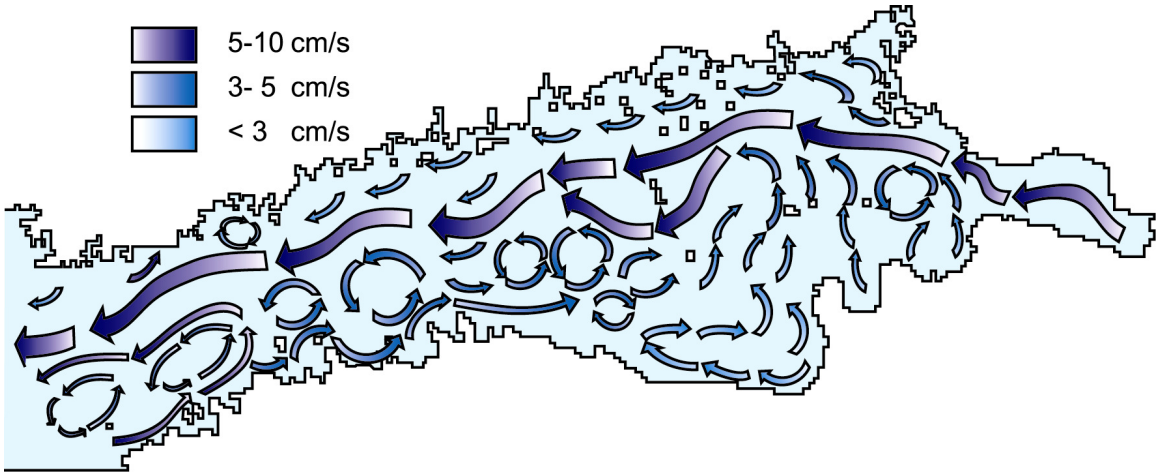
BONUS+ Project

BalticWay

The Potential of Currents for Environmental Management of the Baltic Sea Maritime Industry



Final Report 2009–2011

Annual Report 3: January– December 2011

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BONUS+ Project BalticWay

The Potential of Currents for Environmental Management of the Baltic Sea Maritime Industry (2009–2011)

Executive Summary

The BalticWay consortium consists of eight teams from five Baltic Sea countries: Finnish Environment Institute (SYKE, led by Dr Kai Myrberg); Department of Meteorology, University of Stockholm (MISU, Prof Kristofer Döös); Swedish Meteorological and Hydrological Institute (SMHI, Dr Markus Meier); Danish Meteorological Institute (DMI, Dr Jun She); Institute for Coastal Research, HZ Geesthacht (ICR, Prof Emil Stanev); Leibniz Institute of Marine Sciences at the University of Kiel (IFM-GEOMAR, Dr Andreas Lehmann); Laser Diagnostic Instruments, Estonia (LDI, Dr Sergey Babitchenko). The activities were coordinated by the Institute of Cybernetics at Tallinn University of Technology, Estonia (IoC, Prof Tarmo Soomere).

This project reflects the cooperative and highly interdisciplinary research needs of sustainable development and effective stewardship of the Baltic Sea. It was aimed at preventive reduction of remote risks caused by a release of adverse impact into the sea surface and further transported by surface currents to vulnerable or valuable sea areas (such as spawning, nursing or also tourist areas). Proper handling of such environmental risks is exceptionally important in medium-sized particularly vulnerable sea areas hosting intense ship traffic such as the Baltic Sea, and especially the narrow Gulf of Finland. Pursuing a long-term substantial decrease in the anthropogenic impact on biodiversity, particularly on fragile ecosystems, and greatly reduced costs of accidents, the BalticWay ***core objective*** was to establish key components of a reliable, robust and low-cost technology for the environmental management of shipping (like optimising ship routes in terms of safety and length), offshore industry, and coastal engineering activities.

A substantial decrease in environmental risks is possible by minimizing the consequences of potential accidents beforehand by placing various activities in the safest offshore areas. Our approach is based on a smart use of semi-persistent current patterns, which considerably affect pollution propagation as well as drift of various items (vessels without propulsion, rescue boats, lost containers, etc.). These patterns make the probability of transport of dangerous substances from different open sea areas to vulnerable sections highly variable. For certain *areas of reduced risk* this probability is relatively small, while the (re)-direction of activities to these areas often incurs very limited additional costs.

The systematic quantification of the potential of different sea areas to be a source of danger to the environment through current-driven transport involves solving an inverse problem of pollution propagation. Such problems are frequently mathematically ill-posed and no universal method exists for solving them. BalticWay developed an approximate solution through extensive analysis of a large number of numerically simulated particular solutions to the associated direct problem of propagation of adverse impacts – Lagrangian trajectories of selected water particles (equivalently, passively advected tracers). Coastal areas were used as a generic model for valuable regions.

The developed technology contains four key components: (i) an eddy-resolving, high-resolution circulation model; (ii) an advanced scheme for tracking Lagrangian trajectories of

water or pollution particles; (iii) a technique for the calculation of quantities characterising the potential of different sea areas to supply adverse impacts; (iv) methods to construct the optimum fairway. Several novel measures were introduced to express environmental gain, e.g., in terms of the probability of pollution transport to the vulnerable areas and the time (particle age) it takes the pollution to reach these areas.

The entire approach is based on the analysis of certain statistical features of current-induced transport. Since their outcome is not always explicit, one of the major challenges consisted in further developing techniques for the use of statistical information in solving dynamical problems.

Circulation simulations – with a very high resolution necessary for adequately describing the key features of meso-scale motions – provided detailed information about the extreme complexity of water motions. They have substantially improved our understanding of the current patterns in the Baltic Sea, leading to better knowledge of geophysical forcing of pollution transport and contributing to the predictive capacity of circulation and operational models. In parallel, we have developed and applied knowledge systems for effectively tracking huge amounts of information about current-driven transport. The use of Lagrangian trajectories made it possible to identify a number of concealed transport features, which cannot be inferred from the analysis of Eulerian velocity or from even massive measurements. Novel mathematical methods (e.g. introducing finite-time compressibility of sea surfaces) led to new knowledge about the properties and potential effect of favourable semi-persistent current patterns and established criteria for the existence of areas of reduced risk in different sea regions.

The massive numerical calculations and extensive theoretical studies were supported by specifically designed field experiments. The mapping of long-term behaviour and dispersion properties of subsurface currents in the Baltic Sea and surface currents in the Gulf of Finland was performed using autonomous drifters based on the longest ever recorded time series of drifters' positions.

A variety of approaches was applied to specify an optimum fairway. The 'fair way' of dividing the risks equally between the opposite coasts (the equiprobability line) is a local solution. Approximations to the global optimum for the entire water body were constructed using 2D maps that characterise each sea point in terms of its ability to create danger to the vulnerable regions. The resulting fairways are most promising in terms of minimising the risk of coastal pollution. In the Gulf of Finland, the gain from the use of the optimum fairway is about 40% in terms of the decrease in probability of coastal pollution, and the typical time it takes for the pollution to reach the coast may be almost doubled.

