wider human society.
2	More effective bridging between science and policy. It will establish a novel research area, actively promote dialogue, exchange of research results, lessons learnt and best practices with users and other stakeholders in the Baltic Sea area, other European regional seas and regional seas elsewhere.
3	Promotion of the ecosystem approach to the management of human activities (EAM ¹³). It will facilitate novel integration of transnational research outputs across the natural, technological, social, economic and political sciences.
4	Support for integrated coastal zone management involving diverse human activities, industries, and managers/regulators.
5	Environmental outlooks, scenarios and models for exploring future developments of the Baltic Sea ecosystem. They will have implications for policy actions, including socioeconomic consequences.
6	Support for the European Commission's Environment Directorate General (DG) and DG Fisheries and Maritime Affairs, HELCOM, the European Environment Agency, and the advisory function of ICES. It will improve implementation of the EAM, the Marine Strategy and Maritime Policy, and associated Directives and instruments in the Baltic Sea area.
7	Instruments to support conflict-resolution at cross-sector levels, including communication strategies and social impact assessments.
8	Scientific information on priorities and preferences of the general public on the environmental problems of the Baltic Sea that can be used in EAM decision-making.
9	Improved design, implementation and evaluation of the efficacy of pertinent public policies and governance.
10	Better integration of national and European Community policies, and improved scientific and policy integration and cooperation with third parties beyond the Community (<i>e.g.</i> Russian Federation).
No.	Large scale ecosystem threats and changes including responses and mitigation
1	Robust and credible tools for quantifying and predicting how climate change and variability, eutrophication, pollution, fisheries, and increased human encroachment interact to alter the Baltic Sea and its sub-regions. These will benefit environmental quality, ecosystem health and productivity of the living resources, and sustainable human socioeconomy. Furthermore, they will promote active collaboration between scientists working with different ecosystem components.
2	Innovative observation and surveillance methods and strategies to support holistically integrated assessments of changing status and trends. They involve superior operational forecasting and modelling systems for early warning of current and impending changes and risks.
3	Novel and scientifically robust methods for environmental risk/impact assessment and management that can be applied prospectively (for prevention) and retrospectively (for remediation).
4	Novel analyses and dynamic models of human activities explicitly linked to the Baltic Sea ecosystem components. These will explain and forecast the activities as well as prominent human responses to changes in the ecosystem.
5	Ecological and socioeconomic cost-benefit analyses and models examining causes and effects of different environmental developments, options and targets. They will address cost-efficient abatement and remedial measures.
6	New scientific support for effective and adaptive management, regulatory and mitigation/remedial measures to combat eutrophication, achieve sustainable fisheries, protect biodiversity including loss of vulnerable species and habitats, and prevent pollution.

¹² Deliverables are work *products* and constitute the substantiation of programme/project implementation.

¹³ The definition of the EAM, according to HELCOM and OSPAR and agreed by the European Commission, is provided in Section 1 (Background) of the Science Plan.

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7	Improved awareness of the coupling between ecosystem health and human health and well-being.
No.	Strengthening collaboration and use of common resources
1	Establish the ‘Baltic Sea Research Council’ that will provide coordinated BONUS-169 programme funding for openly competed, peer-reviewed scientific research. This will increase the volume and quality of international scientific publications on Baltic Sea environmental issues.
2	Create an European Economic Interest Grouping (EEIG) to act as a legal entity representing the Baltic Sea Research Council. This includes structures for programme governance, management, advisory support, coordination of Calls for research proposals and joint evaluation processes.
3	Coordinated co-funding of joint activities (<i>e.g.</i> workshops, working groups, conferences, inter-calibration exercises) with other European and global programmes. This will provide more effective exploitation and dissemination of scientific results and policy-related collaboration with other parties.
4	Well-harmonized network for education, training and exchange schemes including development of a BONUS-169 Education and Training Plan. This will be linked to the existing educational network called the Baltic University Programme and advance the educational standards of young scientists in an interdisciplinary manner.
5	Intensified networking, knowledge dissemination, communication, and information flow. This will involve various scientific interest groups (<i>e.g.</i> universities and research institutes), national, European and wider international funding agencies, policy-makers and other users of research outputs.
6	More efficient use and sharing of currently available marine research infrastructures and promoting development of new RTD infrastructures.
7	Better matching of RTD excellence, funding and infrastructure.
8	Openly accessible, common databases of all data collected by or freely donated to the programme in accordance with the production of a BONUS-169 Data Policy.

3.3 Funding policy

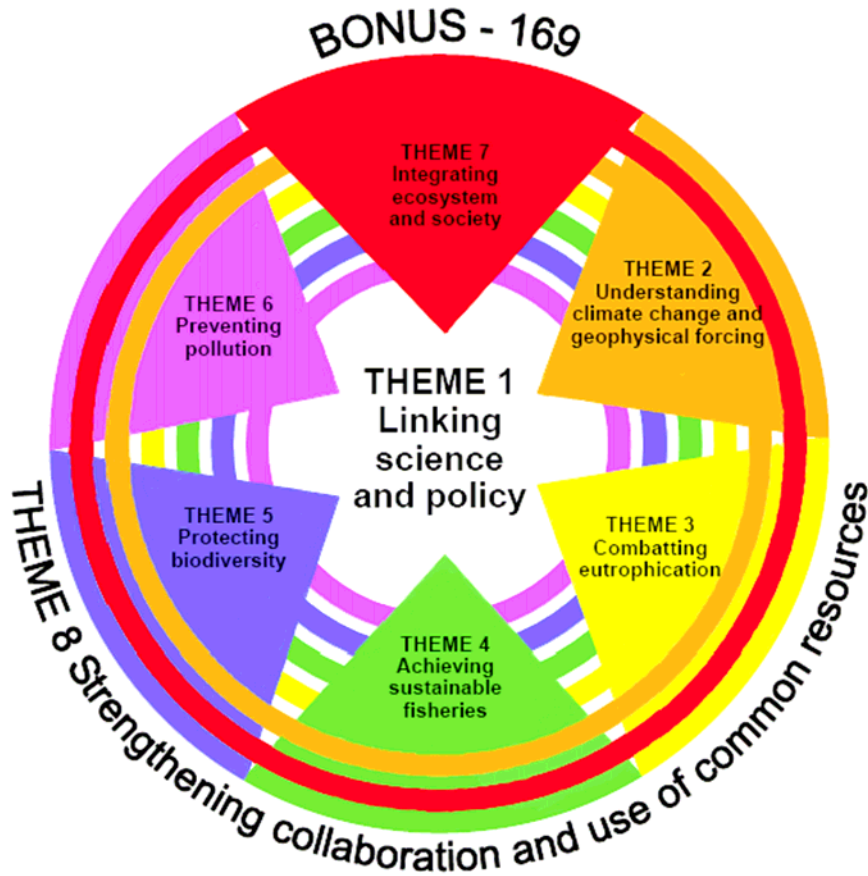
The RTD activities in BONUS-169 include funding of openly competed, peer-reviewed research and analysis, where needs may arise from science but with clear relevance for redressing the environmental problems in the Baltic Sea area.

The focus of the funded research is the Baltic Sea ecosystem. This includes research carried out in the Baltic Sea drainage area when a clear cause-and-effect linkage to the environmental problems of the Baltic Sea can be demonstrated. Important issues for BONUS-169 are the promotion of innovative research ideas, new tools and techniques and integration between human society and a healthy ecosystem, including socioeconomic analyses. An important overall objective is differentiating between naturally and human induced pressures, and discovering their interactions and combined effects, which change the Baltic Sea ecosystem and understanding the related consequences (*e.g.* impacts, costs and benefits) for human communities. The programme aims to promote stronger multi- and interdisciplinary research within the Baltic Sea science community, while retaining core activities. The programme aims at facilitating the dissemination of the science outputs for use by a wider public including national and international advisory bodies and executive authorities. A conceptual sketch of the supply chain running from scientific research to regulation and management is shown in **Fig. 2**.

Cooperation across national boundaries and disciplines will be stimulated by prioritizing the funding of research activities initiated and carried out by at least two Baltic Sea States. Partners from other Community States and third parties may be funded in collaboration with Baltic Sea States when specific expertise or facilities, not existing in the Baltic Sea States, are brought into the project. **Annex 4** provides a definition of terms connected with BONUS-169.

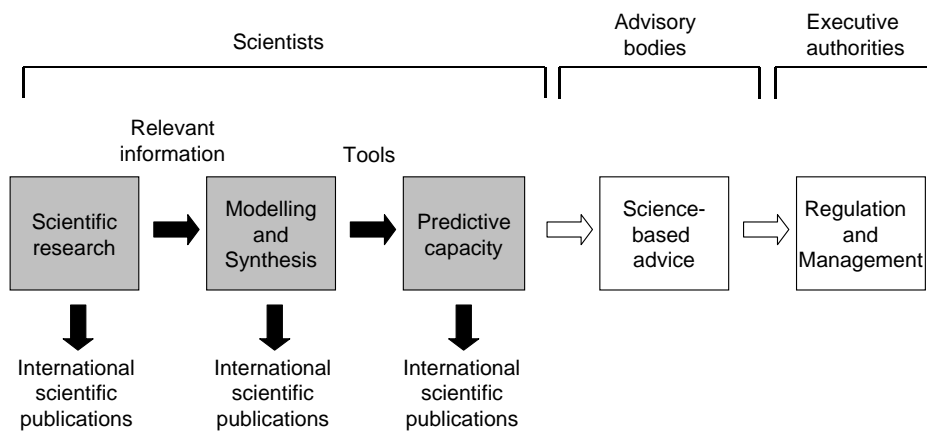
BONUS-169 will not fund repetitious baseline and trend data collection within monitoring programmes, such as statutory fish-stock assessment and water quality monitoring, which is the task of the appropriate non-competitively government-funded national and international authorities. The border between monitoring and science is diffuse by nature; for example, high-quality new scientific knowledge can be based on analyses of long-term data series collected within monitoring programmes and new techniques can be developed that subsequently can be used in monitoring programmes. Such activities can be considered as scientific research and analysis and may be funded by BONUS-169.

Figure 1. *BONUS-169 organizational structure showing the relationship between the eight Themes.*



Special attention is paid to data issues. BONUS-169 will develop a Data policy towards open access of all programme data. In connection with reporting of the research projects, metadata information about the data collected within the project must be delivered to BONUS-169. Thereafter, the data must be made available in one or more common public database(s) to be defined by BONUS-169.

Figure 2. Summary of the activities and scientific output of BONUS-169 ('Scientists') as well as societal use of the knowledge achieved in BONUS-169.



3.4 Research Themes

The aims and issues focused on by the eight Themes addressed by BONUS-169 are described as follows:

3.4.1 Theme 1: Linking science and policy

T1: LINKING SCIENCE AND POLICY

This theme provides the major integrated analyses, syntheses and tools to ensure high usability of the BONUS-169 research products for human society. The goal is to increase the quality and relevance of the products for the benefit of human society, and the responsiveness of the Baltic Sea science community in supplying them. The goal will be achieved by holistically synthesizing and widely disseminating sound and objective scientific knowledge for better advice. This should focus on the importance of healthy marine ecosystems, their relationship to humanity, and communication techniques, approaches and models linking scientists, stakeholders and decision-makers. This will form a basis for societal outreach and understanding, which underpins informed public opinion, development of prudent policies and the political will for their implementation. An integral part of the outcome includes formulating, evaluating and prioritizing appropriate management objectives for prevention, mitigation and adaptation to detrimental impacts. This includes identifying strategies and practical measures to achieve management objectives, as well as devising tools to monitor progress and evaluate success. An important foundation for achieving the goal lies in enhancing multidisciplinary cooperation by bridging and joining together the knowledge bases that comprise the programme's six core thematic areas (*i.e.* Ts 2-7). Stimulating the links within and between the constituent natural and social sciences has a high priority. BONUS-169 collaborative activities are solicited as individual and integrated projects, and concerted actions at the overall programme level. Emphasis will be placed on outreach collaboration with a wide range of stakeholders. Such activities include fostering dynamic and interactive communication, dialogue and consultations using all available media, arranging dedicated meetings and hybrid forums, and other opportunities.

BONUS-169 will actively support the mission of the European Commission's Environment Directorate General (DG) and DG Fisheries and Maritime Affairs, HELCOM, the European Environment Agency, and the advisory function of ICES with respect to implementing the Marine Strategy and Maritime Policy in the Baltic Sea. The key programme outputs will advance the implementation of the ecosystem approach to the management of human activities¹⁴. This includes the elaboration of environmental outlooks, scenarios and models for investigating future developments and implications of policy actions, including human socioeconomic consequences. Lessons learnt and best practices will be exchanged with other European regional seas and regional seas elsewhere.

Environmental policy is made within a context of uncertainty and associated risk arising from imperfect knowledge. Science has a decisive role to play in reducing the extent of that uncertainty. In managing risk and uncertainty, the best available research and scientific evidence must underpin the key knowledge input for all stages of the management and regulatory cycle. Thus, *scientific expertise is a crucial element in the design, implementation and evaluation of the efficacy of public policies*. Environmental and socioeconomic sustainability emphasizes the need for *knowledge integration and mobilization, dialogue and consultation with a view to reaching accord, and wider collaboration* to address 'real world' problems¹⁵. Policy should be supported by excellence in marine science and technology, and integration across all scientific themes and areas is essential for maximizing the benefits from marine research¹⁶. The sustainability issues are diverse and complex and so the science and policy interface is shifting from individualistic discipline/issue and segregated sector-related science and management to more holistic (*i.e.* integrated) and utility-focused. This must cross sectoral research, management and governance boundaries. Today research activities and the funding of gaps in knowledge are shaped and determined not only by scientists but also by other actors in society who have various intellectual and social backgrounds, motivations and user requirements. This

¹⁴ The definition of the EAM, according to HELCOM and OSPAR and agreed by the European Commission, is provided in Section 1 (Background) of the Science Plan.

¹⁵ United Nations 2002. Report of the World Summit on Sustainable Development. Johannesburg, South Africa, 26 August – 4 September 2002. Report No. A/CONF.199/20.

¹⁶ Speech 'How can marine research contribute to the Maritime Policy?' by Commissioner Joe Borg at the European Parliament Conference on the Future of European Marine Scientific Research, Brussels, Belgium, 17 October 2005.

produces an increasing demand and supply for more timely and practical value-for-money knowledge that correspondingly fosters closer, more interactive engagement between researchers and those who fund and apply research. The outcomes of integrated environmental assessments of current and future developments will lead to holistic scientific information and advice, lessons learnt and best practices to form the basis for management options. All these issues must be widely communicated in a more consistent, coherent and convincing manner in order to satisfy societal choice and acceptance criteria.