The key results are:

- Development of a four-step technique for offshore environmental management that minimises current-driven risks for coastal regions; widespread analysis of its applicability; identification and solution of several underlying mathematical issues.
- Implementation of advanced algorithms (e.g. Dijkstra and MonteCarlo-method-based) for the identification of the environmentally safest fairways based on 2D maps of novel measures of environmental risks.
- Quantification of the robustness and stability of the optimum fairways; extension of the technology to the Baltic Proper and SW Baltic Sea; quantification of the impact of local wind and waves for the optimum fairways in the Gulf of Finland.

- Mathematical justification of the developed technology and synthesis for its use in different environments; introduction of the concept of finite-time compressibility of sea surfaces.
- Mapping of long-term behaviour and dispersion properties of subsurface currents in the Baltic Sea and surface currents in the Gulf of Finland based on the longest ever recorded time series of drifters' positions, using the results to improve the underlying trajectory models.
- Quantification of spatio-temporal variability in average and extreme properties of the Baltic Sea wave fields, identifying spatial patterns in their decadal changes and long-term trends.
- Massive dissemination of the results to the scientific community in leading scholarly journals (34 peer-reviewed papers already published, >20 in progress), invited and plenary presentations to high-level conferences, invited presentations to science policy conferences.
- Great success in demonstrating the importance of cutting edge science in the political decision-making process (Nord Stream consultations), leading to public distinctions of team members.
- Winning a follow-up national R&D project (2012–2014) towards practical implementation of the developed technology for sea areas surrounding Estonia.

The results are of vital importance for (inter)national and regional institutions responsible for environmental protection and maritime spatial planning, providing a cost-effective ecosystem-based management technology towards the mitigation of environmental problems and risks. The developed novel scientific strategy for improving the assessment and management of potential pollution is directly usable in the decision-making process in crisis situations, e.g., about different search-and-rescue issues, or how to reposition a leaking vessel.

Practical implementation of the results is expected to substantially decrease the impact of maritime transport and industry on bio-diversity, particularly on fragile eco-systems. It will indirectly contribute to sustainable fishing through better protection of key areas of fish stock reproduction. The method can also be used to support decisions about how far the fairway for ships carrying dangerous cargo should be located from vulnerable areas facing the open ocean.

The wide potential for applications makes the follow-up efforts towards the uptake of the concept particularly important. Now the challenge is to link science and policy through the creation of the necessary transboundary societal, economical, legal and political framework for the real implementation of the research results. The ultimate goal is to have the technology used by maritime boards for a new generation of fairway and ship routing services as a proper way of integrating marine ecosystem management with other needs of society, and linking scientists, stakeholders and decision-makers in the process of elaborating a scientific base for political decisions. The newly granted Estonian project will vigorously pursue this goal.

Project years: Synopsis and highlights

Project Year 3 (Jan–Dec 2011)

- Intense and fruitful work towards detailed analysis of the components of the developed technology, its mathematical justification and synthesis for the use in different environments.
- Application of the developed technology to different sea domains (Baltic Proper, SW Baltic Sea), widespread analysis of its applicability, identification and resolution of several underlying mathematical issues.
- Extensive field measurement campaign towards the mapping of dispersion properties of surface and subsurface currents of the Baltic Proper and the Gulf of Finland; application of the results for improvement of the underlying models.
- Massive dissemination of the results to the scientific community in the leading scholarly journals, invited and plenary presentations to high-level conferences; invited presentations to science policy conferences.

Highlights

- Implementation of more sophisticated algorithms (incl. Dijkstra and MonteCarlo) for the identification of optimum fairways based on 2D maps of environmental risks.
- Extension of the technology to the Baltic Proper and SW Baltic Sea.
- Establishing robustness and stability of the optimum fairways.
- Quantification of the impact of local wind and waves for the Gulf of Finland.
- Mapping of dispersion properties of both subsurface and surface currents in the Gulf of Finland with the use of autonomous drifters.
- Introduction of the concept of finite-time compressibility of sea surfaces.
- Quantification of spatial variability in decadal changes and long-term trends in the average and extreme wave properties of the Baltic Sea.

Project Year 2 (Jan–Dec 2010)

- The work gathered full speed in the 2nd project year; most of the delays of the 1st year levelled off.
- The basic steps of the technology for environmental management of offshore sea areas established and documented.
- Success in dissemination of the results to the scientific community in the form of conference presentations, publications and public lectures.

Highlights

- Mapping of long-term behaviour and dispersion properties of subsurface currents in the Baltic Sea with the use of autonomous drifters based on the longest ever recorded time series of drifters' positions.

- Formulation of the four key steps of the technology of fairway design, development of algorithms for the identification of an optimum fairway based on local features of environmental risks.
- Quantification of spatial and temporal variability of average and extreme properties of the Baltic Sea wave fields based on numerical simulations for 1970–2007 and historical wave data.

Project Year 1 (Jan–Dec 2009)

- The project started overall successfully, in spite of some delays in the first half-year because of financing issues that needed to be resolved.
- Cooperation established; deliverables and (internal) milestones mostly on track; one deliverable ahead of the schedule; two additional deliverables released.
- Clear progress in scientific content; very positive feedback from several scientific conferences.
- Estimated 80% of the first-year activities performed; several items ahead of time.
- Great success in dissemination & demonstration of the importance of cutting edge science in the political decision-making process (Nord Stream consultations), followed by public distinctions of the members of the IoC group.

Scientific Results

Work Package 1 – Forcing and boundary data: ICR

- Task 1.1 *Gathering and unification of data for running the circulation models*, PM 1–12, Leader: IoC
- Task 1.2 *Gathering and unification of data for running the risk model*, PM 1–18, Leader IoC
- Task 1.3 *Common weather forcing and wave-induced radiation stress*, PM 7–24, Leader: DMI

Overall appraisal: The WP has fulfilled its key goal – to ensure that the modelling and analysis teams have at their disposal all necessary data reflecting forcing and boundary information for circulation models and data about ship traffic for risk models. The resulting database (http://waveserv.ioc.ee:7000/) has been considerably expanded and contains also detailed information about the Baltic Sea wave climate.

A common meteorological forcing database (12 nautical mile (nm) resolution downscaled product of the ERA-40 data covering the North Sea and the Baltic Sea) was constructed. A total of 40 years of hourly weather forcing data has been extracted and pre-processed: surface pressure, temperature, wind velocity, precipitation, snow depth, actual albedo, short and long wave radiation, evaporation, relative and specific humidity and total cloud cover. Forcing data and oceanic responses have been validated against independent data sources. The constructed data was shared by all BalticWay partners as a core data set for fulfilling the tasks of WP2.

Wind fields for 1961–2007 from a regional atmosphere model driven by ERA-40 data at the lateral boundaries were evaluated, validated and shared by BalticWay partners as alternative forcing data. The widely used sources of climatological data for the Baltic Sea have been provided and adjusted by DMI for use by all partners. This data set, known as the *Baltic Sea Climatology*, was compiled for temperature and salinity in the area of the North Sea and the Baltic Sea. The river runoffs of 31 rivers into the Baltic Sea included in the data set have been extracted as monthly river discharge data from the Hydrographical Center for BALTEX (BHDC) and converted for use by the models run by the partners.

Processing of the 25-year SMHI wind data was performed with the goal to separate windy and calm seasons in the Gulf of Finland in the context of establishing the annual course of measures of environmental risk and optimum fairways. 20 years (1982–2001) of data have been analysed by ICR and compared with the ECMWF data set. Boundary values for oil drift modelling (WP3) were extracted from the 40-year database generated in the Danish "Sunfish" project with 6 nm resolution in the North Sea and the Baltic Sea, and 1 nm in the Wadden Sea and the Danish Straits. A comprehensive analysis was performed for the basic properties of atmospheric forcing over the Baltic Sea (Lehmann et al. 2011; Getzlaff et al. 2011; see also Task 4.3).

In order to fulfil the requirements of high-resolution models for the quality and resolution of initial, boundary and forcing data, boundary information at the entrance of the Gulf of Finland was recalculated for high-resolution (0.5 nm and 0.25 nm) circulation. In addition, the above

SMHI metocean data set was readjusted for running the circulation mode for the high-resolution (0.5–0.25 nm) models of the Gulf of Finland.

For validation purposes, an analysis of the meteorological forcing data for 1986–2008 was performed for the BSH model input. A one-year validation simulation of the BSH model was successfully compared against climatic sea temperature and salinity data.

The locations of the main ship routes in the Gulf of Finland, the Baltic Proper and in the southern Baltic Sea were extracted from databases of national maritime boards and converted into the form necessary for use in the risk modelling for different parts of the fairway. The resulting information was used for simulations of the propagation of tracers and oil drift in the southern Baltic Sea (see WP3, WP6 and WP7, Xi et al. 2012), the Baltic Proper (Höglund and Meier 2012) and in the Gulf of Finland (Murawski et al. 2012). It was also used for the analysis of links between specific sections of the fairway and frequently hit coastal areas (Viikmäe and Soomere 2012). This information also served as reference data in the analysis of the risk associated with and the gain from optimal ship trajectories.

The SMHI geostrophic wind database was shared with the IoC in order to perform calculations of wave properties in the Baltic Sea for more adequate estimates of realistic metocean conditions and wave-induced radiation stress. Wave properties for the Baltic Sea were calculated for 1970–2007 with a resolution of 3 nm (Räämet and Soomere 2010, 2011; Soomere and Räämet 2010, 2011a, 2011b, 2012). As a substantial extension of Task 1.3, partially performed in 2011, visual observation data from coastal hydro-meteorological stations were merged into the detailed analysis of spatio-temporal variations in average and extreme wave properties in the Baltic Sea (Zaitseva et al. 2009; Räämet et al. 2010; Soomere et al. 2010b, 2011b, 2011f, 2012; Kelpšaite et al. 2011; Soomere and Kurkina 2011) and also used to estimate the magnitude of certain wave-driven coastal hazards (Soomere et al. 2011h; Soomere and Viška 2012). A subroutine was developed to calculate the wave-induced radiation stress (i.e. the wave-induced momentum) for scenario runs based on common wave properties.

The work has been performed mostly according to schedule. An extension of the WP towards merging various wave data into the data pool was mostly performed in 2011.

Key progress in 2011: Establishing spatio-temporal variations in average and extreme wave properties and associated values of the wave stress in the Baltic Sea.

- Detailed analysis of patterns of trends in long-term average and extreme wave properties in the Baltic Sea; evaluation of the wave climate in the south-western Baltic Sea (ICR, IoC).

Future plans: The pool of data covering atmospheric forcing, boundary information, river runoff, wave properties, etc. is a highly valuable data set in many aspects of ocean modeling. It will be kept open to all partners. Its "life-time", however, is quite limited. The gradually improving atmospheric models and increasing computational power make it possible to create similar information with much better resolution (e.g. ERA-85 that is currently in progress). Many features of the Baltic Sea wind fields (e.g. a substantial turn in the wind direction when crossing the Gulf of Finland see Keevallik and Soomere 2010) are, however, still not properly represented by existing atmospheric models. This calls for the implementation of new physics into the models and for a proper re-analysis of meteorological forcing in the recent past for the Baltic Sea with a high resolution (at least using 10 km × 10 km grid size).

Work Package 2 – Circulation modelling in the target areas: SMHI

- Task 2.1 *Simulations of circulation in the entire Baltic Sea with a moderate resolution*, PM 4–18, Leader: SMHI
- Task 2.2 *High-resolution simulations of circulation in the Gulf of Finland and the western Baltic Sea*, PM 7–30, Leaders: SYKE and IFM-GEOMAR
- Task 2.3 *Validation modelling of the circulation of the entire Baltic Sea*, PM 7–24, Leaders: ICR and DMI

Overall appraisal: The WP worked as expected, providing highly valuable sets of simulated data for use in other WPs. The amount of simulations was about twice as large as originally planned. A number of in-kind contributions from the partners towards substantial improvement of the RCO, IFM-GEOMAR, DMI, HZG and OAAS models have been made.

Simulations of the circulation in the entire Baltic Sea (T2.1) with a moderate resolution (2 nm) for 48 years (instead of the planned 20 years) were performed using the Rossby Centre Ocean (RCO) coupled sea-ice ocean circulation model that is optimized for multi-year long simulations of the past and future climate. The initial, forcing and simulated data were distributed within the consortium. The velocity data served as the starting point for research reflected in more than 15 peer-reviewed publications addressing statistical parameters of transport extracted from Lagrangian trajectories (see WP3, WP4, WP6, WP7 and the list of publications below).

The current velocity, sea ice concentration and thickness, water temperature, and salinity fields were also used as boundary information for higher-resolution circulation simulations in the Gulf of Finland (T2.2) and to calculate spatial distributions of the risks of oil spills (Höglund and Meier 2012; more than 1.5 million hypothetical oil spills based upon RCO using an idealized passive tracer, see also WP3, WP4, WP6 and WP7). The results were validated against simulations using the RCO model with an improved vertical resolution (83 layers), and recently improved atmospheric forcing and model parameterizations (e.g. a new multi-category sea-ice model to improve the surface currents during winter). Intricate test simulations (concerning stability, mass conservation in the model, etc.) were performed in 1 nm resolution with the RCO for the ERA-40 period.