Key research issues are:

1) Development and application of the ecosystem approach to management for the Baltic Sea

The ecosystem approach to the integrated management of human activities (EAM) is internationally accepted as a cornerstone policy for promoting sustainable use of the seas by humans and conservation of healthy marine ecosystems¹⁷. The EAM considers the entire ecosystem including humans, with the goal of maintaining ecosystems in a healthy, productive and resilient condition in order to provide a broad suite of the ecosystem goods and services humans want and need. In the European Union, the need for the prompt and effective implementation of the EAM is promoted by the 6th Environment Action Programme, the Common Fisheries Policy, and the Water Framework Directive. Moreover, the EAM forms a key element in support of the European Marine Strategy and the European Maritime Policy through specifically tailored ecoregion action plans (*e.g.* Baltic Sea Action Plan of HELCOM). The plans focus on the ambient environmental, economic, social and political aspects. Sound ecosystem-based management must be founded on comprehensively and credibly integrating scientific data and knowledge that involves the interactions between the ecosystem and environmental components and the cumulative impacts of different human activities. Guidance on the application of the EAM in the European marine environment has been provided recently by an ICES and European Commission core group, as input to the development of the European Marine Strategy¹⁸. This guidance covers all relevant notions required to start work on implementation of the EAM at regional levels such as the Baltic Sea, whereby the establishment of a system of indicators, limits, reference points, and targets will form the scientific basis for operationalizing the EAM. The EAM is an evolutionary and adaptive process whose concept and implementation must eventually be made profoundly simple and understandable to gain political and public support. Thus, the Baltic Sea science community has a vital function in producing the RTD needed to provide the best available, politically impartial, scientifically objective knowledge and advice required by the EAM. Accordingly, the EAM represents the primary forum for linking science and policy. To realize the aims of actively conserving, and when appropriate restoring, the health of the Baltic Sea ecosystem, major research is needed. The research outputs must support improved scientific knowledge and advice, advance holistically integrated ecosystem assessments of changing status and trends, and promote adaptive and cost-effective ecosystem-based management measures. Areas of focus include:

- Together with Ts 2-7, developing a comprehensive approach to the concept of ecosystem health¹⁹, taking into account the need to implement the EAM and using a variety of complementary measures to

¹⁷ Browman H.I. & K.I. Stergiou (Eds) 2005. Politics and socio-economics of ecosystem-based management of marine resources. *Mar. Ecol. Prog. Ser.* 300: 241-296.

¹⁸ Rice J.R., V. Trujillo, S. Jennings, K. Hylland, O. Hagström, A. Astudillo & J. Nørrevang Jensen 2005. Guidance on the Application of the Ecosystem Approach to Management of Human Activities in the European Marine Environment. ICES Cooperative Research Report No. 273. 22 pp.

¹⁹ Hopkins C.C.E. 2005. The concept of Ecosystem Health and association with the Ecosystem Approach to Management and related initiatives. ICES BSRP/HELCOM/UNEP Regional Sea Workshop on Baltic Sea Ecosystem Health Indicators. 30 March – 1 April 2005. Sopot, Poland.

²⁰ Drivers, Pressures, State, Impacts and Responses assessment framework for organizing causal linkages information on the state of the environment. DPSIR builds on the existing OECD model, and is applied by the European Environment Agency and HELCOM for analyzing the inter-related factors that impact on the environment.

²¹ Global Monitoring of Environment and Security & European Marine Monitoring and Assessment.

²² In 2002, European Member States adopted a Recommendation on implementing ICZM in Europe ((2002/413/EC).

²³ Connolly N., J. de Leew, J. Mees, J.-F. Minster, T. Nepstad, N. Kostas, G. O'Sullivan, M. Rivo & M. Webb (Eds) 2006. Navigating the future – III: Updated synthesis of the perspectives of marine sciences and technology in Europe. European Science Foundation Marine Board. 32 pp.

²⁴ Used as important sustainable development tools by organizations such as the EEA, GEF, OECD and UNEP.

²⁵ Prandle D., H. Los, T. Pohlmann, Y.-H. de Roeck & T. Stipa (Eds) 2005. Modelling in coastal and shelf seas – European challenges. European Science Foundation, Marine Board Position Paper No. 7.

conserve and, where necessary restore, the structure, function and integrity of coastal and marine ecosystems. It is important to identify and quantify major naturally and human caused factors/stresses that affect ecosystem health, incorporating further developing and applying indicator-based systems (e.g. DPSIR²⁰) in an integrated manner. In this context, there is a need to establish a cohesive and comprehensible suite of indicators with target, precautionary, and limit reference points that should not be transgressed for specified ecosystem quality objectives. Also strategies (e.g. actions and measures) for achieving targets and ways to measure achieved performance are needed. It is also important to establish 'cause-and-effect' relationships, based on causal chain analyses, between those human activities causing serious impacts on ecosystem components. Management/regulatory measures should aim to redress the causes of the pressures and also to achieve desired decreases in the detrimental ecosystem effects. It is highly desirable to highlight the longer term economic consequences of various management decisions.

- Together with Ts 2-7, elaboration and application of novel rapid, cost-effective integrated surveillance and assessment systems for the Baltic Sea ecoregion and its sub-systems. This comprises the analysis of the essential characteristics and changing environmental status and trends, analysis of the predominant natural and human induced pressures and impacts, and the social and economic analysis of use and the cost of environmental degradation. There is a need to develop quick and efficient systems for communicating the emerging information and advice, including providing early warnings, in a scientifically rigorous but intelligible manner (c.f. GMES²¹ and EMMA initiatives).
- Together with Ts 2-7, advancing integrated coastal zone management (ICZM) and marine spatial planning²². These are widely becoming recognized as tools with a range of potential benefits including reconciling different and often competing objectives, delivering agreed priorities at various scales, better coordination between sectoral activities, and tackling cumulative effects²³. Land- and sea-use planning should bridge the land-sea interface, and indicate where impacts at sea need to be better taken into account in framing land-based activities. ICZM requires robust indicators of sustainability that gauge the 'health' of the coast in relation to environmental, social and economic activity, and which minimize detrimental affects. These indicators must be based on rigorous scientific, social and economic research, and form essential tools for assessing the state of the coastal environment. The indicators must be usable by managers and policy-makers to measure the effectiveness of sustainability strategies.
- Together with Ts 2-7, evaluating strengths and weaknesses of existing policies, governance systems and management measures, and recommending improvements in organizational, institutional and governance frameworks. One of the central issues to be tackled by the Maritime Policy will be the question of the overall governance framework through which the users and uses of oceans and seas can be regulated. This is provisionally considered in the Green Paper on Maritime Policy, and the governance arrangements foreseen in the Marine Strategy constitute a first step. A broader governance framework is expected to also take account of the highly diverse legal and political specificities in the Baltic Sea and the other European regional seas.

2) *Environmental outlooks, scenarios and models for investigating future developments and implications of policy actions*

Environmental outlooks, scenarios and models provide important and complementary approaches to analyzing how complex environmental and human interactions may plausibly shape current and future developments in the Baltic Sea ecosystem. They should include the effects on human livelihoods and welfare. Outlooks and scenarios provide indispensable tools for assessing options and for creating robust and longer term strategies for sustainable development²⁴. They generate alternative visions in a complex system with uncertainty and provide decision-makers and stakeholders with a range of policy and management options to explore. Environmental outlooks and scenarios provide a basis for political discussions about which futures society desires or may wish to avoid. Additionally, modelling represents an essential methodology for actively synthesizing our knowledge of marine ecosystems. Models provide a potentially more precise, focused, and quantitative analytical tool to further explore and better understand the forces driving environmental change. They should be able to predict the impacts of recent and projected pressures on the marine ecosystem and on human society²⁵. Areas of focus include:

- Together with Ts 2-7, formulating a series of plausible future outlooks and scenarios for the development of the Baltic Sea ecosystem. These can be used for strategic planning and informing a wide variety of potential users, whereby marine conservation objectives can be better integrated with

sustainable socioeconomic goals. The best knowledge should be assembled with respect to developing scenarios for an approximately 20-50 year time perspective. The DPSIR framework needs to include the following elements: practical application, review of social and economic drivers, and cost and benefit analyses of the scenarios using integrated biophysical – socioeconomic models. It is important to outline the social, economic, political and environmental contexts behind each scenario, as well to link back changes in the environment to socioeconomic drivers and policy options. Estimates should be made of the likely changes in key environmental and socioeconomic variables (*e.g.* sea and atmospheric climate, nutrient inputs, fishing and maritime activities, pollution, changes in coastal landscape, social attitudes) in order to support possible modelling work. The models should also examine wider impacts and their consequences, and mitigation measures. Scenarios can play a central role in public education and in focusing the policy debate over what actions should be taken to tackle current and anticipated changes to the ecosystem and related human activities.

- Together with Ts 2-7, development of advanced, nested suites of diagnostic and prognostic models and extension of ecosystem models, seamlessly integrating across modelling disciplines and the programme's thematic areas to encompass the whole Baltic Sea basin. The models should include important mechanisms/processes, couplings, feedback and controls, and interactions. The approach should aim to link the Baltic regional understanding to the other European regional seas and the wider global scale. This will contribute to the development of predictive capacity for ocean systems and sub-systems. Accordingly, the models should provide contributions to the development of a comprehensive Earth System Model approach. They will form an essential tool for assessing and predicting the impact of natural and human induced pressures on the Baltic Sea ecosystem and human society. Modelling should integrate diverse knowledge and data types across appropriate temporal and spatial scales. Accordingly, they must be underpinned by sustained, long-term observations, surveys and integrated assessments of physical, chemical, biological and socioeconomic parameters for interpreting variability and providing prognoses of future changes.

3) *Making a difference through dialogue, consultation, and information exchange and dissemination*

Development of interactive systems for effective dialogue, consultation and information exchange, besides that more generally associated with information dissemination, are essential for the success of internal and external programme collaboration. Linking science and policy will be more effective and comprehensive through access to appropriate societal outreach schemes. This relates to internal programme activities, as well as to external affairs linking the programme with the outside world and *vice versa*. Areas of focus include:

- Together with Ts 2-8, developing and applying knowledge systems for effectively compiling and tracking considerable amounts of complex information relating to the Baltic Sea environment and ecosystem. This includes facilitating 'recall', integration and linking information, and developing and providing tools and networks that will help knowledge workers obtain information on demand from the programme. These should contribute to developing approaches, tools and models for synthesizing and analyzing information on multiple marine environmental/ecological disturbances, and should include quantification of financial costs to society from losses of resources, recreational opportunities, and in remedial actions. There should be continuous updating and sharing of information in relation to observed changes.
- Together with relevant Ts 7 and 8 activities including interactions with stakeholders and external affairs, identifying specific types of scientific information and advice needed for management and policy development. The advice should be matched with research and funding needs expressed by the scientific community.
- Together with Ts 2-8, promoting active participation from the programme's personnel in scientific working groups, *etc.*, in governmental and non-governmental organizations. This will promote the access by BONUS-169 to timely exchange of information and knowledge on major scientific issues of relevance to policy development, management and regulation.
- Together with Ts 2-7, establishing strategies and synthesis activities to ensure that the programme's outputs are well-integrated in a scientifically inclusive, rigorously objective and credible manner across the programme's core thematic areas. Thus, engagement in national (*e.g.* individual Baltic Sea country) and international (*e.g.* pan Baltic, Baltic Sea linking with other regional seas and with other scientific projects and programmes) forums should be promoted. Activities can be, for example, seminars/workshops, study/working groups, education and training courses, conferences, joint research

cruises and laboratory exercises, and other networking activities, which will holistically validate, synthesize and discuss results concerning threats. Relevant topics could be risks and impacts, policy and management/regulation objectives, and remedial measures including combatting and control practices. These forums should develop techniques, approaches and models for meaningful dialogue and consultations, including exchanges of differing views and conflicts of interest. Consultations between BONUS-169 and stakeholders and users are necessary to build confidence via mutual understanding and new partnerships. The scientific outputs, including new communication techniques, approaches and models, should be published in appropriate scientific journals.

- In collaboration with Ts 7 and 8, identifying stakeholders and their interests, concerns and motivations, including appropriate multi-level engagement activities to produce constructive change. This should, in turn, lead to the identification of available resources and collaborative partnerships to achieve strategies. Important aspects for synthesizing and mobilizing knowledge for ecosystem-based management in the Baltic Sea area include developing techniques, approaches and models for communication and engagement with key actors in different sectors of society, and moving across levels of governance and politics; generating and integrating a diversity of ideas, viewpoints and solutions; re-conceptualizing and envisioning the future together with key societal actors; providing forums for trust building among actors; initiating projects and selecting problems that can be turned into possibilities; describing ways to influence decision-makers to maintain/enhance governance structures that allow for adaptive co-management; exploring new system configurations and alternative approaches to governance; institutionalizing organizational structures that can facilitate cross-scale interactions; and development of composite policies or solutions. ‘Shadow networks’, characterized by political independence and out of the fray of regulation and implementation, potentially represent places for developing alternative policies, daring to learn from each other and think creatively about how to resolve environmental and economic sustainability challenges. The new scientific outputs, including new communication techniques, approaches and models, should be published in appropriate scientific journals.

3.4.2 Theme 2: Understanding climate change and geophysical forcing

T2: UNDERSTANDING CLIMATE CHANGE AND GEOPHYSICAL FORCING

The goal is to improve the capacity to detect, understand and accurately predict how naturally and human induced climate change and variability and direct human encroachment²⁶ affects the geophysical forcing of the biological and biogeochemical characteristics of the sea and coasts. Such change and variability can be expected to have fundamental impacts on the status, productivity, sustainability and biodiversity of coastal and offshore ecosystems, as well as on human communities. There is a clear need for the development of likely future Baltic Sea scenarios under consideration of climate change and its interactions with human activities and settlements. A further aim is to develop strategies for prevention, mitigation and adaptation to detrimental impacts.

Key research issues are:

1) Analyses of historical and current climate change and direct human encroachment

Climate is a consequence of interactions linking the atmosphere, biosphere, geosphere and oceans, involving fluxes of matter and energy among these compartments²⁷. The understanding of regional climate variability and change is a major goal of research in shelf seas oceanography, meteorology and hydrology. The semi-

²⁶ In the context of T 2, *human encroachment* applies to the physical impact (e.g. due to physical presence including disturbance of currents and water flow, increased noise, vibration, electromagnetic waves) of motile and stationary man-made structures, and landscape/seascape alterations and other mechanical/acoustical disturbances in coastal and offshore areas. Other aspects of human encroachment are examined in the other thematic areas of the Science Plan.

²⁷ 2001 International Panel on Climate Change (IPCC) Assessment Report; 2006 BALTEX Assessment of Climate Change for the Baltic Basin (BACC) Initiative; Climate Change in the Baltic Sea area – HELCOM Thematic Assessment in 2006: HELCOM Stakeholder Conference on the Baltic Sea Action Plan, March 2006.

enclosed Baltic Sea area is greatly influenced by natural and human induced climate change and variability, and the impacts of direct human encroachment on coastal and offshore areas, although their mechanisms and the resulting responses are insufficiently understood. Our capacity to recognize and predict such change and variability depends critically on our capability to measure, understand and realistically model the relevant processes determining the water, energy and geophysical cycles within and between system components.

Areas of research focus include:

- Analyzing the climate mechanisms, variability and change over several centuries and providing short to longer term climate projections for the Baltic Sea basin. This includes developing and validating more accurate ocean–land–atmosphere models for predicting future climate status including periodic and abrupt variability and changes, and distinguishing between natural and human-induced causes.
- Analyzing meteorological, oceanographic and hydrological forcing factors (*e.g.* magnitude and periodicity in the North Atlantic Oscillation Index), and dynamics and variability of the processes affecting water mass exchange and renewal (*e.g.* control of ventilation, residence time of the deepwater, phosphorous and nitrogen sinks, and dissolved oxygen concentrations) and the water circulation patterns in the Baltic Sea.
- Examining the responses at the Baltic Sea regional, sub-regional and system levels to climate variability and change. These include abrupt responses to the shift of storm tracks, abrupt/extreme climate change and climate change through North Atlantic – North Sea water exchange affecting the intensity and frequency of inflow events, the amount of freshwater run-off input and associated sediment/material discharges, depth of mixing/mixed layer characteristics and boundary level fluctuations (*e.g.* thermocline and halocline), thermal effects (*e.g.* heating and cooling), the duration and extent of sea-ice cover, the characteristics of atmospheric forcing and wave environment, including investigations by downscaling from larger scale climate models, reconstruction of past Baltic Sea states from sediments, for the purpose of Baltic Sea climate reconstructions and predictions, and the analysis of natural and human-induced climate changes.
- Investigating and reconstructing the past of the Baltic Sea area by means of palaeoclimate records on millennium and centennial scales or analyzing historical hydrographic data on centennial and decadal scales, in order to a) comprehend long-term processes in the region's climate system, with a view to better understanding current and future developments, including distinguishing between natural and human induced climate drivers, and b) understand and predict future developments, including changes in sea level and coastlines related to human settlements and sustainable development planning in the coastal zone.