High-resolution simulations of circulation in the Gulf of Finland (T2.2) were performed using the regional OAAS model and newly constructed bathymetry data with a resolution of 0.5 nm in the central and eastern parts of the basin and 0.25 nm in Estonian and Finnish waters (Andrejev et al. 2010). These high-resolution data from runs with a resolution of 1 and 0.5 nm covering 20 years (Andrejev et al. 2012a, 2012b) are a milestone of this WP because the hierarchy of models with different resolutions allows to study the impact of the very irregular bathymetry and the impact of mesoscale structures (depending on the internal Rossby radius) on the fairway optimization. A circulation model with a 1.3 nm resolution has been run for 1990–2009 by IFM-GEOMAR in order to analyse the circulation and drift patterns in the whole Baltic Sea. The DMI model CMOD has been run for the Baltic Sea over 20 years with a resolution of 3 nm in the North Sea and Baltic Sea and 0.5 nm for the western part of the Baltic Sea (T2.2).

The results of the above simulations were extensively validated against results of independent ocean models (T2.3). Using the DMI code and 40 years forcing database, a comparison was carried out between the performance of the DMI and BSH models based on a

one-year simulation (for the year 2002). The results have been compared against the climatology and post-processing tools have been developed. An overview of the underlying issues in the Baltic Sea and the Gulf of Finland in the context of BalticWay framework is given in (Lehmann and Myrberg 2012; Myrberg and Lehmann 2012). A comprehensive analysis of the modelling issues with different models and in different basins is presented in (Stanev and Xi 2012).

The circulation of the western Baltic Sea has been evaluated as well. It was ensured that the features evident in the simulations of T2.1 and T2.2 are robust and independent of the particular circulation model or its resolution. It was demonstrated that the results in the high-resolution domain in the western part of the Baltic Sea were of good quality and could serve as input to the TRACMASS model as they presented a reliable dynamic ocean state. Additionally, climatic analyses have been carried out on inflow regimes during the last 20 years.

The robustness and reliability was also checked using both the regional HZG operational 3D ocean model and the IFM-GEOMAR model for the entire Baltic Sea during long simulations. Drift modelling and comparisons of drift behaviour in the western Baltic Sea and the Gulf of Finland have been performed (Xi et al. 2012; Stanev and Xi 2012).

Overall, the large data set of model simulations based upon very different models and a large range of horizontal resolutions is unique. These data were very important as input for the other WPs and guaranteed the success of the entire project.

The work has been performed mostly ahead of schedule. Tasks 2.1 and 2.2 were completed a few months before the scheduled time and Task 2.3 as scheduled but with even higher resolution than planned.

Key progress in 2011: Extensive validation simulations of circulation and hydrographical parameters for the entire Baltic Sea; several simulations in extremely high resolution (0.5 nm) for the Gulf of Finland.

- Several long-term runs (over 20 years) with a resolution of 0.5 and 1 nm performed with the OAAS model in the context of optimisation of fairways based on surface and subsurface dynamics (SYKE).
- Demonstration of the insufficient performance of models with a resolution of 2 nm for adequate identification of the optimum fairway in the Gulf of Finland; evidence that the use of models with a resolution of 0.5–1 nm leads to adequate results (SYKE, IoC).
- Extensive high-resolution simulation of circulation for the south-western Baltic Sea for validation purposes (ICR, DMI, IFM-GEOMAR).
- Climatic analyses have been carried out on inflow regimes during the last 20 years (ICR).

Future plans: Some essential results of this work package are in preparation for publication (e.g. in the forthcoming BalticWay book *Preventive Methods for Coastal Protection: The Use of Ocean Dynamics for Pollution Control*, T. Soomere and E. Quak (eds.), Springer, Autumn 2012) and require additional efforts from the partners during 2012. The database will be used for follow-up projects and other relevant applications studying the risks of oil spill. The data are freely available from IoC.

Work Package 3 – Particle trajectory and oil spill modelling: MISU

- Task 3.1 *Implementation of the MISU method for exact and invertible calculations of trajectories at IoC and ICR*, PM 1–12, Leader: MISU
- Task 3.2 *Calculation of Eulerian and Lagrangian trajectories of water particles*, PM 4–30, Leader: MISU
- Task 3.3 *Modelling of oil drift patterns in the Baltic Sea*, PM 10–33, Leader: DMI

Overall appraisal: The WP worked as expected, providing the necessary tools, methods and data sets for further synthesis in other WPs.

The basic tool – the TRACMASS code – was updated, extensively documented (Döös and Kjellsson 2012) and adjusted for use in the Baltic Sea conditions. A new user-friendly release of the TRACMASS manual was created (available over the TRACMASS website http://tracmass.org). An intense course for the BalticWay personnel was organised in Tallinn (July 14–24, 2009; 7 participants). The TRACMASS code was implemented by partners IoC, ICR and DMI and adjusted for the use of information about hydro-physical fields created by different ocean models.

Large sets of Eulerian and Lagrangian trajectories were calculated for the Gulf of Finland, the Baltic Proper and the southern Gulf of Finland, using both offline (TRACMASS code) and online (simultaneously with the integration of different circulation models) methods. The trajectories constructed offline have been organised into a data set at the IoC for further use. Based on this data, analysis of net and bulk transport patterns in the surface layer in the years 1987–1991 was performed for the Gulf of Finland (Soomere et al. 2011a) and for the year 1985 for the western Baltic Sea. Online data sets for both surface and subsurface flows have been utilised for the direct construction of spatial distributions of measures of environmental risk. See WP4, WP6 and WP7 for the use of the trajectories.

Optimum parameters for the length of trajectory calculations, the time lag between the starting points, and the proper definition of the near shore were established based on the analysis of temporal variability in the number of trajectories reaching the nearshore and leaving the Gulf of Finland (Viikmäe et al. 2010). A novel method accounting for the strong rotational component of mesoscale currents in the Gulf of Finland was developed for the parameterization of subgrid-scale turbulence in numerical simulations (Andrejev et al. 2010).

Extensive efforts were made to model potential oil drift patterns in all target areas using both Eulerian (Höglund and Meier 2012; Lehmann et al, in preparation) and Lagrangian viewpoints. Tracking drifters along the positions of the main ship routes through the southern Baltic Sea was performed using the IFM-GEOMAR drift model; the times when drifters hit the coast were evaluated for different seasons. The drift model for the southern Baltic Sea was adapted to the resolution of 1.3 nm. The resolution of the DMI operational circulation and oil spill model was extended to 0.5 nm in the Gulf of Finland (Murawski et al. 2012).