2) *Deepening the understanding of processes relevant for the geophysical forcing of the ecosystem*

The building of predictive capacity for estimating the impact of naturally and human induced climate change and the impacts of direct human encroachment on the Baltic Sea system requires a comprehensive and robust understanding of processes relevant for the geophysical forcing of the ecosystem. This means that the process understanding must be profound enough to be valid not only under present conditions but also for conditions dominant in the geological and more recent past and for a wide range of conditions that are likely to be relevant in the future. Numerous complex processes relevant for the geophysical forcing of the Baltic Sea ecosystem are insufficiently understood, such that the following research areas need to be focused on:

- Improving the understanding of internal transport and thermohaline water mass transformation. This includes the dynamics of inflow events, inter-basin exchange, their interaction with the ambient waters and their impact on the Baltic Sea circulation, mixing and hydrography. Other critical processes for the transport of energy and solutes on time scales ranging from seconds to centuries are internal wave dynamics, deep rim currents, topographically trapped subinertial waves, their generation, propagation, transformation and dissipation mechanisms as well as their impact on diapycnal mixing, including meso-scale processes as effective isopycnal transport mechanisms.
- Analyzing interface and boundary layer dynamics including surface waves and their impact on air-sea transport of momentum, heat, fresh water and matter as well as their near-shore effects. This also

²⁸ Global monitoring for Environment and Security.

²⁹ The three Global Observing Systems: Global Climate Observing System (GCOS), Global Ocean Observing System (GOOS) and its Baltic Ocean Observing System, BOOS), and the Global Terrestrial Observing system (GTOS).

³⁰ Global Earth Observing System of Systems.

³¹ Drivers, Pressures, State, Impacts and Responses.

includes the near seabed dynamics, such as sediment transport and the exchange of momentum and matter within the bottom boundary layer and through the water-sediment interface. Directly related to climate change are processes near the sea surface such as surface waves, sea-ice dynamics, the radiation budget, the specific Baltic Sea winter conditions and thermodynamics and their impact on air-sea exchange.

- Studying coastal and estuarine dynamics and processes and interactions with the open sea, including the effects of rivers, estuaries, lagoons, straits, bays, islands, banks and other morphology. Important aspects include river inputs and transport of dissolved and suspended matter, their influence on water transparency and primary production, jet and plume dynamics, flooding, marginal filter effects and littoral-pelagic water exchange, sediment dynamics including wave-sediment interactions, and coastal erosion. This incorporates prioritizing their role among other physical factors governing the Baltic Sea ecosystem dynamics and vulnerability to climate change. An important objective is contributing to the development of regional and sub-regional physical-chemical-biological models.
- Improving understanding and modelling capacity regarding the energy, water and associated biogeochemical cycles affecting the Baltic Sea and its surrounding watershed. A key aspect of this includes setting the conditions for biological distributions and productivity modelling in the Baltic Sea.
- Development of advanced process-oriented models, theories, and observation techniques including remote sensing techniques, which serve the research areas mentioned above and which reproduce and analyze the fundamental Baltic Sea key processes. Many of the standard numerical models and observational techniques are applicable for the Baltic Sea only in a limited way, due to the sea's characteristics: such as the strong stratification, the narrow and shallow entrances/exits or the winter water conditions, which are all challenging for numerical modelling; or the copious maritime traffic and intense fisheries, the ionic composition of the Baltic Sea water, or the transient character of the Baltic Sea, which are all challenging to ship-based or moored observational techniques.

3) *Developing and applying innovative observation strategies, and operational forecasting and modelling systems*

It is important to make systematic observations of atmospheric, coastal terrestrial and sea parameters, including those of climate and geophysical forcing, in order to improve integrated forecasting of the marine, atmospheric and coastal environments of the Baltic Sea basin, consolidate long-term observations for modelling and predictive purposes, establish and apply shared regional databases, and to provide regional contributions to international programmes. Areas of focus include:

- In the area of operational meteorology, oceanography and hydrology with respect to climatic and geophysical variability and change, working to a) improve, coordinate and harmonize observation and information systems including remote sensing techniques, b) increase the quality of, and standardize, user-orientated operational products, c) provide high quality data and long time-series required to advance the scientific understanding of the Baltic Sea basin, and d) provide data, products and forecasts for climate change research and risk management strategies and mitigation of periodic and abrupt/extreme events (*e.g.* storms and maritime accidents) that can cause serious ecological and socioeconomic impacts. Large observing/surveillance/operational forecasting/modelling networks should take into account GMES²⁸ developments and provide a regional dimension to G3OS²⁹ and GEOSS³⁰.
- Integrating observations and knowledge into predictive models, metrics and indices, including coupling observationally-driven models across spatial and temporal scales and model types providing improved understanding of linkages between geophysical and biological models (*e.g.* regional climate models and food web models, regional climate influences on structure and function of ecosystems and their components). In order to have credible predictive capacity, operational and forecasting systems need to be based on process-orientated models, theories and observational techniques (see key research issue 2 above).
- Providing infrastructure and resources for BONUS-169 programme-related projects advancing knowledge of relevance to environmental change prediction.

4) *Scenarios, predictions, risk assessments and response strategies: environmental, ecosystem and human consequences*

It is not only necessary to understand and predict what the rate, magnitude and direction of natural and

human induced climate change and direct human encroachment will be at the regional and sub-regional scales in the Baltic Sea, but also to assess and predict what the likely key environmental, ecosystem and human consequences of such change will be. It is prudent to incorporate scientifically-based scenarios and models of climate and variability, and direct human encroachment into management and regulatory decision-making involving the conservation and utilization of natural resources, and the planning and location of human constructions, thereby providing greater prudence and resilience in tackling current, emerging and future challenges. Areas of research focus include:

- Advancing understanding and predictive capacity about environmental/ecological impact and risk, on appropriate spatial and temporal scales, of human constructions, of landscape/seascape alterations and other mechanical/acoustical disturbances in coastal and offshore areas. These comprise, for example, ports/harbours, bridges and tunnels, pipelines, wind farms, platforms, piers, opening new high-speed ferry links, prospecting/excavation/extraction of substrates and minerals (including dredging, mining, oil and gas exploration and production), dumping, and impeding and diverting water-courses including dam-building, and other potential disturbances. Likewise, it is important to analyze and assess how the above-mentioned activities/constructions may be impacted by climate change and variability, particularly with respect to potential detrimental environmental and socioeconomic consequences. In all these cases, it is desirable to develop scientifically based measures and strategies for prevention, mitigation and adaptation to potential detrimental impacts.
- Advancing understanding and predictive capacity about interactions and feedbacks among climate, biogeochemical cycles and ecosystems, including sensitivity to change by application of observational, experimental, conceptual and numerical modelling studies. Examples include the cycling (*e.g.* production, remineralization, transport and transformation) of matter and energy within and between compartments of the food web (*e.g.* from microbes to top predators) concerning *inter alia* light, nutrients/nutritional components, cycles involving carbon and methane, nitrogen, phosphorous, and sulphur; the impacts of harvesting regimes on food webs, biogeochemical cycles and climate; and the role of biogeochemistry and ecosystems in influencing the regional climate. An important dimension includes understanding the biology (*e.g.* physiology, biochemistry and reproduction) and distribution of marine organisms and biodiversity in relation to their ambient environment. The marked hydrographic, geophysical and biogeochemical gradients in the Baltic Sea area provide unique opportunities for applying both the comparative approach and controlled experiments in examining organism reactions to changes and variability in environmental conditions and additionally for testing modelling performance.
- Advancing understanding and predictive capacity concerning how climatic and geophysical changes affects the DPSIR³¹ system concerning nutrients/eutrophication, pollution, overexploitation of living resources, and alteration of biodiversity, as well as the socioeconomic consequences of these changes. In all cases it is desirable to develop scientifically based measures and strategies for prevention, mitigation and adaptation to potential detrimental impacts.

The main areas of cooperation with other Themes include:

- a) In collaboration with Ts 3-5, elaborating the climatic and geophysical basis determining areas of specific and important biodiversity and biological productivity (*e.g.* sea-ice, upwelling areas and frontal systems), including relating the importance of these areas/systems/habitats for microbial and primary productivity, and associated abundances of secondary producers/grazers and their consumers such as foraging concentrations of fish, waterbirds and marine mammals.
- b) In collaboration with Ts 3-6, developing coupled physical-biogeochemical models that explain and predict the distribution/prevalence and transport in the Baltic Sea of microbes including pathogens and diseases, nutrients/eutrophication, and pollutants, and pelagic biota such as phytoplankton (including harmful algal blooms), zooplankton, fish eggs and larvae, and alien (*i.e.* non-indigenous) organisms, and which bridge the gap between fish and ecosystem models.
- c) In collaboration with Ts 3 & 5, investigating how climate change and geophysical forcing directly and indirectly modifies the inputs, transport, dispersion/retention, transformation and deposition, bioavailability of nutrients and pollutants.
- d) In collaboration with Ts 1 and 3-7, examining—with the aid of integrative scenarios and models—the past, present and potential future human socioeconomic impacts and developments connected with climate change and geophysical forcing affecting the quantity and quality of ecosystem goods and services provided by the Baltic Sea.

- e) In collaboration with T 7 and other Themes, contributing to the development of comprehensive Earth system models incorporating aspects of atmospheric dynamics, ocean dynamics, land dynamics and hydrology, ice dynamics, atmospheric chemistry, land biogeochemistry and ocean biogeochemistry.
- f) In collaboration with T 1 and other Themes, enhancing interactions with human society and diverse user groups on climate and geophysical forcing impact assessments including providing information and advice to help mitigate detrimental impacts.
- g) In collaboration with T 8, developing communal observational and data acquisition techniques and tools including databases, and data quality control and data analysis tools concerning combined physical and biogeochemical measurements that suit the specific characteristics of the Baltic Sea environment and the needs of the Baltic Sea research community.

3.4.3 Theme 3: Combatting eutrophication

T3: COMBATTING EUTROPHICATION³²

The goal is to investigate the origins and inputs, transport and distribution, together with biogeochemical transformation and cycling of nutrients within the ecosystem, with a view to understanding the causes and impacts of eutrophication at relevant spatial and temporal scales on the coastal and offshore ecosystems and human communities in the Baltic Sea region. A further aim is to develop predictive capacity through advanced model systems, and to elaborate scientifically-based measures for assessing and mitigating the environmental risks and consequences of eutrophication. The mitigation includes novel approaches and methods to reduce nutrient inputs.

Interpretation of the results should take account of the special abiotic (*e.g.* hypoxia, anoxia, low salinity, low temperature, limited water exchange) and biotic characteristics that predominate at particular temporal and spatial scales in the Baltic Sea basin and drainage area.

Key research issues are:

1) Inputs and origins, distributions, flux and mass balances of nutrients

Eutrophication, caused mainly by excessive human-induced inputs of nitrogen and phosphorus since the mid-19th century, is a characteristic feature of most coastal and offshore areas of the Baltic Sea. Currently, discharges and emissions involving agriculture³³ and forestry, aquaculture, households, industry and traffic, continue to provide substantial loads of nutrients in coastal and open waters, via rivers, direct discharges, diffuse losses, and deposition from the atmosphere. Forming a foundation for effectively reducing eutrophication, advanced scientific knowledge is needed on the manner in which abiotic and biotic driving forces and pressures in the drainage basin and the sea, including their coupling and interactions, determine the amounts and relative levels (*e.g.* elemental ratios) and bioavailability of macronutrients (N, P, Si) and micronutrients in the water and sediments of the Baltic Sea. Areas of focus include:

- Investigations of hydrological and biogeochemical processes and biological productivity—moderated by climate variability and change—that affect the inputs and loads, origins, transport and dispersion, flux and mass balances governing the temporal and spatial (*e.g.* sub-regional) prevalence of eutrophication.
- Characterization and quantification of relevant abiotic and biotic background levels and reference conditions in diverse sub-regions, including long-term historical/retrospective analyses (*e.g.* paleoecological techniques), as a basis for assessing and understanding past, present and future nutrient

³² Defined by the EC Urban Waste Water Directive (91/271/EEC) as ‘*enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, causing an accelerated growth of algae and higher forms of plant life to produce undesirable disturbance to the balance of organisms present in the water and to the quality of water concerned.*’

³³ The UNEP 2005 GIWA Regional Assessment No. 17 Baltic Sea identifies the contribution of nutrients from the agricultural sector as remaining an immediate cause of the eutrophication in the region.

and eutrophication dynamics and trends. The outcome also should contribute to the ability to appropriately define and verify 'good environmental status' with respect to nutrients in the Baltic Sea sub-regions under changing situations.

- Comprehending and predicting how episodic hydrodynamic events (*e.g.* run-off, inflows and flushing) as well as littoral, benthic and pelagic ecosystems modify nutrient cycling and its stoichiometry, with respect to patterns of nutrient surplus, balance and limitation. These aspects may be further elaborated through modelling scenarios.
- The unique characteristics of the Baltic Sea call for increased understanding of the role of the pelagic food web in the context of nutrient limitation and stoichiometry, with nitrogen-fixing cyanobacteria as an important, but not an isolated, functional component. Likewise, the exceptionally important pelagic-benthic coupling of the Baltic Sea—encompassing the interaction between seafloor and water column processes, interplay of sedimentation fluxes, bottom water oxygen conditions, and benthic nutrient release—modifies nutrient mass balances and consequently limitation patterns, necessitating better comprehension of their controlling mechanisms.

2) *Effects and consequences of eutrophication in the ecosystem*

The Baltic Sea is pervasively affected by eutrophication, but there is a lack of innovative scientific knowledge (*e.g.* cause-and-effect studies, causal chain analyses) that clearly demonstrates and predicts how eutrophication—either alone or together with other environmental pressures—alters the structure, function and integrity of the Baltic Sea ecosystem, and affects human communities. Areas of focus include:

- Enhancing knowledge on the wide-ranging effects of eutrophication on the environment, ecosystems and their biota including effects on the pelagic and benthic/littoral food webs and at various levels of biological and ecological organization, *e.g.* opening new niches for indigenous, but so far subordinate, species including potentially harmful species (*e.g.* harmful algal blooms) as well as for non-indigenous species introduced to the ecosystem.
- Understanding and predicting the effects of eutrophication in relation to system/regime changes connected with climate variability and change, pollution, overfishing and degradation of habitats and altered land-use (*e.g.* agricultural practices), including changing inputs and loadings, transport, retention and transformation of nutrients and associated modification of biogeochemical and ecological characteristics, processes and responses.
- Developing and verifying analyses and models (*e.g.* dose-response) linking nutrient loads and elemental ratios to ecological impacts at different organizational, spatial and temporal scales, as a basis for aiding selection of appropriate management options. These analyses and models also should aim at verifying possible non-linear regime shifts within the ecosystem, and be capable of identifying corresponding drivers for these shifts.
- Developing integrated ecological-socioeconomic analyses, scenarios and models regarding the cost-benefit of the historical progression of eutrophication in the Baltic Sea as well as the potential effects of eutrophication abatement options.