Several models were substantially updated based on high-resolution bathymetry information and chains of models with a resolution from 0.25 to 2 nm were applied for the Gulf of Finland (Andrejev et al. 2011, 2012a, 2012b). The results of simulations of purely current-induced transport of adverse impacts, performed for all the target areas, are described in detail in WP4, WP6 and WP7.

Massive simulations of oil fate and drift were performed in realistic conditions, accounting for wave- and wind-induced transport in the Gulf of Finland and improved sets of metocean data from the HIRHAM meteorological model (Murawski and Nielsen 2012; Murawski et al. 2012). A development plan for the improvement of the description of the wave effects in oil drift models has been worked out.

Key progress in 2011: Extensive calculations of trajectories of water particles using different types of circulation models and codes for particle tracking; massive simulations of oil fate and drift in realistic conditions (accounting for wave- and wind-induced transport) in the Gulf of Finland.

- Task 3.1 and most of Task 3.2 completed in 2010.
- (3.2) Substantial update of the database of trajectories calculated off-line (IoC).
- (3.2) Extensive modelling of trajectories for the southern Baltic Sea (ICR, IFM-GEOMAR) and for both surface and subsurface flow in the Gulf of Finland (SYKE).
- (3.3) Massive simulations of oil fate and drift in realistic conditions (accounting for wave- and wind-induced transport) in the Gulf of Finland using the updated version of the DMI operational model (DMI).
- (3.3, 4.3) Drift model based assessments and estimation of spatio-temporal variability in oil drift patterns under seasonally varying metocean conditions, based on more than 150,000 spill simulations (DMI).
- (3.3, 4.3.) Quantification of average and extreme effects of waves on oil transport patterns in terms of the distributions of the measures of risk; estimates performed for average conditions and for the winter storm 2005 (DMI).
- (3.2, 3.3) More than 1.5 million hypothetical oil spills in the Baltic Proper and Gulf of Finland have been simulated. For each spill, a time series of how much of the oil has not yet reached the coast was recorded. Different statistical measures have been constructed and applied to the results for each spill location to draw maps showing how severe an oil spill would be in each location relative to other locations (SMHI).

Future plans. The objective of this WP was to realize the intermediate step from the enormous amount of raw data produced in WP2 towards practically usable results by calculating the set of potential trajectories of water particles. The database of trajectories calculated off-line will be gradually updated by the IoC. This set has a long-term value. Only a small fraction of its potential for solving different problems of the quantification of environmental risks, for decision support systems and for maritime spatial planning has been exploited so far. We already started using the data and updated online trajectory modelling systems for further analysis and mitigation of anthropogenic pressure based on realistically distributed values of the near shore.

Work Package 4 – Synthesis: Identification of areas of reduced risk: IFM-GEOMAR

- Task 4.1 *Identification of areas of reduced risk from the analysis of Lagrangian and Eulerian trajectories*, PM 7–30, Leader: MISU
- Task 4.2 *Uncertainties and seasonal and inter-annual variability of the areas of reduced risk*, PM 13–36, Leader: IoC
- Task 4.3 *The effect of local wind and waves*, PM 13–33, Leader: DMI
- Task 4.4 *Areas of reduced risk associated with favourable subsurface current patterns*, PM 16–36, Leader: SYKE

Overall appraisal: the WP worked as expected, providing highly valuable input for WP6 and WP7 and on-going cooperation between partners. The results may have major implications in maritime spatial planning. Due to an abundance of results in the final stage of the project, some of them from the 3rd project year are not yet published.

Several new dynamic patterns of current-induced transport (incl. those for net transport and the ratio of net and bulk transport; see also WP6 and WP7) were established based on the implementation of fast methods for search, analysis and comparison of large pools of trajectories (Soomere et al. 2010, 2011a). It was shown that the chosen approach of Lagrangian trajectories is indeed feasible and may reveal certain features of the dynamics of currents that cannot be extracted directly from the velocity fields.

The basic time scales for the first hit and for the time of massive hits of current-driven adverse impacts for the Gulf of Finland were established for solely current-induced transport (Viikmäe et al. 2010) and for realistic forcing (Murawski et al. 2012). The new concept of equiprobability lines for elongated sea areas and two algorithms developed for their calculation (see also WP6) were applied to identify areas of reduced risk in the Gulf of Finland (Soomere et al. 2010; Viikmäe et al. 2011). Substantial spatial variations in gradients of risk measures in seemingly similar sea areas were discovered, with potential implications for maritime spatial planning. This feature led to a considerable expansion of the concept of areas of reduced risk. Namely, the safest fairway should follow the equiprobability line in areas with large risk gradients and the reduced risk areas in domains with relatively low gradients (Soomere et al. 2011c). See WP6 and WP7 for the construction and testing of the algorithms for optimal fairways between any given two points, and for estimating the quality of concrete fairways.

Several new integral measures of environmental risk, introduced in WP6, were applied to identify the areas of reduced risk in the Gulf of Finland (Andrejev et al. 2011), the Baltic Proper (Viikmäe et al. 2011) and the south-western regions of the Baltic Sea (Xi et al. 2012). The quantification of the potential of offshore domains of the Baltic Proper was performed in terms of transport of released pollution to the near shore by Eulerian velocities (Höglund and Meier 2012; Meier and Höglund 2012).

Uncertainties in the areas of reduced risk and in the associated optimum fairways were quantified by means of using different methods for the calculation of the equiprobability line (Soomere et al. 2010; Viikmäe et al. 2011) and the globally optimum fairway (Soomere et al. 2011d), different resolutions of the circulation model (Andrejev et al. 2011), different measures of environmental risk (Soomere 2012; Soomere et al. 2012b) and by the construction of a

"corridor" for sailing lines corresponding to small deviations of the overall environmental risk from the global optimum (Soomere et al. 2011e).

The positions of the main ship routes through the western Baltic Sea were collected and prepared for drift model calculations. The results of the direct problem of tracer propagation in the Kiel Baltic Sea Lagrangian drift model have been analysed with respect to the identification of areas of reduced risk for the southern Baltic Sea and their seasonal and inter-annual variability (Lehmann et al., publication in progress). The seasonal and inter-annual variability of net transport and the ratio of net and bulk transport in the Gulf of Finland were quantified based on the RCO model results for 1987–1991 (Soomere et al. 2011b). It was shown that the location of areas of reduced risk and the optimum fairway in the southern Baltic Sea and around the Danish Straits is governed by irregular saline water inflow and outflow conditions rather than by seasonal variability (Xi et al. 2012).