3) *Scientific strategies for improving surveillance, assessment and management*

International policy and agreements (*e.g.* via EC Marine Strategy and related Directives, and HELCOM Convention) for limiting eutrophication in the Baltic Sea aim *inter alia* at substantially reducing particular nutrient discharges and emissions with a view to achieving 'good environmental/ecological status'. This requires the implementation of *novel and improved* (*e.g.* responsive, coherent and cost effective) *scientifically-based measures*—in the drainage basin and in the sea, for point and diffuse sources—to determine the success of management-related actions to meet specified environmental targets. Accordingly, there is a need for innovative research and development to deliver an improved capacity to assess and predict the changing status and trends related to eutrophication at the appropriate temporal and spatial scales, and also to devise sub-regionally and locally applicable management and remedial (*e.g.* load reduction, restoration of wetlands) measures. Areas of focus include:

- Elaborating, harmonizing and verifying appropriately justified and effective surveillance methods and strategies, nutrient scenarios and models for assessment and predicting human- and naturally induced nutrient loading into the drainage basin and coastal and offshore waters. This also includes further

³⁴ Driving forces, Pressures, State, Impacts, and Responses

developing and testing normalized indices and ecological quality objectives/indicators, use of new technologies and analyses, and improved integration of surveillance and sector-based information, for demonstrating nutrient and eutrophication effects in an operational context (e.g. for use with the EC Water Framework Directive and the Marine Strategy Directive, and by HELCOM).

- Elaborating, harmonizing and verifying appropriately justified and effective management strategies and remedial measures, including eutrophication abatement/nutrient load management strategies within the Baltic Sea and its catchment area, and the development and application of decision support systems to calculate and predict the consequences of various multi-criteria management decisions on the state of the environment and the associated socioeconomic costs and benefits for achieving a desired (e.g. target) environmental status.
- Enhancing integration of research, surveillance, assessment, management and policy operations with respect to further developing and applying a coherent eutrophication-related DPSIR³⁴ framework/thematic matrix.
- Developing integrated ecological-economic analyses and models of the causes and mechanisms of nutrient inputs to the Baltic Sea from point and diffuse sources and developing cost-efficient means for eutrophication abatement at the national and transboundary levels.

The main areas of cooperation with other Themes include:

- a) In collaboration with T 2, investigating how geophysical forcing, including climatic variability and change, directly and indirectly modifies the inputs, transport and dispersion of nutrients at pertinent temporal and spatial scales, with a view to understanding and predicting sub-regional and local eutrophication status.
- b) In collaboration with T 4, investigating how the aquatic ecosystem associated with fisheries and aquaculture, and seafood, is affected by eutrophication and *vice versa*.
- c) In collaboration with T 5, examine how ecosystems, and the goods and services provided by their biodiversity, are affected by and respond to eutrophication on different levels of diversity.
- d) In collaboration with Ts 2 & 6, studying how eutrophication interacts with and modifies biogeochemical cycles affecting toxicity of pollutants.
- e) In collaboration with T 1 and T 7, examining—with the aid of integrative scenarios and models—the past, present and potential future human socioeconomic impacts and developments connected with eutrophication affecting the quantity and quality of ecosystem goods and services.
- f) In collaboration with T 1 and T 8, and other appropriate Ts, synthesizing and preparing information and advice for diverse user groups, including policy- and decision-makers on the need to combat eutrophication with a view to enhancing the health of the Baltic Sea ecosystem.

3.4.4 *Theme 4: Achieving sustainable fisheries*

T4: ACHIEVING SUSTAINABLE FISHERIES³⁵

The goal is to develop and transfer scientific knowledge for achieving responsible and effective ecosystem-based management³⁶ of fisheries and aquaculture, and to develop an improved information system for producers, processors, retailers and consumers of seafood products that arise from sustainable practices in healthy ecosystems.

Key research issues are:

1) Developing the scientific basis for implementing the ecosystem approach to fisheries management

³⁵ The EC Common Fisheries Policy includes both capture fisheries and aquaculture.

³⁶ The EAM is defined in Section 1 of the Science Plan.

Modern resource management requires broader scientific understanding and prediction of ecosystem effects that go beyond the direct impact of fishing on commercially important target species^{37,38}. Accordingly, account needs to be taken of the wider direct and indirect effects of fishing activities—and the impact of particular fisheries and their deployed gear—on target and non-target species and their habitats (*e.g.* seabed) and on the structure and function of the ecosystem, including the influence of environmental change and variability (*e.g.* climate and pollution) on the productivity of the harvested stocks and the ecosystems sustaining these stocks. Areas of focus include:

- Acquiring, and integrating, new fundamental knowledge and data not only on the population biology and community relationships of species or species groups/assemblages targeted by harvesters, but also those indirectly affected by the harvesting process and those identified as critical to food chain dynamics. This embraces the acquisition and synthesis of innovative data and knowledge on life history, vertical and horizontal distribution patterns, trophic and other multispecies relationships, physiology, growth, mortality including pathogens and diseases, reproduction including early development/recruitment and maturity, habitat utilization, as well as novel information on stock/population structure and dynamics in relation to the impact of fisheries and environmental/climatic regime changes.
- Conducting retrospective analyses to describe, understand and disentangle the human and naturally induced causes of historical variations in fish stocks and fisheries-related dynamics. Use of alternative sources of data, such as historical records, is encouraged to extend time series.
- Developing and applying simple yet robust and informative indicators characterizing the sustainability of the fisheries, involving ecological quality and socioeconomic reference points including the target stocks and non-target species, their environment and habitat, and exploitation levels and their effects (*e.g.* viability of the fisheries, specific fish stocks and sustaining endangered migratory stocks).
- The emerging knowledge should be used to produce advances in the development and application of single species and multispecies fish stock into ecosystem models, with a view to bridging the gap between fisheries and ecosystem models with linkages to lower (*e.g.* plankton and benthos) and higher (*e.g.* waterbirds and marine mammals) trophic levels.
- Developing and applying improved technical measures for fishery management, including selectivity and technological devices, as well as fishing practices, that minimize by-catches and discards of non-target and undersized target species, and reduce physical impacts on the seabed and habitats.
- Investigating the operational activities, behaviour and development of fishing fleets, including fleet specific effort allocation, capacity development and catch (including by-catch) composition with respect to appropriate spatial and temporal resolution, as prerequisites for the application of fleet-based spatially explicit multispecies assessment models, facilitating the estimation of uncertainties in hind-, now- and forecasting of stocks and fisheries and considering natural and human induced variability and change.
- Critical evaluation of the performance of scientific advisory and management systems for achieving sustainable fisheries, involving investigations of the strengths and weaknesses of the scientific knowledge production (*e.g.* research, surveillance, assessment and advisory processes) and policy and decision-making (*e.g.* management and regulatory) systems and reaction of stakeholders (*e.g.* regulatory compliance by the fishery). Clear analyses of the use of scientific advice by managers, including the degree of adherence to the advice and the grounds for deviations from the advice, are also desirable.
- Designing and evaluating alternative policies for effective management of sustainable fisheries, including integrated actions involving limitation of total effort and catch, better structuring of fishers rights and responsibilities, use of individual fishing quotas and permits/licences and bans (*e.g.* discarding), application of technical measures including changes of selectivity and substitutions of gear, development of harvest rules, establishment of marine protected areas including closed areas and no-take zones, and implementing ecolabelling/certification schemes.

2) Assessment and mitigation of the ecosystem impacts of aquaculture

³⁷ Statement of Conclusions. Intermediate Ministerial Meeting on the Integration of Fisheries and Environmental Issues. 13-14 March 1997, Bergen, Norway.

³⁸ FAO 2003. The ecosystem approach to fisheries. FAO Technical guidelines for responsible fisheries No. 4. Suppl. 2. FAO, Rome.

Although there are numerous benefits from aquaculture, the environmental impacts can be diverse and substantial. Accordingly, it is necessary to scientifically investigate, identify and understand the nature and causes of these impacts and to elaborate appropriate mitigatory measures to ensure that aquaculture activities have minimal environmental impacts. Areas of focus include:

- Understanding the local ecosystem-related effects of nutrients, organic materials and chemicals, including antibiotics and biocides, from aquaculture facilities and developing innovative, cost-effective and environmentally friendly measures to limit inputs to the ecosystem and their effects.
- Investigations of the dynamics of stock movements (*e.g.* introductions and transfers) of cultivated species including understanding the effects of the loss of ‘escapee’ organisms that may impair gene pools, transfer parasites and diseases, and compete for food and habitats in the wild.
- Conducting investigations of bacterial, viral and parasitological pathogenesis in and around aquaculture systems and developing environmentally friendly and effective methods to guard against or control economically important pathogens and diseases affecting aquaculture organisms and spreading to the surrounding environment and ecosystem.
- Developing new and improved diets that are from environmentally sustainable sources, cost-effective and sustain favourable growth.

3) *Improving food safety and risk assessments, and developing dependable information systems for producers, retailers and consumers of seafood products.*

The consumption of safe and sustainable seafood products from capture fisheries and aquaculture provides an important contribution to maintaining human health, food security and socioeconomic welfare, as well as providing incentives to conserve the quality and sustainability of the environment and ecosystems upon which such products depend on. Accordingly, there is a need to improve the collection, analysis and dissemination of scientifically credible information and knowledge about the health, safety, quality and sustainability issues connected with the harvesting and production, processing, retailing and consumption of seafood products. Areas of focus include:

- Documenting the human nutritional and health benefits of consuming safe seafood products.
- Advancing knowledge concerning contamination and infection of seafood products by chemical and biological agents (*e.g.* parasites and bacteria), and providing risk-benefit health analyses for fish consumption.
- Developing operational approaches and technologies to detect, assay and diminish toxins, contaminants and residues.
- Developing certification schemes (*e.g.* ecolabelling, organic production) to attain sustainable practices for fisheries and aquaculture, offering a market- and information-based system for consumers of products that are healthy, safe, and of good quality, as well as promoting high animal health and welfare standards.

The main areas of cooperation with other Themes include:

- a) In collaboration with T 2, investigating how environmental forcing (*e.g.* climatic variability) directly and indirectly affects the living resources and the aquatic environment upon which fisheries and aquaculture depend.
- b) In collaboration with T 3, studying how eutrophication affects fish population dynamics, the production and sustainability of fisheries and aquaculture, and how fisheries and eutrophication interact to affect the productivity and characteristics of ecosystems.
- c) In collaboration with T 5, examining how the characteristic structure and function of ecosystems, and their associated biodiversity, are affected by fisheries and aquaculture and, in turn, how healthy ecosystems and their biodiversity support sustainable fisheries and aquaculture.
- d) In collaboration with T 6, investigating how the aquatic environment including fish and shellfish, fisheries and aquaculture, as well as seafood, is affected by pollution.
- e) In collaboration with T 7, examining the past, present and potential future co-evolution of fisheries and aquaculture and their associated human communities, changing natural resources and their environment.
- f) In collaboration with T 1 and T 8, and other relevant Ts, developing and disseminating understanding about the dependence of sustainable fisheries and aquaculture on the conservation of healthy ecosystems through application of the ecosystem approach to management of human activities, and also taking into

account the influences of naturally induced environmental variability.

3.4.5 Theme 5: Protecting biodiversity

T5: PROTECTING BIODIVERSITY³⁹

The goal is to describe, assess and characterize the biodiversity of the Baltic Sea region with a view to improving our understanding of ecosystem structure and functional dynamics, evolutionary processes, and the relationship between biodiversity and ecosystem functions. A comparative approach should be applied to examining patterns along gradients at a range of temporal and spatial scales. A further aim is to advancing our knowledge and predictive capacity concerning the impacts of naturally and human induced pressures—including climate change—on biodiversity and on the goods and services arising from coastal and offshore ecosystems⁴⁰. There is also a need to investigate and improve the efficacy of scientifically-based management measures for conserving and, where appropriate, restoring biodiversity.

Key research issues are:

1) Understanding indigenous biodiversity and assessing status and trends including change and loss

The biodiversity of the Baltic Sea area is substantially lower in terms of species richness than other sea areas of comparable size, reflecting the sea's short post-glacial ecological history involving colonization by immigrants of marine species, freshwater species and glacial relicts. Gradients in the natural environment and ubiquitous human-induced pressures affect the biodiversity of the Baltic Sea ecosystem, including the spatial and temporal abundance and distributions of plant and animal species. To conserve biodiversity in the Baltic Sea area, research focus includes:

- Advances in comprehensively measuring, characterizing and providing enumerations of biodiversity, incorporating essential building blocks such as recognition and understanding of the structural and functional role of biodiversity through applying, and where appropriate integrating, genetic and molecular, taxonomic and biosystematic, biological, ecological, and population dynamics and bioeconomic methods and approaches. These should improve the capacity to recognize change and loss of biodiversity, and identify and quantify the natural and human induced drivers of such change and loss, with a view to understanding the causative processes and ultimate consequences for biodiversity.
- Progressing knowledge (theoretical, experimental, and empirical) of evolutionary and ecological processes that regulate biodiversity and affect the resilience and recovery of communities and ecosystems, as a basis for enhancing the capability to predict future biodiversity change. This incorporates constructing conceptual and mathematical models on ecosystem functioning, based on new and existing biodiversity data.
- Developing concepts, scenarios and predictive models to examine the impacts of biodiversity change at the population, community and ecosystem levels, including the goods and services that ecosystems provide, and investigating ecosystem resource limits and human societal impacts.
- Elaborating ecological quality indicators and their metrics for evaluating the impacts of human pressures on biological diversity, as well as establishing targets and limits for long-term conservation and remedial measures.

2) Conservation of habitats and their associated species and communities

Conservation of habitats is vital for protecting the species that are dependent on the habitats for their

³⁹ In the 1992 Convention on Biological Diversity the term means 'the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems.' In essence, biological diversity according to this interpretation is defined on the levels of 1) genes, 2) species and 3) ecosystems.

⁴⁰ Including also the habitats of diadromous species.

viability. Substantial degradation, fragmentation, and eventual loss of habitats in the Baltic Sea area—together with associated threats to their characteristic faunal and floral communities—have become increasingly evident over the past centuries due to a range of encroaching human activities and changes in climate. Accordingly, the conservation of habitats is a rapidly growing need with regard to the protection of biodiversity. To conserve habitats in the Baltic Sea area, research focus includes:

- Providing enhanced knowledge of the characteristics of particular pelagic and benthic habitats, and the distinguishing features of their associated biological communities, occurring in coastal and offshore areas. With respect to habitats, this necessitates comprehensively integrating information and data regarding the physical, chemical, geological and biological surroundings that support healthy, self-sustaining populations and communities of living resources.
- A major aspiration is to reveal the dynamics of the major coastal and offshore habitats and biotopes, and to understand the role of healthy habitats in providing ecological goods and services, and to quantify the responses of habitats and their biodiversity to natural and human induced changes. A key objective is to assess the relative importance of combinations of environmental variables in determining the incidence of particular habitats, and to develop, validate and apply techniques to survey, model and predict the occurrence of habitats, with a view to producing probability maps of habitat distributions, founded on the interactions between environmental parameters and the distribution of biological communities.
- There is a need to apply analytical, empirical and modelling tools for establishing inventories of habitat-related biodiversity in coastal and offshore areas with a view to identifying loss of biodiversity and setting conservation priorities at the appropriate spatial and temporal scales.
- The scientific basis should be elaborated for developing and evaluating the effectiveness, through trials and experiments, of techniques and practices (*e.g.* marine protected areas and reserves) for rehabilitating, restoring or creating productive habitats for fauna and flora.

3) *Combatting alien organisms*⁴¹

Invasive alien species (IAS, also called introduced, non-indigenous, exotic, *etc.*) are one of the primary and growing environmental concerns affecting the conservation of biodiversity, including impacts on ecosystems, habitats and their associated species (Convention on Biological Diversity and HELCOM). IAS threaten biodiversity, alter ecosystem processes, act as vectors for new parasites and diseases, and cause socioeconomic consequences for humans. The vectors facilitating the introductions and spreading of aquatic IAS include transport via shipping-related ballast water discharge and hull fouling, the aquaculture and aquarium industries, tourism and recreational activities, and removal of natural barriers (*e.g.* construction of man-made canals). The proportion of introduced species, relative to the total number of indigenous species, is high in the Baltic Sea area: since the early 1800s more than 100 alien species have been recorded, of which more than 50 have been registered in the 20th century and are colonizing new areas at a rapid rate. In the brackish conditions, horizontal and vertical gradients provide the IAS of different origin with an extended range of hospitable conditions. To combat IAS in the Baltic Sea area, research focus includes:

- Improving the scientific capacity to predict risks and spreading of IAS, as well as for devising optimal measures for regulating, controlling and eradicating IAS.
- Developing strategies and measures to reduce risks to biodiversity from introductions and transfers of IAS. Such capability depends on enhanced knowledge of life histories and biology, ecology and multispecies interactions, physiology, genetics and genomics, taxonomy and biosystematics, area of origin, vector of introduction, distribution history in the region and specific area, ecosystem functioning and abiotic environmental and habitat preferences, risks concerning ecological and socioeconomic impacts, and best practices for eradication and control.
- Elaborating and applying techniques and methodologies, including models, for environmental impact assessments and risk analysis concerning IAS, comprising quantifying and predicting the role of different vectors (*e.g.* shipping and aquaculture) and pathways affecting the introduction and spread of IAS; establishing the scientific basis for developing effective early warning and rapid response systems (*e.g.* developing GIS-based mapping, and developing scientifically-based surveillance, assessment and

⁴¹ Defined as a species, subspecies, or lower taxon occurring outside of its natural range and dispersal potential (*i.e.* outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans) and includes any part, gametes or propagule of such species that might survive and subsequently reproduce (1999 IUCN Guidelines for the Prevention of Biodiversity Loss Due to Biological Invasion).

information dissemination) for new unwanted (black-listed) introductions, including development of prudent and effective control, combatting and eradication measures; and evaluation of legislative systems and their performance. In addressing these objectives, it is desirable to foster closer collaboration between the natural, technological and socioeconomic sciences.

The main areas of cooperation with other Themes include:

- a) In collaboration with T 2, investigate how the structure and function of ecosystems, and the goods and services provided by their biodiversity, are affected by and respond to climatic and geophysical forcing on short to longer term scales.
- b) In collaboration with T 3, investigate how the structure and function of ecosystems are affected by and respond to nutrient loading.
- c) In collaboration with T 4, examine how the characteristic structure and function of ecosystems, and the goods and services provided by their biodiversity, sustain fisheries and, in turn, how fishing activities directly and indirectly impact ecosystems and their biodiversity.
- d) In collaboration with T 6, examine how ecosystems, and the goods and services provided by their biodiversity, are affected by and respond to pollutants on different levels of diversity.
- e) In collaboration with Ts 1, 7 & 8, strengthening interactions with the wider public and decision-makers, and outlining and further developing schemes for educational, capacity-building and outreach activities for emphasizing the dependence of human socioeconomic sustainability on ecological sustainability. There is a need to strengthen interactions with decision-makers and wider society, with emphasis on the need to conserve, and where appropriate restore, biodiversity. Better awareness and understanding must be promoted amongst a wide group of stakeholders in society as to how the goals of numerous international agreements and instruments concerning biodiversity may be applied at local, national, and regional scales through appropriate research, policies, litigation and regulatory practices.

3.4.6 *Theme 6: Preventing pollution*

T6: PREVENTING POLLUTION⁴²

The goal is to investigate and forecast the inputs and origins, transport and dispersion, biogeochemical cycling and fate of key pollutants⁴³ in the Baltic Sea and the effects on the ecosystem and its biota. A further aim is to elaborate scientifically-based measures for assessing and mitigating the environmental risks from pollution.

Interpretation of the results should take account of the special abiotic (*e.g.* hypoxia, anoxia, low salinity, low temperature, limited water exchange) and biotic characteristics that predominate at particular temporal and spatial scales in the Baltic Sea area.

Key research issues are:

1) Inputs, distributions, flux and mass balances of pollutants

There is increasing evidence that the Baltic Sea environment is a sink for many pollutants, either originating

⁴² **Marine pollution is defined as** 'Introduction of man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazard to human health, hindrance to marine activities including fishing, impairment of quality for use of seawater, and reduction of amenities' (GESAMP 1987)

⁴³ For example, heavy metals, persistent organic pollutants, artificial radionuclides, oil pollution, acoustic pollution, litter and garbage, and sewage. Pollution by excessive nutrients, including related production of organic matter, is considered under Theme 3. Studies regarding the intake of contaminants and nutritional factors associated with the consumption of fish and other aquatic food products by humans and their health implications are considered under Theme 4.

from local and regional sources or from extraneous introduction by advective processes, via various vectors including airborne transport and land-based run-off. In order to reduce and limit pollution effectively, solid scientific knowledge is needed *inter alia* on the identity, sources/origins and amounts and rates of inputs, and accumulation of pollutants in the environment and biota. Areas of focus include:

- Studies of inputs, origins, transport, dispersion, flux and mass balance, and fate of pollutants, including elaborating biogeochemical cycles of pollutants in sampling matrixes (*i.e.* water, sediment, and biota).
- Characterization and quantification of background levels and reference conditions for pollutants.
- Historical/retrospective analyses for assessing and understanding past environmental pollution trends.
- Detection and quality assured measurements of novel and emerging substances and environmental toxins, including development of rapid and effective assessment techniques.

2) *Detecting and predicting effects of pollutants on populations, communities and ecosystem*

In order to fully understand the consequences of pollution on the Baltic Sea ecosystem it is insufficient to collect information regarding the presence and distribution of pollutants in water, sediments and biota. There is a pressing need for advanced knowledge about the various biological and ecological impacts caused by exposure to existing and novel/emerging pollutants from the level of sub-cellular systems to ecosystems, including the potential for transfer or accumulation in the food web. Areas of focus include:

- Enhancing knowledge on the effects of pollutants on the ecosystem and its biota, including in the food web and at various levels of biological and ecological organization.
- Development and application of biological effects methods, including biomarkers and bioindicators (*e.g.* biochemical, physiological, pathogenic/parasitological, genetic/mutagenic, ontogenic and reproductive, molecular and cellular, organ, individual and population levels) related to various pollution stressors.
- Improving risk assessments and environmental impact assessments of exposures to pollutants, including use of integrated ecotoxicological assessments and better forecasting of combined biological effects of current and novel/emerging contaminants and complex contaminant ‘cocktails’ (*e.g.* synergistic mixtures of substances/chemicals).
- Understanding and predicting the effects of pollution in relation to system changes, *e.g.* climate variability and change, eutrophication, etc., including modification of transport, retention and transformation, bioaccumulation and toxicity of pollutants; effects on naturally occurring matter (*e.g.* humic substances, algal toxins, nutrients, metals) and their role in the transport process of pollutants; and modification of biological and ecological characteristics, processes and responses.

3) *Scientific strategies for improving surveillance, assessment and management*

A long-term goal for the Baltic Sea is to progressively reduce discharges, emissions and losses of pollutants towards concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances. This requires the implementation of timely, responsive and effective measures to determine the progress of management-related actions to meet agreed targets. Accordingly, there is a need for research and development, including the production of appropriate tools, to deliver an improved capacity to assess and predict the changing status and trends related to environmental pollution at the appropriate temporal and spatial scales, and formulate suitable regulatory and remedial measures. Areas of focus include:

- Elaboration and application of integrated water quality and dispersion models for pollutants in brackish and marine water bodies.
- Development and application of improved (*e.g.* rapid yet sensitive and responsive, cost effective) surveillance and assessment approaches and strategies, including use of new technologies and analyses, and improved integration of surveillance and sector-based information.
- Elaborating a comprehensive and integrated ‘multilevel toolbox’ approach for enhancing assessments, encompassing contaminant concentrations, biological effects/biomarkers, bioassays, combined effects of contaminants, modeling, long-term effects and risk assessments.
- Developing more scientifically robust approaches for environmental risk/impact assessment and management that can be applied prospectively (for prevention) and retrospectively (for remediation).
- Developing appropriately justified and prioritized scientifically-based and cost-effective remedial measures, including pollution abatement/waste management strategies for point and non-point sources.

The main areas of cooperation with other Themes include:

- a) In collaboration with T 2, investigating how naturally induced environmental forcing (*e.g.* climatic variability) directly and indirectly modifies the inputs, transport, dispersion/retention, transformation and deposition, bioavailability and toxicity of pollutants.
- b) In collaboration with T 3, studying how eutrophication interacts with and modifies biogeochemical cycles and toxicity of pollutants.
- c) In collaboration with T 4, investigating how the aquatic environment associated with fisheries and aquaculture, and seafood, is affected by pollution.
- d) In collaboration with T 5, examine how ecosystems, and the goods and services provided by their biodiversity, are affected by and respond to pollutants on different levels of diversity.
- e) In collaboration with Ts 1 & 6, examining—with the aid of integrative scenarios and models—the past, present and potential future human socioeconomic impacts and developments connected with pollution affecting the quantity and quality of ecosystem goods and services provided by the Baltic Sea.
- f) In collaboration with Ts 1 & 8, and other appropriate Themes, synthesizing and preparing information and advice for diverse user groups, policy-makers and managers about the biological effects of pollution on living marine resources and human health.

3.4.7 *Theme 7: Integrating ecosystem and society*

T7: INTEGRATING ECOSYSTEM AND SOCIETY

The goal is to provide the social science information needed to support BONUS-169's integrated ecosystem approach to management (EAM⁴⁴) of Baltic Sea resources. When developing policy, management authorities must account for how human activities affect the Baltic Sea ecosystem properties, and account for how those ecosystem properties affect the well-being of citizens socially, economically, and culturally. The goal will be achieved by collecting and assembling data and producing analyses that explain and forecast human interactions with the natural components of the Baltic Sea ecosystem. To further aid policy makers, the research programme will assess how humans have been and will be impacted by the spatial and temporal variations in all components (natural and human) of the Baltic Sea ecosystem; and assess society's preferences and priorities for conserving, protecting and restoring Baltic Sea ecosystem resources.

Key research issues are:

1) Explaining the spatial and temporal variations in human's uses of Baltic Sea ecosystem resources

Applying EAM to Baltic Sea resources requires an understanding of the fundamental, underlying mechanisms that drive human behaviour, and more specific knowledge of how humans use and encroach upon marine ecosystems directly and indirectly for social, cultural, and economic purposes⁴⁵. In the Baltic Sea, the following human activities benefit from, as well as potentially threaten, the marine environment and its living marine resources in coastal and offshore areas: Oil and gas exploration and production including platforms and pipelines; power generation including wind-farms; shipping and maritime transport; dredging and dumping of wastes and litter; mining and mineral and aggregate extraction; fisheries and aquaculture; coastal engineering and land reclamation; human settlements and coastal industries (*e.g.* pulp and paper, iron and steel, chemicals and petrochemicals, and food processing operations); and recreation and tourism^{46 47}.

⁴⁴ The Science Plan in Section 1 (Background) stresses that the EAM is the 'the comprehensive integrated management of human activities...'...[emphasis added]

⁴⁵ Liu J. 2001. Integrating ecology with human demography, behavior, and socioeconomics: Needs and approaches. *Ecological Modeling* 140: 1-8.

⁴⁶ UNEP 2005. Lääne A., E. Kraav & G. Titova. Baltic Sea, GIWA Regional Assessment No. 17. University of Kalmar, Sweden.

The benefits draw people to settle in and visit coastal areas of the Baltic Sea, increasing the crowding and ecological impact in the coastal areas. The settlement and growth of populations in the coastal zone, in conjunction with the associated economic activities, constitute a set of major forces affecting the Baltic Sea ecosystem.

There are three basic governance mechanisms that drive and shape humans' use of and encroachment upon ecosystem resources: markets, government, and the institutions and arrangements of civil society.⁴⁸ Individually and collectively the three mechanisms of governance affect how humans use and otherwise interact with a marine ecosystem such as the Baltic Sea. *Markets*, where goods and services are exchanged by profit-seeking producers, traders, and consumers, affect how the environment is utilized, what resources are extracted, and the manner in which these resources are exploited. In many cases, markets do not reflect the ecological costs of the economic activities that use and encroach upon ecosystem resources. As a consequence, market-driven economic activities are one of the direct causes of pollution, overexploited fishery resources, and of the marine ecosystem's altered productivity and biodiversity, and poor overall health. *Government* policy and regulation, whether at a local, regional, national or European Union level, are well recognized mechanisms that can affect human behaviour. Fiscal policies can provide incentives for particular types of conduct and, through government spending patterns, a substantial portion of society's resources may be directed to promote specific objectives. Regulatory efforts, such as zoning and permitting, can channel efforts along desired paths and, with their potential for unpleasant consequences in the form of fines or even imprisonment, can discourage undesired behaviour. Governmental institutions are not always perfect, however, and can sometimes implement policies that are counter-productive and ultimately harm the status of an ecosystem (for example, subsidies that aggravate fishing overcapacity). The institutions and arrangements of *civil society* play a central role in influencing behaviour. Social norms and networks (social capital) shape individual and collective behaviour, and also facilitate cooperation among individuals and between groups of individuals. The social norms and networks can encourage trust, civic engagement, and enhance effective governance while reducing management costs. These have considerable potential for advancing the EAM in informal governance systems. The institutions and arrangements establish 'working rules' that are commonly known, monitored and enforced.⁴⁹ Though different from the legal requirements established through governmental processes, they are powerful factors that influence individual and group actions. The violation of patterns of behaviour adopted by the formal and informal institutions of civil society can produce potent peer pressures and, ultimately, can lead to isolation or expulsion from the community or even physical retribution. As with markets and government, the institutions and arrangements of civil society are not always supportive of sustainable development, since social norms are not always consistent with conserving marine ecosystem resources, protecting habitats and the quality of the aquatic environment.

Humans also respond to changes in the status of marine ecosystem components. The growth of the population and economic activities that occurred along the coast of the Baltic Sea during the 20th century has been due in large part to economic and quality of life advantages of the Baltic Sea marine ecosystem. Human encroachment in the Baltic Sea's drainage basin has, in turn, led to degradation in ecosystem health that has resulted in detrimental socioeconomic impacts in the region. Such changes in ecosystem health will likely induce human responses that have significant consequences for changes in population size and composition, types of economic activities, and distribution of incomes in coastal areas. Other responses, such as changes in perceptions, values, innovations, laws and other institutions, also shape the overall well-being of society

⁴⁷ Rydén L., P. Migula & M. Andersson (Eds) 2003. Environmental Science: understanding, protecting, and managing the environment of the Baltic Sea region. Baltic University Press, Uppsala.