In order to properly estimate the impact of wind and waves on the results, 25 years of SMHI wind data were processed to separate windy and calm seasons in the Gulf of Finland. A similar analysis was performed for the basic properties of atmospheric forcing (Lehmann et al. 2011; Getzlaff et al. 2011). The spatio-temporal variability in the Baltic Sea wave properties in weekly, seasonal, inter-annual and climatological time scales was established based on numerical simulations using SMHI geostrophic wind data for 1970–2007 and an analysis of historical wave observations (see references in WP1). Uncertainties in wind information, potentially leading to inaccuracies in the representation of wave properties were analysed for the Baltic Proper (Räämet et al. 2009).

The effect of local wind and waves on the location of areas of reduced risk was studied using simulations of the oil spread and drift caused by realistic metocean conditions (accounting for wind and waves) (Murawski et al. 2012; Murawski and Nielsen 2012). The results revealed substantial seasonal variations in the location of the optimum fairway. Finally, areas of reduced risk associated with cases when subsurface currents dominate the transport pattern (e.g. for ships without propulsion in calm seasons) were estimated for the Gulf of Finland based on high-resolution simulations of the OAAS model (Andrejev et al. 2012a).

Key progress in 2011: Identification of areas of reduced risk for several sub-basins of the Baltic Sea using both Lagrangian and Eulerian transport patterns. Development and implementation of several methods to estimate uncertainties in such areas and of methods to study wind and wave effects on the seasonal variability of characteristic oil drift patterns. Detailed analysis of spatio-temporal changes to forcing fields and extensive assessments of wind and wave effects under average conditions and storms were performed.

- (4.1, 4.2) The results of the Kiel Baltic Sea Lagrangian drift model have been analysed with respect to the identification of areas of reduced risk and the seasonal and inter-annual variability (IFM-GEOMAR).
- (4.1) Identification of areas of reduced risk for the northern Baltic Proper (IoC), southern Baltic Sea (IFM-GEOMAR) and for the region of the Danish Straits (ICR, IoC, DMI).
- (4.1) Quantification of the potential of offshore domains of the Baltic Proper in terms of transport of released pollution to the near shore by Eulerian velocities (SMHI).
- (4.2) Demonstration that the location of areas of reduced risk and of the optimum fairway around the Danish Straits is governed by irregular saline water inflow and outflow conditions rather than by seasonal variability (ICR, IoC, DMI).

- (4.2) Seasonal maps for the reduced risk areas, optimum fairways and dangerous sections of commonly used fairways were constructed for the Gulf of Finland and for the region of Danish Straits (SYKE, IoC, ICR, DMI).
- (4.2) Uncertainties in the location of the areas of reduced risk and optimum fairways were quantified using different methods for the calculation of the optimum fairway, different resolutions of the circulation model, different measures of environmental risk and by the construction of a "corridor" for sailing lines corresponding to small deviations of the overall environmental risk from the global optimum (SYKE, IoC, IFM-GEOMAR, MISU).
- (1.1, 4.3) A detailed analysis of the changes to seasonal patterns in atmospheric forcing was performed (IFM-GEOMAR). The spatio-temporal variability in the Baltic Sea wave properties in various time scales was established based on numerical simulations for 1970–2007 and an analysis of historical wave observations (IoC).
- (4.3) Development of statistical methods for the extraction of characteristic wind and wave dependent risk measures (oil landing probability and residence time at sea) from comprehensive sets of realistic oil drift and fate simulations (DMI).
- (4.3) Drift model based assessments and estimation of spatio-temporal variability in oil drift patterns under seasonally varying met-ocean conditions (based on more than 150,000 spill simulations) (DMI).
- (4.4) Substantial seasonal variations in the location of areas of reduced risk and the optimum fairway due to the effect of local wind and waves identified (DMI).
- (4.4) Areas of reduced risk associated with subsurface currents were estimated for the Gulf of Finland based on high-resolution simulations of the OAAS model and the developed technology (SYKE).

Future plans. Some important results (e.g., areas of reduced risk based on the dynamics of subsurface currents) are still in preparation for publication and require additional efforts in 2012. Several outcomes of this WP (e.g., the presence of largely varying gradients in measures of environmental risks in seemingly similar sea areas, or dependence on the inflow or outflow situation, Xi et al. 2012; Xi and Stanev 2012) apparently have important implications for maritime spatial planning and for integrated coastal zone management. Systematic quantification of offshore domains from this point of view is highly desirable and may become a standard tool in the relevant decision-making process. The drastic seasonal variation in the location of the reduced risk areas, calculated with realistic met-ocean forcing and oil fate models, suggests that the real gain from the use of optimum solutions may largely exceed our conservative estimates in WP6 and WP7 based on climatologically valid solutions.

Work Package 5 – Validation experiments: SYKE

- Task 5.1 *Measurement of the current-induced surface drift and its dispersion properties in the Baltic Sea Proper*, PM 4–18, Leader: MISU
- Task 5.2 *Measurement of current-induced surface drift and its dispersion properties in the surface layer and subsurface layer of the Gulf of Finland*, PM 7–30, Leader:SYKE
- Task 5.3 *Measurement of current-induced surface drift and its dispersion properties with the use of airborne and remote sensing methods*, PM 1–36, Leader: LDI

Overall appraisal: the WP fulfilled the expectations; the amount and quality of data from the Baltic Proper are well above the expected level.

Extensive new knowledge has been obtained about the long-term behaviour and properties of both absolute and relative dispersion properties of currents in the upper layers of the Baltic Sea (Kjelsson and Döös 2012; Kjelsson et al. 2012). This was achieved based on the longest ever recorded time series (over one year) of professional autonomous drifters' positions in the Baltic Sea region, and on numerous experiments with drifters following the drift in the uppermost layer in the Gulf of Finland (Soomere et al. 2011).

During 3 deployments, a total of 8 drifters (one pair in 2010; two triplets in 2011; drogue depth 12–18 m) were deployed in the Baltic Proper. A substantial deviation of the measured absolute dispersion (that implicitly characterises the typical time scale of water staying in an area of reduced risk) and relative dispersion (that characterises the local dispersion properties of motions) from the values estimated using common circulation models was established (Döös et al. 2011; Jönsson et al. 2011; Döös and Kjellsson 2012; Kjellsson et al. 2012). In addition, one pair was deployed in the Gulf of Finland in autumn 2011. The corresponding data is still in the processing stage.

Preparation, testing, field validation and optimisation of a database of laser induced fluorescence spectra of typical oils for remote sensing measurements considerably increased the capacity for operational detection and tracking of oil spills in natural environments (Babitchenko 2012). Airborne measurements of the spatial distribution of the concentration of dissolved organic matter were performed by LDI in Tallinn Bay and Muuga Bay. The equipment for remote sensing of pollution was updated for new airborne carriers, the spectral resolution increased and test flights performed. The adjustment procedure of the telescope has been developed based on the Raman scattering signal on water molecules and is applicable in field (especially ship borne) conditions (Babitchenko 2012).