⁴⁸ Juda L. 1999. Considerations in Developing a Functional Approach to the Governance of Large Marine Ecosystems. *Ocean Development and International Law* 30: 89-125.

⁴⁹ Ostrom E. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. New York: Cambridge University Press.

⁵⁰ Olsen S.B., J.G. Sutinen, L. Juda, T.M. Hennessey & T. A. Grigulanans 2006. *A Handbook on Governance and Socioeconomics of Large Marine Ecosystems*, University of Rhode Island (downloadable from http://www.iwlearn.net/abt_iwlearn/pns/learning/b2-2lme/riworkshop) provides more details on these tools and their application.

⁵¹ Sutinen J.G. & M. Soboil. 2003. *The Performance of Fisheries Management Systems and the Ecosystem Challenge*. In: M. Sinclair & G. Valdimarsson (Eds), *Responsible Fisheries in the Marine Ecosystem*. Rome: Food and Agriculture Organization of the United Nations.

and human interactions with the environment. Areas of research focus include:

- Documentation and analysis of the spatial and temporal variations in the uses of and encroachment upon the principal ecosystem resources (*e.g.* land use, waste disposal, extraction of living marine resources, recreation and tourism) in the Baltic Sea ecosystem. This will require research (in the social science areas of geography, demography, sociology and anthropology, social psychology, political science, and economics) that focuses on developing scientific explanations of the spatial and temporal variations in human activities that affect, and that are affected by ecosystem resources.
- Documentation and explanation of the human responses to changes in the Baltic Sea ecosystem that tend to occur over large spatial and long temporal scales. These issues are best examined by a large, diverse body of research that includes demography (population size and structure), sociology (perceptions, attitudes, values, social institutions), economics (market and non-market outcomes), and political science and law (laws, regulations, processes).

2) *Integrated modelling for forecasting the trajectory of the Baltic Sea ecosystem under various scenarios for management policies, environmental variability, and human actions*

As the EAM is applied to the Baltic Sea ecosystem, there will be increased demand by managers for spatially- and temporally-dynamic models of human activities that are explicitly linked to the natural components of the Baltic Sea ecosystem. Such models will need to be nested within larger and more complex ecosystem models, or at least be systematically linked to other component models. For example, ecological models can be combined with economic models to investigate nutrient loads to the Baltic Sea.

As another example, economists working with fishery scientists can develop bioeconomic models of fishing activity that can be linked to models of climate variability to demonstrate how this form of environmental forcing affects human use of fish resources and, in turn, how the fishing community is affected by climate-induced changes in yields from the fishery. Since the feedback does not necessarily stop with the fishing community, the bioeconomic model could be linked to models of land use and other human activities in coastal watersheds – which, when varied, will affect the coastal environment in different ways. Areas of research focus include:

- Explore options for developing spatially- and temporally-dynamic models of human activities that are explicitly linked to the natural components of the Baltic Sea ecosystem and that can both explain and forecast those activities.

3) *Estimating society's values for conserving, protecting and restoring Baltic Sea ecosystem resources*

The policies directed at managing the human activities that impact the Baltic Sea ecosystem will no doubt be shaped in large part by the public's preferences and priorities. Market prices are good indicators of the public's preferences and priorities in cases where markets work reasonably well. However, markets generally do not reflect the full ecological costs of using ecosystem goods and services, and additional information is required on public preferences and priorities that can be used in decision making for ecosystem management.

Areas of research focus include:

- Assembling and producing information on public priorities and preferences that can be used in EAM decision-making. For this purpose, structured surveys are needed that specifically ask respondents to make trade-offs, such as stated preference methods, (*e.g.* contingent choice and contingent valuation). Another is the more labour-intensive ethnographic fieldwork to provide in-depth assessment of values and the degree to which they are strongly or weakly held. This will require development of improved social science (anthropology, economics, sociology, social psychology) methods for producing information on public priorities and preferences that can be used in EAM decision-making. This work will require assessment of the market and non-market value of human uses of, and the natural services of ecosystems in each region, and assessment of the benefits and costs of conserving, protecting, and/or restoring ecosystem resources (*e.g.* habitats, marine mammals) in each region; and assessment of the sociocultural values of the uses of ecosystem resources and services in each region.

4) *Developing the scientific basis for improving governance of the Baltic Sea ecosystem*

Governance processes produce government policies, regulations, and incentives – the principal mechanisms for managing human behaviour. By encouraging certain behavioural patterns and discouraging others, governance is a matter of central importance to managing human behaviour in an ecosystem context. To

make an ecosystem approach to management effective, experts must apply the common tools of governance and socio-economic analysis to analyze how government policies and regulations are produced, and to ask what conditions lead to government successes and failures.⁵⁰ Of particular interest are the conditions that encourage social and technological innovations leading to improvements in the state of the environment. With such analysis and understanding, it is possible to prescribe ways (such as co-management approaches) to correct the obstacles in the public sector that lead to failures of government processes and policies; these obstacles are expected to be common when governments are faced with the complex trade-offs inherent in ecosystem approaches to integrated management.⁵¹ Areas of research focus include:

- Documentation and analysis of how government policies and regulations are produced, how management services are produced; investigation of the conditions that lead to government successes and failures; and analyses of the emergence of social and technological innovations that have improved the state of the environment. The behaviour of individuals and agencies in the public sector can be analyzed to understand and explain whether the underlying conditions promote government failure or success. This requires social science (political science, public administration, economics, and legal) research to assess how government (through its laws, regulations, processes) influences the uses of ecosystem resources and services, diagnose sources of governance failure, and identify the necessary and sufficient conditions for producing successful EAM-related policies and innovations.
- Estimate the ecological costs of the human activities that are harming the marine ecosystem and otherwise altering the environment. This work will require integrating the socioeconomics research with natural science research on fisheries, pollution and ecosystem health, and productivity. Once the ecological costs of resource extraction, pollution, and reduced productivity are calculated, scientists and policy makers can examine ways for factoring the ecological costs into market forces.

In addition, there is a major need to

- 5) *Acquire, assemble, and archive time series data (i) on all human uses and other interactions with ecosystem resources; (ii) on perceptions, attitudes and values of the ecosystem; and (iii) on local laws and regulations that govern the use of land, water, fishery and other ecosystem resources*

To improve the understanding of and ability to explain variations in those human activities that impact habitats, pollute, cause eutrophication, and over-exploit the ecosystem's natural resources the social science research community needs readily accessible time series data that will support investigations of these human activities. Data on market and non-market values are critical for supporting broad-based ecological decision making, and for understanding the social and economic processes that affect the Baltic Sea environment. These data need to be available in a common format and easily accessed by the broad research community.

The main areas of cooperation with other Themes include:

- a) In collaboration with T 2, investigating how environmental forcing directly and indirectly influences human uses of ecosystem resources and affects humans' social, cultural, and economics values derived from the Baltic Sea ecosystem.
- b) In collaboration with T 3, T 4, T 5, and T 6, exploring options for developing spatially- and temporally-dynamic models of human activities that are explicitly linked to the natural components of the Baltic Sea ecosystem.
- c) In collaboration with T 1 and T 8, and other relevant Ts, participating in public outreach efforts to disseminate the scientific understanding of humans' interactions with the Baltic Sea ecosystem.

3.4.8 *Theme 8: Strengthening collaboration and use of common resources*

T8: STRENGTHENING COLLABORATION AND USE OF COMMON RESOURCES

The goal is to enhance the capacity of the Baltic Sea science community to respond to the objectives, goals and research needs described under Themes 1-7 of the BONUS-169 Science Plan. The goal will be achieved by creating the necessary structures for the programme governance and management, for networking, information flow and data archiving and exchange, as well as for capacity building

and synergistic use of marine research infrastructures. Integral parts of these structures include forming the 'Baltic Sea Research Council' via establishing the legal entity of an 'European Economic Interest Grouping', creating *inter alia*: thematic and crosscutting clusters of consortia; a governance, management and supporting advisory structure; a web portal and an internal data inventory to facilitate the extensive exploitation of results achieved within the programme; a joint education and training plan; and a mechanism for shared use of research infrastructures and facilities. An important foundation for achieving the goal lies in work already done by the BONUS ERA-NET project, in the existing regional scientific associations, biennial Baltic Sea Science Conferences, ICES Baltic Committee with its Working Groups, the Baltic University Programme, ongoing EC funded research projects, integrated projects, networks of excellence and various EC and Nordic funding instruments to enhance mobility of researchers and training activities.

Key activities are:

1) Programme governance, management, advisory support, and measuring progress, success and impacts

The 'common structure' is set out as an European Economic Interest Grouping (EEIG⁵²) called *BONUS – Baltic Organizations' Network for Funding Science*. The BONUS EEIG is founded by the nine Baltic Sea States, comprising the eight European Community States (Denmark, Estonia, Finland, Germany, Latvia Lithuania, Sweden and Poland) and the Russian Federation. The BONUS EEIG is the executive structure and manages BONUS-169 through its Programme Secretariat. The main programme structures and relationships, and collaborative linkages to external parties are shown in **Fig. 3**. Areas of focus include establishing:

- The BONUS-169 Programme Steering Committee (PSC), presided by the BONUS-169 Chairman and comprising senior officers of the national research funding and management institutions appointed by the governments of the nine participating States. The PSC is the highest authority of BONUS-169, forming its decision-making body and board governing its dedicated legal structure.
- The Programme Secretariat, headed by the Executive Director, to implement the decisions of the PSC and act as the principal representative of the programme to both the European Commission and the national funding agencies. The Secretariat is responsible for the overall coordination and monitoring of the programme activities, including: a) Organizing Calls and evaluations; b) Carrying out the everyday management of the programme; c) Implementing the programme communications strategy; d) Ensuring timeliness and quality of outputs; e) Preparing progress reports and annual programme reports, and overseeing the preparation of all substantive and operational reports required; f) Preparing terms of reference for any engaged consultants, contractors and technical personnel; g) Managing the overall budget, and chairing appropriate administratively related management meetings connected with the smooth running of the programme; h) Supporting the work of the programme's internal bodies: Advisory Board, Project Evaluation Panels, Forum of Consortium Leaders, Data Management Steering Group, Forum of Infrastructure Managers, Forum for Training and Education, *etc.*; i) Supporting networking among the members, internal bodies and projects; j) Liaising with collaborating national and international activities and organizations to ensure maximum synergy and cooperation, avoid unnecessary duplication, and also ensure continued funding and political commitments; and k) Periodically reporting to the PSC and the European Commission on the progress and financial aspects of the programme.
- An Advisory Board (AB) to support the PSC and Secretariat. Its members are scientists of high international reputation and include representatives of relevant stakeholders (*e.g.* HELCOM, ICES). The role of the AB is to provide independent advice, guidance and recommendations, and strategic planning regarding scientific and policy related issues of the programme. These include advising on the objectives, priorities and direction of the programme, and on ways of strengthening the programme's performance and delivery and the quality of its research outputs. The AB also provides counsel on capacity building, networking, and the relevance of the work to achieve the objectives of the programme, and acts as advocates of the programme. It may contribute towards reviews and evaluations of research proposals and progress reports, and advise on their merits.
- Systems for measuring progress, success and impacts of individual projects and project clusters.
- *Ad hoc* forums and panels, steering/working and technical groups, workshops, and conferences as

⁵² EEIG established by Council Regulation (EEC) No. 2137/85 by the Members States.

required (*c.f.* other sections below).

2) Programme funding, Calls for submissions of research proposals, evaluation process, and financial and progress reporting

Having agreed on the overall Science Plan, BONUS-169 will launch common coordinated Calls for project proposals, and the applications will be evaluated through a joint evaluation procedure. The basis for arriving at mutually accepted best-practices was reviewed in BONUS Publication No. 2⁵³ and BONUS Publication No. 4⁵⁴. The funding of the programme is established by a Virtual Common Pot (**Annex 5**). The programme is proposed to have a duration of five years (*i.e.* 2008 – 2012). The nine Baltic Sea States have pledged a total of EUR 94.6 millions in funding contributions (**Annex 6**). The total budget for the Virtual Common Pot of the joint programme is anticipated to be EUR 189.3 millions, including the European Community contribution. Actions to implement a Joint Call include:

- PSC determines the contents and focus (*e.g.* thematic priorities) of the specific Call.
- The PSC decides on the budget and funding proportions of the specific published Calls for research proposals. The minimum proportion between national and EU funding of BONUS-169's direct R&D activities for each Call for project proposals is set by the PSC, depending on the overall proportion of national and European Community funds in the programme budget. Based on the outcome of the Call evaluation (*i.e.* project proposals received), the PSC issues binding instructions on the distribution of the national funds and allocates the Community funding, and the BONUS-169 dedicated structure distributes the agreed amount of the Community contribution to the participating funding agencies. The proportions between national and EU funding may not be lower than the previously agreed percentage. The successful research groups receive the appropriate mix of national and EU funding to implement direct R&D activities.
- Establishing international Project Evaluation Panels (PEPs) of independent, external evaluators recruited from the scientific community, private organizations, industry, *etc.*, to rate the project applications responding to the Calls. The rating is given for each project proposal with regard to approved programme guidelines that include the scientific quality, originality and relevance of the project, the expected outcome and benefits to the scientific field, feasibility of the research plan, expertise of the researcher/research group, national and international networking and cooperation, researcher training and educational perspectives. The composition of the PEPs may vary depending on the Themes and focus covered by the specific Calls. The PEPs make justified recommendations on the rating of the project proposals. The PSC decides on the ranking of proposals, which serves as the basis for funding decisions.
- All funding organizations and the European Commission require appropriate reporting and evaluation of the funded projects and programme as a whole. The BONUS-169 dedicated structure will collect inputs from the national funding agencies in a standardized form that ensures approved financial reporting to the European Commission. The progress of the funded projects will be reviewed based on annual reporting from the involved researchers, and will include descriptions of the major scientific discoveries and results, the status of any proposed collaboration, education and publications, and divergences from the original plan or timetable. A Final Report will be prepared by the programme and its involved projects/clusters, and approved by the PSC.

3) Networking, information exchange, knowledge dissemination and outreach

The existing Baltic Sea structures for scientific networking (*e.g.* ICES, Baltic Marine Biologists, Conference of Baltic Oceanographers, and Baltic Sea Geologists, and HELCOM), which were primarily established on the basis of more traditionally independent scientific disciplines, should be strengthened and closer linked and complemented with a view to facilitating multi-, inter- and transdisciplinary exchanges and developments (*c.f.* T 1). Additionally, overarching knowledge management and outreach activities, including exchange and dissemination, form vital aspects of the programme that will be coordinated and implemented via Theme 8. Areas of focus include:

- Establishing a Forum of Consortium Leaders (FCL) to act as the core organ for the scientific coordination of the programme. The coordination structure should encourage collaboration and

⁵³ BONUS 2005. The Joint Baltic Sea Research Programme — Best Practice, Possibilities and Barriers.

⁵⁴ BONUS 2006. Guidelines for a Common Evaluation Scheme for a Joint Baltic Research Programme.

interdisciplinarity within and across the Science Plan's Themes. The FCL will be responsible, in cooperation with the Secretariat, for creating the programme's coordination structure after the selection of the funded consortia.

- Forming thematic and/or crosscutting clusters of projects on the basis of the coordination plan prepared by the FCL. Each cluster should have an appointed Cluster Leader (CL). The distribution of the cluster leadership should take into account balanced geographic/regional representation and selected on the basis of their scientific and managerial competency. The overall goal of the CL is— together with the pertinent Project Coordinators and their supporting Principle Investigators—to develop, implement, and refine strategies that build effective collaboration across the work of the constituent clustered projects.
- Integrating BONUS-169 Conferences with the biennial Baltic Sea Science Conference. A new component which BONUS-169 can bring into the Conference structure is a session of socio-economic-policy aspects of the Baltic Sea research, arising for example from Themes 7 and 1 of the Science Plan. The Conference will be the main forum for the BONUS-169 funded community to be brought together with other scientists and stakeholders, to present and discuss their research results. It will also strengthen collegiality and wider personal relationships, build confidence, and provide critique and feedback regarding progress. Additionally, the programme will contribute to the ICES Baltic Committee sessions and its working groups, and co-sponsor relevant Baltic Sea Theme Sessions at the ICES Annual Science Conferences.
- Developing an External Communications and Outreach Plan for the programme in consultation with relevant institutions from the public, private sectors (including non-governmental organizations) and international organizations. Potential stakeholders comprise a wide range of private and public organizations from the environmental, shipping/maritime, aquaculture, fisheries, health, agriculture/forestry, travel and transport, tourism and recreation, and trade and commerce sectors, as well as municipalities and local communities. Outputs will include newspaper articles and popularized scientific articles made available in a widely accessible form, TV and radio presentations, DVDs/CDs/Videos, and brochures and posters.
- Expanding the existing web-based BONUS Portal to better reflect the information needs of the Baltic Sea science community and the wider public. The portal shall form the major information source about the programme and its stakeholders, its goals and its activities including ongoing research, contact information, electronic publication of reports and a newsletter, existing infrastructures, relevant national, European and other international policies, additional research funding sources outside BONUS-169, as well as a tool for searching for new partners for collaborative projects, shared use of infrastructures and data collected within the programme. The BONUS Portal will be synergistically linked to other relevant marine research and policy information portals, *e.g.* European Commission, EEA, EurOcean, FAO, HELCOM, ICES, OceanPortal of IOC/UNESCO and SEA-SEARCH.
- Publishing the majority of research and policy documents in peer-reviewed scientific journals, thereby raising the quality of the product and assisting the training of young scientists to engage in this publication process. Progress towards this will be measured by bibliometric studies. Guidelines, protocols, codes of practice and management recommendations, after being vetted by the programme, will be distributed to interested parties with need to know, learn from, and understand and discuss interests. Information dissipation should maximize use of the existing communication media of the full range of stakeholders.

4) Data archiving and exchange

The BONUS-169 programme will produce a considerable amount of data, which must be made widely and conveniently available as soon as possible to the science community and stored for posterity, after its primary publication. Thus, effective data management and exchange—including data mining/archaeology and use of relevant data stored beyond the programme (*e.g.* before its start, or by other programmes and institutions), and contributions to other ongoing programmes and initiatives—are key issues to be addressed at both the BONUS-169 programme and project levels. Areas of focus include:

- Establishing a Data Management Steering Group (DMSG) to plan, initiate and oversee the creation and maintenance of the BONUS-169 meta-database and implementation of the BONUS-169 data management work programme, including facilitating effective collaboration, coordination and compatibility (*e.g.* data flow and monitoring including use of best available quality control and

exchange standards and formats, and follow-up procedures) with national and international data banking and management bodies and programmes (*e.g.* IODE of IOC/UNESCO, SCOR/IGBP, BOOS/GOOS, ICES, GODAR, WDC-MARE). The foundation for this includes the establishment of a BONUS-169 Data Policy and guidelines on data banking, exchange and use of data, information and results obtained during the programme, including the creation and maintenance of the BONUS-169 meta-database. The database should include efficient search functions for all relevant keys, and provide information about the quality aspects of the data.

- Archiving and managing the data as the basis to drive the development of holistic, integrated assessments of the changing status and trends of the Baltic Sea ecosystem, including natural and human induced effects, as required by the programme.

5) *Education, training and exchange schemes: developing a convergent cross-cutting knowledge base for tomorrow's needs*

Education and training is an integral part of the Baltic Sea science mission, as new knowledge arising from research—including lessons learnt and best practices—must be fed-back into appropriate levels of the education, training and human resources development system. It is imperative that tomorrow's scientific community more fully understands the need for responsible and sustainable use of the seas, the role of the seas in human welfare, and the important linkages between science, policy and society. Furthermore, as research is becoming increasingly interdisciplinary and multidisciplinary, opportunities for collaboration should be stimulated in education and training that cross the traditional boundaries between disciplines, issues, and academic and maritime industrial sectors. Areas of focus include:

- Establishing a Forum for Education and Training (FET) to plan and facilitate the education, training, and professional development of researchers and technicians at all developmental levels through advancing intellectual, technological, information integration and team-building skills in a large but cohesive multidisciplinary forum. This should include developing a BONUS-169 Research and Training Network (RTN, *c.f.* Marie Curie programme) with a view to enhancing the capacity of scientists and technicians connected with the programme. The RTNs should each consist of a consortium of teams that are complementary and located in different countries, proposing a common research project to serve as a vehicle for providing training and transfer-of-knowledge. A key aim is to achieve a critical mass of qualified researchers and technicians that are specialized and/or fragmented, and contributing to overcoming institutional and disciplinary boundaries, including between academia and industry, through the promotion of multidisciplinary research. There is a need to improve human potential/resources, including provision of training/transfer of knowledge, career development opportunities, fostering mobility schemes, and integration into a joint international research project. In all cases, appropriate infrastructural facilities must meet current and future needs.
- Developing a broad-based BONUS-169 Education and Training Plan, in close collaboration with the Baltic University Programme, as a strategic contribution towards capacity building in the Baltic Sea States, flexibly accommodating new drivers (internal & external) as they come into play. The initiative should involve research and teaching institutions and other potential partners (*e.g.* maritime industries), and should aim at providing a harmonized and commonly accepted system of electives, credits/diplomas and inter-comparable gradings.
- Facilitating awarding of individual stipends/grants to researchers and technicians for study/research/training and exchange schemes, involving persons resident from the Baltic Sea States and visiting persons from outside bringing sought after knowledge into the region.
- Supporting the establishment, with appropriate justification, of a system of Centres and Networks of Excellence that will progress application of interdisciplinary approaches of relevance to BONUS-169.

6) *Mechanism for optimal sharing of marine research infrastructure*

Scientific infrastructure forms a major expense in marine research covering environmental, fisheries, oceanographic and meteorological sciences. These infrastructures include research vessels of different sizes, autonomous observational, surveillance and early warning buoys and moorings, drifters and gliders, offshore platforms, field stations, laboratory facilities, data centres and unique capital equipment. It has been estimated that 50 percent of national budgets for marine science is required for operating and replacing marine infrastructure assets. Accordingly, there is a need for improved coordination and management of infrastructures: major synergisms can be achieved by widening the access, avoidance of overlap and

duplication, as well as cost-sharing the development and replacement of major infrastructures. Areas of focus include:

- Establishing a Forum of Infrastructure Managers (FIM) to exchange information and synchronize annual deployment schedules of research vessels and other infrastructure use. The FIM goal is that the infrastructure needs arising from collaborative research projects should be fulfilled in the optimal, most synergistic and cost-efficient way.
- Developing a Baltic Sea Research Infrastructure Strategy for synthesizing national and European strategic views on future regional needs. It may lead to initiatives addressed to the EC and Member States to enhance new jointly funded, owned and/or operated Baltic Sea research infrastructures.
- Maintaining and updating the already established infrastructure directory on the web-based BONUS Portal. The inventory should have efficient search functions, information on possibilities to barter/charter equipment as well as all necessary contact information.

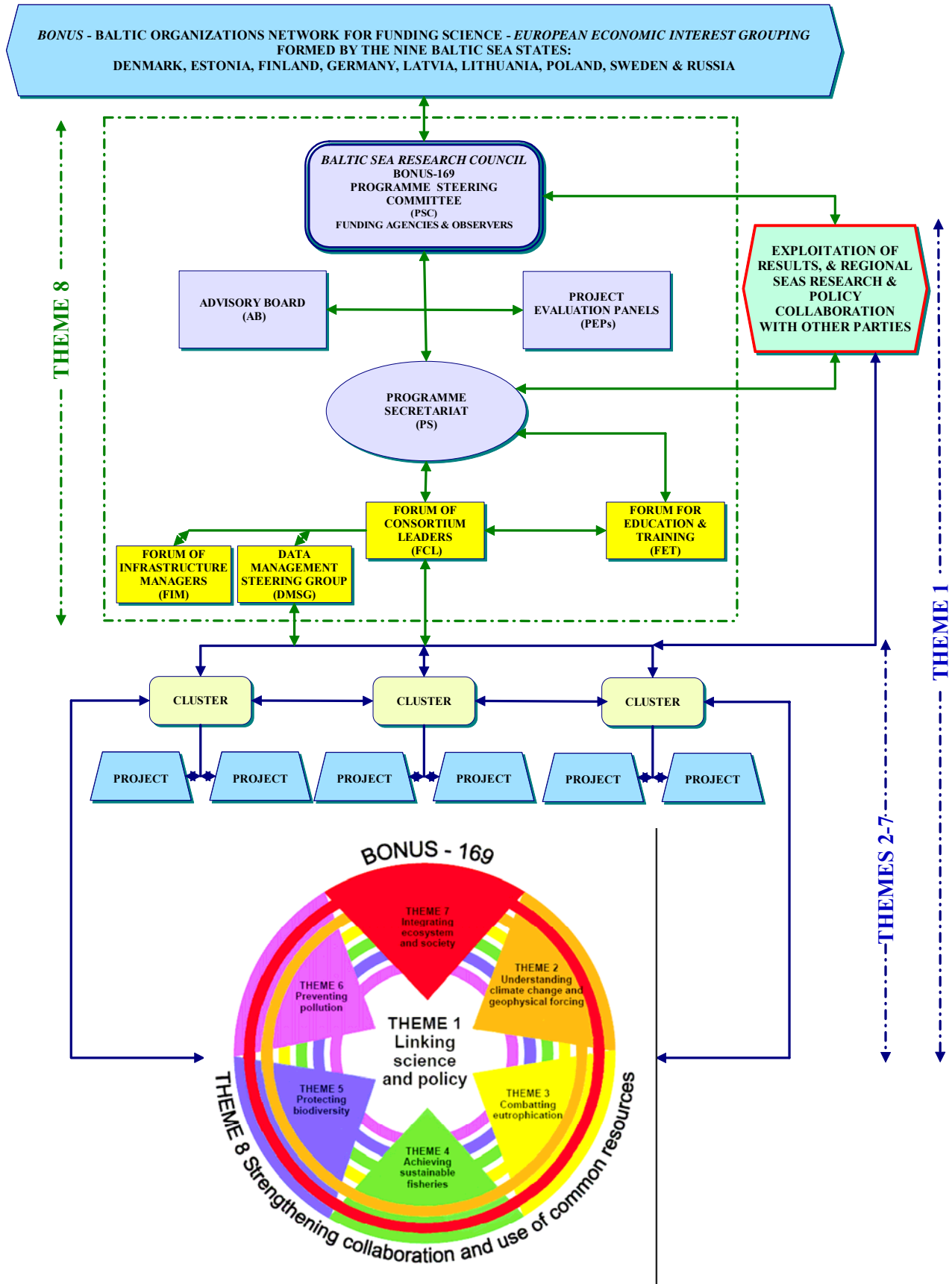
7) *Regional seas research – policy collaboration: Current and future developments for exchanging lessons learnt and best practice*

As BONUS-169 aims to develop and promote a model for collaboration in integrating research and policy related to ecosystem-based management, it is important that the lessons learnt and best practices arising from the Baltic Sea programme are exchanged reciprocally with the European Seas (*e.g.* Mediterranean Sea, North Sea, and Black Sea) and other relevant international initiatives. Areas of focus include:

- Identifying key institutional actors (*e.g.* projects, programmes, and international organizations) having overlapping interests with BONUS-169 regarding developing ecosystem-based management, including implementation of the European Marine Strategy and Maritime Policy.
- Using wherever possible existing opportunities, and practical mechanisms and forums (*e.g.* via the European Commission, CIESM, FAO, GEF, ICES, IOC/UNESCO, UNDP) with these actors for coordination, cooperation and the establishment of joint partnerships and activities, including the establishment of *ad hoc* scientific groups, workshops, and the production of joint reports.

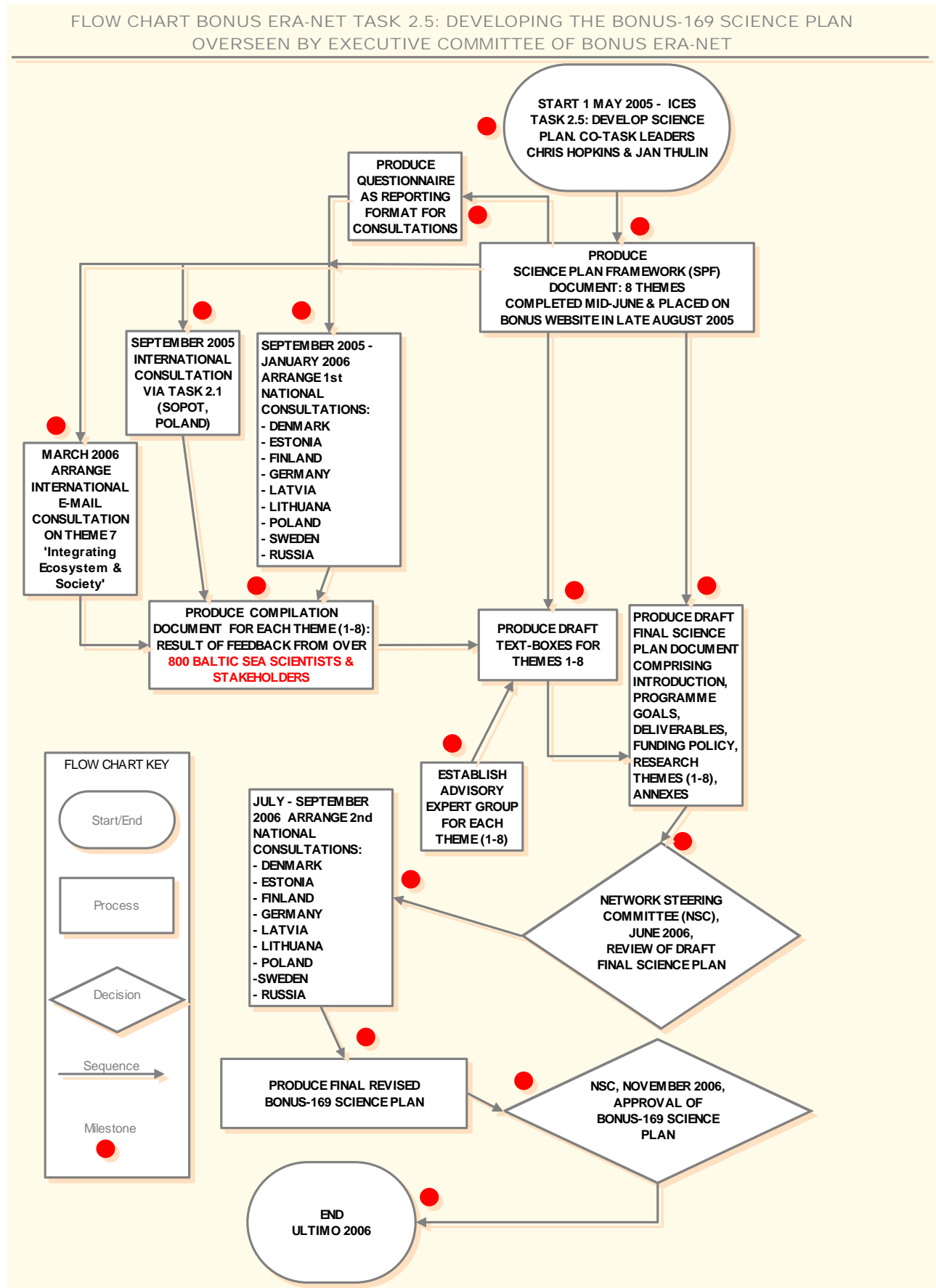
Figure 3. BONUS-169 organogram showing the main programme structures, relationships, and collaborative linkages to other parties.