An economical technical solution was developed for drifter experiments on the sea surface (Soomere et al. 2011g). The use of low-cost autonomous surface drifters made it possible to track the drift until small depths (down to about 1.5 m) and in coastal areas, earlier accessible only by remote sensing. Extensive use of ships of opportunity and small vessels made it possible to considerably increase the amount of measurements.

Properties of relative dispersion of surface drift were established for the Gulf of Finland using clusters of such drifters following the surface layer drift (depths 0–1 m). Triples of drifters were deployed in 4 sessions in 2010 and in 7 sessions in 2011 at different locations, resulting in 27 single trajectories with duration up to four weeks. A two-section power law for the increase in relative dispersion in time was identified for the drift in the uppermost layer of the Gulf of Finland (Soomere et al. 2011g). In 2011 an upgrade of the active devices for remote

measurements made it possible to gather a much more complete data set and to establish properties of absolute dispersion. The relevant analysis is currently in progress.

Key progress in 2011:

- (5.1) Measurement of absolute and relative dispersion in an upper layer in the Baltic Proper using two deployments of pairs of drifters with drogues at a standard depth range of 12–18 m (MISU).
- (5.2) Measurement of absolute and relative dispersion in a subsurface layer of the Gulf of Finland using one deployment of a pair of drifters with drogues at a standard depth range of 12–18 m (MISU, IoC).
- (5.1) Establishing a substantial deviation of the actually measured absolute and relative dispersion of surface currents in the Baltic Proper from the values estimated by commonly used circulation models based on standard Eulerian velocities; recommendations for the improvement of circulation models and Lagrangian trajectory models (MISU).
- (5.2, 5.3) Numerous experiments for the measurement of current-induced surface drift and absolute and relative dispersion in the uppermost layer of the Gulf of Finland by tracking upgraded versions of low-cost autonomous drifters (IoC, LDI).
- (5.2, 5.3) Identification of a two-section power law for the increase in relative dispersion in time for the uppermost layer of the Gulf of Finland (IoC, LDI).

Future plans. The most important long-term impact of the results of this WP consists in the systematic use of the established characteristics of the actual drift regime in upper layers of the Baltic Sea for the adjustment of parameterisations in the circulation models and for the improvement of the trajectory models. This could be a key component in the development of the next generation scientific and operational circulation models for the Baltic Sea (such as the NEMO model). Some of the data, obtained during the autumn 2011 campaign in the Gulf of Finland (both in surface and subsurface layers), are still in the processing stage. Preliminary analysis suggests that the dispersion regime in this basin is rather different from that in the Baltic Proper. Further analysis will definitely be carried out by MISU and IoC, and will eventually result in important information about the statistics of dispersion in surface currents in this basin.

Work Package 6 – Risk analysis and mathematics of inverse problems: IoC

- Task 6.1 *Modelling of environmental risk*, PM 1–33, Leader: IoC
- Task 6.2 *Analysis of the properties of the water age*, PM 7–33, Leader: SMHI
- Task 6.3 *Development of a probabilistic approach for ensemble forecasts*, PM 13–33, Leader: SMHI
- Task 6.4 *Mathematical background of the concept of areas of reduced risk*, PM 1–36, Leader: IoC

Overall appraisal: the WP with the largest amount of scientific results; much richer in content than expected. The overall amount of modeling efforts were larger than planned. Only the performed risk modeling was kept limited to the original plan: for the particular case of a fixed major fairway in the Gulf of Finland and constant probability of accidents.

Typically, much longer time slices (5–20 years) were used in the modelling efforts than originally proposed (one year), allowing the resolution of seasonal and inter-annual effects. The majority of the performed studies cover the entire basin (not only technically acceptable ship routes) except for the analysis of environmental risks stemming from different parts of the fairway (Viikmäe and Soomere 2012). In order to reach reliable statistics, the target measures are estimated as ensemble means over a large number of runs for the same forcing conditions and release locations but for different starting instants. The choice of the parameters of the numerical models was made based on estimates in (Soomere et al. 2010, Viikmäe et al. 2010).

Both Eulerian (Höglund et al. 2012) and Lagrangian tracers (Andrejev et al. 2011, Soomere et al. 2011a, 2011c; Viikmäe and Soomere 2012, Xi et al. 2012, among others) were used to analyse the dispersion and residence times of assumed oil spill events. Instead of integrating backward in time (a procedure which is not unambiguously justified), a better justified approximate solution to this inverse problem was constructed from large sets of solutions (Lagrangian trajectories) to the associated direct problem (Soomere et al. 2011d).

Several new integral measures of environmental risk have been introduced and numerical methods for their calculation have been tested and analysed, where the necessary Lagrangian trajectories have been constructed both on-line [the tracers' evolution solved simultaneously with the integration of the circulation model (Andrejev et al. 2011, 2012a, 2012b)] and off-line [based on precomputed and stored velocity fields of the forward simulations (WP2) (Soomere et al. 2011a, 2011c, 2011d, 2011e; Xi et al. 2012)].

The concept of equiprobability lines for elongated basins has been introduced based on a quantity characterising how risks are shared between opposite coasts (Soomere et al. 2010); two algorithms for the calculation of an equiprobability line for the Gulf of Finland have been tested (Soomere et al. 2010; Viikmäe et al. 2011).

A principally new concept of the (water or particle) age was introduced as the time it takes for the released adverse impact to reach vulnerable areas (Andrejev et al. 2010, 2011). It characterises not only the pollution propagation from a given area but also the time available to combat the pollution. A detailed analysis of the particle age for the Gulf of Finland was performed based on 2 nm RCO data (Soomere et al. 2011d, 2011e) and on high-resolution versions (down to 0.25 nm) of the OAAS model (Andrejev et al. 2011, 2012a, 2012b). The areas of largest particle age match the areas of reduced risk well. An extension of the classical probability of coastal hit (Andrejev et al. 2010, 2011) was analysed from different viewpoints (Soomere et al. 2011a, 2011c, 2011d, 2011e; Viikmäe et al. 2011; Xi et al. 2012).

The variation in the resulting risk along the optimum fairway (in terms of probability for coastal pollution or of particle age, equivalent to the available response time) is used to measure environmental gain. It was shown that basin-wide integrals of the probability of pollution and of the particle age provide options for rapid estimates of the applicability of the entire approach (whether or not substantial gain can be obtained from this technology for a particular sea area; Andrejev et al. 2011). It typically takes 3–5 years for these basin-wide integrals to reach their asymptotic values in the Gulf of Finland.