It should be noted that the actual numbers of Clusters and Projects are purely for illustrative purposes.



4 ANNEXES

4.1 Annex 1. Process for developing the BONUS-169 Science Plan



4.2 Annex 2. International conventions, agreements and codes of conduct/guidelines concerning the environment and biodiversity, including conservation of fishery resources, of the Baltic Sea region. The list is illustrative rather than definitive.

Year	Instrument
1964	Convention for the International Council for the Exploration of the Sea (ICES), which was established in 1902, applying to the North Atlantic and its adjacent seas, including the Baltic Sea, aims to a) promote and encourage research and investigations for the study of the marine environment and its living marine resources, b) draw up programmes for this purpose and organize supporting research and investigations, c) publish or otherwise disseminate the results of research and investigations. Since the 1970s, a major task for ICES has involved the provision of scientific information and advice to intergovernmental regulatory commissions (e.g. HELCOM and IBSFC in the Baltic Sea), the European Commission, and the governments of ICES Member Countries, for purposes of fisheries conservation and the protection of the marine environment and its associated biodiversity and ecosystems.
1971	Ramsar Convention on Wetlands of International Importance, especially as Waterfowl Habitat.
1972	Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention, formerly the London Dumping Convention). Prohibits dumping at sea, and bans disposal of radioactive waste at sea.
1973	MARPOL 73/78 – IMO Convention on Marine Pollution from Ships. Limits operational discharges of oil, noxious liquids, and ship generated garbage including litter.
1973	Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival.
1974/92	The Convention for the Protection of the Marine Environment of the Baltic Sea Area, established the Helsinki Commission (Baltic Marine Environment Protection Commission, HELCOM) with the main objectives of protecting the marine environment of the Baltic Sea area from all sources of pollution, and to restore and safeguard the ecological balance of the Baltic Sea area. The 1992 Convention places greater focus on nature conservation and the protection of biological diversity including conserving natural habitats and protecting ecological processes to ensure sustainable use of natural resources.
1979	Bonn Convention on the Conservation of Migratory Species of Wild Animals, including 1991 ASCOBANS to protect and conserve small cetaceans in Baltic Sea and North Sea
1979	Bern Convention for Conservation of European Wildlife (fauna and flora) and Natural Habitats, giving particular emphasis to endangered or vulnerable species including those that are migratory species.
1982	UN Convention on the Law of the Sea (UNCLOS) identifying rights and responsibilities of States regarding resource management and protection of the marine environment.
1992	Convention on Biological Diversity (CBD) promoting the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources.
1992	UN Framework Convention on Climate Change (UNFCCC) sets an overall framework for intergovernmental efforts to tackle the challenge posed by climate change. It recognizes that the climate system is a shared resource whose stability can be affected by industrial and other emissions of heat-trapping 'greenhouse' gases (e.g. carbon dioxide, methane and chlorofluorocarbons). The Kyoto Protocol, an international and legally binding agreement to reduce worldwide the emissions of greenhouse gases, entered into force on 16 February 2005.
1995	FAO Code of Conduct on Responsible Fisheries providing guidelines and principles that promotes responsible fishing and fisheries activities, taking into account relevant biological, technological, economic, social, environmental and commercial aspects.
1995	UN Convention on Straddling Fish Stocks and Highly Migratory Fish Stocks seeks to lay down a comprehensive regime for the conservation and management of such stocks.
1998	UN Economic Commission for Europe (UNECE) Aarhus Convention ensuring access to information, public participation in decision-making and access to justice in environmental matters.
2004	International Maritime Organization (IMO) International Convention for the Control and Management of Ships' Ballast Water and Sediments.

4.3 Annex 3. Some European Community instruments applicable to the protection of the environment and biodiversity, including conservation of fishery resources, of the Baltic Sea region. The list is illustrative rather than definitive.

Year	Instrument
1976	Directive on Bathing Water (76/160/EEC) sets cleanliness standards for bathing water.
1976	Directive on Dangerous Substances (76/464/EEC) aims to reduce or eliminate pollution from chemicals.
1979	Directive on the Conservation of Wild Birds (79/409/EEC) establishes special conservation measures to protect habitats of rare or vulnerable species including migrants.
1979	Directive on Shellfish Growing Waters (79/923/EEC) aims to protect and, where necessary, improve the quality of waters where shellfish grow and contribute to high quality of directly edible shellfish products.
1983 and ongoing	Common Fisheries Policy (CFP), applying to fisheries and aquaculture, aims to ensure exploitation of living aquatic resources that provides sustainable economic, environmental and social conditions. Recent reforms of the CFP have <i>inter alia</i> aimed at greater integration of environmental and biodiversity concerns into fisheries policy, including implementation of the ecosystem approach to management.
1985/97	Environmental Impact Directive (85/337/EEC superseded by 97/11/EC) requires developer to provide information to competent authority about likely significant environmental effects.
1991	Directive on Aquaculture Animals and Products (91/67/EEC) aims to increase productivity, introduce health rules, and limit the spread of infections and contagious diseases.
1991	Urban Waste Water Treatment Directive (91/271/EEC) addresses the major point sources, namely the municipal waste water discharges, and sets minimum standards for the collection, treatment, and disposal of waste water dependent on the size of the discharge.
1991	Nitrates Directive (91/676/EEC) concerning the protection of surface and ground waters from pollution caused by the application and storage of inorganic fertilizers and manure from diffuse agricultural sources (farmland).
1992	EC Directive on Conservation of Natural Habitats and Wild Fauna and Flora (92/43/EEC) designates and implements conservation measures for Special Areas of Conservation
1997	Amsterdam Treaty, strengthens previous environmentally orientated declarations, sets environmental policy objectives by explicitly stating, as Community tasks, ‘a high level of protection and improvement of the quality of the environment’.
2000	Water Framework Directive (2000/60/EC) (WFD), promotes the integrated management of all water-related operations in fresh and marine waters, including coastal waters. The WFD will apply the ecosystem approach, and enhance conservation and where necessary recovery and restoration of ecosystems and their habitats, by establishing measures to terminate or phase out discharges, emissions and losses of pollutants including nutrients, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances. The WFD requires classification of the quality status of coastal marine waters. By 2013, several aspects of EC water legislation will be streamlined and subsumed into the WFD.
2005 and ongoing	<i>European Marine Thematic Strategy for the Protection and Conservation of the European Marine Environment</i> ’ (COM (2005) 504) recognizes that diverse human activities pose major threats that impact the marine environment and its associated ecosystems. The Marine Strategy, and its supporting Marine Strategy Directive ‘ <i>Establishing a Framework for Community Action in the field of Marine Environment Policy</i> ’ (COM (2005) 505), aim to cover all the actions needed to ensure that all human activities impacting upon the oceans and seas are managed so that marine biological diversity and critical habitats are conserved and human use of them is sustainable. The Strategy and Directive focus on the application of an integrated ecosystem approach to management, aiming to achieve good environmental status of the Community’s marine waters by 2021 and to protect the resource base upon which marine-related economic and social activities depend. The Strategy constitutes the environmental pillar of the emerging Maritime Policy, as envisaged in the <i>Maritime Green Paper: Towards a Future Maritime Policy for the Union: A European Vision for the Oceans and Seas</i> (COM (2006) 275) that is designed to achieve the full economic potential of oceans and seas in harmony with the marine environment. The Marine Strategy Directive will establish European Marine Regions on the basis of geographical and environmental criteria. Each Member State, in close cooperation with relevant other Member States and third countries within a Marine Region, will be required to develop Marine Strategies for its marine waters. The Marine Strategies will contain a detailed assessment of the state of the environment, a definition of ‘good environmental status, at the regional level and the establishment of clear environmental targets and monitoring programmes. Each Member State will draw up a programme of cost-effective measures. Impact assessments, including detailed cost-benefit analysis of the measures proposed, will be required prior to the introduction of any new measure.

4.4 Annex 4. Definition of terms connected with BONUS-169.

The **BONUS Science Plan** is a framework programme defining the strategy for funding Baltic Sea Research by BONUS – Baltic Organization’s Network for Funding Science.

Themes are the subdivisions of the science plan describing its thematic areas.

Calls for proposals are based on the funding strategy of the science plan and its themes. They define all conditions which are necessary for the scientific community to formulate detailed applications to BONUS-169. The applications are the basis for evaluation including peer reviewing.

Project is an entity, which addresses the scientific goals described in the call for proposals. A project is typically composed of several workpackages.

Consortium is a group of at least two institutes, universities, companies or other entities, which have agreed to submit a project proposal to BONUS-169 programme and to jointly implement the work described in the project proposal.

Participant is a research institute, university, company or other entity, which is a part of a consortium and implements part of the work described in the project proposal. It is also the receiver of the research funds (mixed EU and national funds) from the national funding agency.

Project coordinator is a participant chosen by the consortium, who has overall responsibility and authority over a project in relation to the project management towards participants and towards BONUS general management.

Principal scientist is in charge of the project in each institute and has the responsibility over his/her Task in relation to the participant institute and the national funding agency.

Workpackage is a thematically circumscribed contribution to a project. It may consist of one or more tasks.

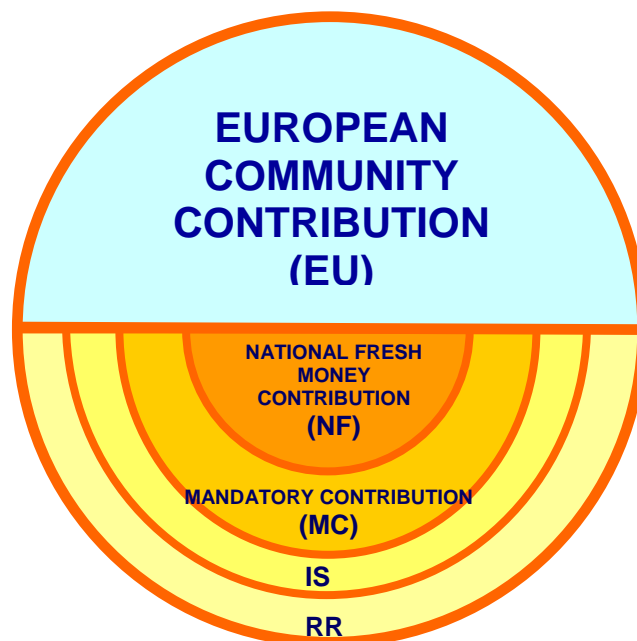
Task is a contribution of a principal scientist and his/her group to a workpackage.

Deliverables are work *products* and constitute the substantiation of programme/project implementation.

Stakeholders are all those persons/institutions that have an interest in the Science Plan and its outputs.

Users are those stakeholders that will practically make use of the outputs from the Science Plan.

4.5 Annex 5. Schematic presentation of the BONUS-169 Virtual Common Pot and explanations



EU – EU contribution: Added on top of the consolidated national research funds to assist EU Member states jointly implement a research activity in accordance with Article 169.

NF – National fresh money contribution: National research funding agencies participating in the programme must commit themselves to hand over their contribution in a binding way over the programme duration (*e.g.* 2008 – 2012), under the sole restriction of budget availability. These funds will remain with the particular national research funding agency, but will be governed and distributed strictly and completely according to the PSC recommendations

MC – Mandatory contribution: In the case of a successful research project proposal, the eligibility rules concerning project proposals will stipulate the mandatory in-kind contribution by the funded institutions as a percentage of the fresh money obtained by them from the programme. The percentage will be 10% from university structural units, and 30% from governmental and independent research institutes. For pre-estimation purposes, the amount of the mandatory contribution shall be calculated as 20%⁵⁵ of doubled⁵⁶ national fresh money contribution.

IS – In-kind contribution by the programme partners to run research infrastructures that are directly involved in projects funded by the programme. For pre-estimation purposes, each of the programme partners shall estimate the typical proportion between fresh money value of competed research projects and additional running costs of infrastructures directly used to support these projects. The most obvious, and potentially large, portion of infrastructure costs is ship-time. If, for instance, partner X typically awards *A* millions EUR fresh money grants/year for Baltic Sea research projects, and these grants are subsidized by *B* millions EUR/year of ship-time contribution from other sources, *e.g.* from the State budget to research institutes, specific infrastructure funds, local governments, etc., then IS (ships) is calculated as $2^1 \times NF \times B/A$. Another example of an infrastructure contribution is administration costs by national research funding agencies. Again, if for instance, partner X typically awards *A* millions EUR of fresh money grants/year, and spends *B* millions EUR/year to administrate the associated projects, IS (administration) is calculated as $2^{57} \times NF \times B/A$. Partners also may identify other substantial infrastructure units, *e.g.* databases or computational facilities, data acquisition facilities, experimental facilities. Partners are advised to: a) include only infrastructures that really can be financially substantiated and that realistically can be justified as direct contributions to the programme, and b) check carefully that contributions identified as MC do not overlap with the declared IS contribution.

RR - Related research: A situation may occur whereby a project proposal, whose consortium comprises a team or researcher related to the particular national funding agency, is positively evaluated as meeting programme objectives and scientific quality criteria but is not awarded a grant due to budgetary limitations. In this case, the national funding agency may decide to fund the project from its own resources. Such funding then may be designated as RR. It is not possible to pre-estimate the amount of RR. The applicable proportion will be identified from the partner's financial reports and applied during further years.

⁵⁵ For pre-estimation purposes it is assumed that the programme awards will be distributed evenly between university structures and other kind of research institutes.

⁵⁶ It is assumed that the EU contribution will be at least equal to the national fresh money contribution (NF).

⁵⁷ It is assumed that the EU contribution will be at least equal to the national fresh money contribution (NF).

4.6 Annex 6. BONUS-169 participation share estimates for five years by the nine Baltic Sea States.

Values are in millions of EUR. Part of the share estimates have already been confirmed by authorized signatures (28 August 2006), while some others need to await decisions by the respective governing body meeting during autumn 2006.

State	Funding agency	Fresh funds	R&D	'In kind' contribution	Total
Denmark	Danish Agency for Science, Technology and Innovation; Danish Natural Science Research Council; Ministry of Food, Agriculture & Fisheries; Ministry of Environment		5,8	19,4	25,2
Estonia	Estonian Science Foundation		0,5	0,5	0,1
Finland	Academy of Finland		5,0	8,8	13,8
Germany	Project Management Organization Juelich		5,0	22,0	27,0
Latvia	Latvian Council of Science		0,4	0,4	0,7
Lithuania	Ministry of Education and Science		0,5	1,2	1,7
Poland	Ministry of Science and Higher Education		1,3	1,7	2,9
Russia	Russian Foundation for Basic Research		7,5	4,6	12,1
Sweden	Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning; Swedish Environmental Protection Agency; Foundation for Strategic Environmental Research		8,0	3,2	11,2
Total			33,9	61,8	94,7