Based on 2D distributions of the above quantities, several methods have been developed, implemented and tested to identify the optimum fairways (Andrejev et al. 2011; Soomere et al. 2011c; Andrejev et al. 2012b), see also WP7. The multi-model approach was widely used to characterise the robustness of the estimates of the most likely areas of reduced risk, e.g., using different resolutions of the underlying ocean models for the Gulf of Finland (Andrejev et al. 2011), different methods for the calculation of the equiprobability line (Soomere et al. 2010), and different methods for estimating the trajectories (Soomere et al. 2011c). The same approach was also employed to assess the reliability of the resulting optimum fairways and related uncertainties caused by the ocean models (Soomere et al. 2011e).

An initial analysis of the direct problem of tracer propagation has been made for the southern Baltic Sea (IFM-GEOMAR), followed by an implementation of the entire approach for the south-western Baltic Sea and the Danish Straits (Xi et al. 2012).

Simulations of the oil spread and drift caused by realistic met-ocean conditions (accounting for wind and waves) were performed in detail for a constant probability of accidents (Murawski et al. 2012; Murawski and Nielsen 2012) and demonstrated substantial seasonal variations in the location of the optimum fairway. For this analysis, a detailed quantification of the spatial and temporal variability of average and extreme properties of the Baltic Sea wave fields was performed based on numerical simulations for 1970–2007 and historical wave data (references in WP1). A similar analysis was performed for the basic properties of atmospheric forcing (Lehmann et al. 2011; Getzlaff et al. 2011).

Extensive studies were performed to develop and validate the mathematical background of the concept of areas of reduced risk. The presence of nontrivial patterns in the net transport and the ratio of net and bulk transport in the Gulf of Finland were demonstrated. Their geometry, time scales and seasonal and inter-annual variability were estimated based on 2 nm RCO model results (Soomere et al. 2011a). The persistence and geometric features of the areas of reduced risk were addressed using ocean models with different resolution (Andrejev et al. 2011) and by an analysis of the geometric features of relatively safe “corridors” for fairways (Soomere et al. 2011e).

Surface dispersion estimates were provided based on field experiments (Kalda et al. 2012, Kjellsson and Döös 2012; Kjelsson et al. 2012; Soomere et al. 2011g). Most notably, a novel and promising measure, considerably expanding the context of the proposed technology, namely the finite-time compressibility of a sea surface, was introduced and estimated for the Gulf of Finland (Kalda et al. 2012). This measure is tightly related with the general spectrum of turbulence in Lagrangian chaotic flows (Kalda 2011).

Key progress in 2011:

- (6.1) Extensive studies of the impact of realistic met-ocean parameters (combination of wind, waves and currents) on the optimum fairway; discovery of substantial dependence of the optimum fairway for the Gulf of Finland on the windy and calm season (DMI).

- (6.1, 6.2) Modelling of environmental risks and estimates of the location of areas of reduced risk using Eulerian velocities (SMHI).
- (6.1, 6.2, 6.3) Extension of the risk analysis and the technology for calculation of the optimum fairway to the Baltic Proper and the south-western part of the Baltic Sea (ICR, IoC).
- (6.2) Construction of the 2D spatial maps of water (particle) age for the Gulf of Finland based on an extremely long (20 years), high-resolution (0.5 nautical miles) version of the OAAS model (SYKE).
- (6.3) Quantification of the uncertainty in the identification of the location of the optimum fairway based on gradients in the 2D fields of measures of environmental risk (IoC).
- (6.4) Introduction of the novel concept of finite-time compressibility of a sea surface overlaying complicated 3D current fields (IoC).
- (6.3, 6.4) Establishing a two-section power law for the relative dispersion of surface currents in the Gulf of Finland; analysis of this feature in the light of existing theories for the dispersion of particles on sea surfaces (IoC).
- (6.1, 6.4) Quantification of the spatio-temporal variability in average and extreme properties of the Baltic Sea wave fields; identification of spatial patterns in their decadal changes and long-term trends for use in the analysis of the impact of winds and waves on the optimum solutions (IoC).

Future plans. The outcomes of the project have revealed a large number of highly interesting problems in theoretical physical oceanography, applications of the proposed technology and even in certain fundamental aspects. Although several fit-for-purpose estimates for the applicability and robustness of the proposed approach have been established during the project, there is a clear need for the continuation of the efforts towards rigorous mathematical justification of the entire technology. First of all, for practical applications it is necessary to estimate more precisely the seasonal and inter-annual deviations of the optimum solution from the climatologically valid one. A detailed analysis of the gradients in the 2D fields of quantitative measures of environmental risk is evidently necessary for implementations of the technique for open ocean coasts. The theory of the finite-time compressibility of sea surfaces should be developed further. The potential for gradual generation of sea surface patchiness in small areas hosting high compressibility (Kalda et al. 2012) calls for extensive research towards the understanding of its role in the natural variability of different concentration fields on the sea surface.

Work Package 7 – Applications: DMI

- Task 7.1 *Development of a prototype of the fairway design*, PM 10–33, Leader: DMI
- Task 7.2 *Implementation plan and estimates of the gain of the proposed technology*, PM 16–33, Leader: IoC
- Task 7.3 *Implementation plans for potential applications of the results*, PM 16–36, Leader: IoC

Overall appraisal: the number and scope of developed applications extend far beyond the original intentions; some national follow-up financing already secured.

The four key steps of the technology of fairway design (ocean model, trajectory model, maps of environmental risks, and algorithms for the fairway) were formulated in 2009–2010 (Soomere et al. 2010), leading first to the development of a generic application in which these four steps are used as independent blocks (Soomere et al. 2011d), and where the specific methods used within one block are interchangeable.

The BalticWay teams have developed and published a number of different techniques for the determination of the optimum fairway for the Gulf of Finland. They started with the local technique of an equiprobability line for elongated basins developed in 2009–2010 (Soomere et al. 2010) and a simple step-by-step approach to construct approximations to the globally optimum solutions (Andrejev et al. 2011; Soomere et al. 2011c), including estimates of the increase in the fairway length and of the gain in terms of an increase in response time to the pollution.

Several more sophisticated algorithms such as the Dijkstra algorithm (Andrejev et al. 2012b) and several options based on Monte Carlo methods (Murawski et al. 2012) have been elaborated and tested in realistic conditions, including accounting for wind- and wave-driven transport (Murawski et al. 2012). New measures (based on a line integral technique) to unambiguously estimate the potential gain of the proposed technology have been introduced (Soomere et al. 2011c, Andrejev et al. 2012b; Murawski et al. 2012).

Additionally to the Gulf of Finland, selected algorithms have been used for the Baltic Proper (Viikmäe et al. 2011) and for the south-western part of the Baltic Sea (Xi et al. 2012). A straightforward method to estimate the applicability of the entire approach has been developed and published (Andrejev et al. 2011). An overview of the relevant efforts is given in (Soomere et al. 2012a, 2012b).

The necessary preconditions for the further development and implementation of the developed technology have been formulated as a technical report (Deliverable 7.2). Much more importantly, they have been presented and discussed at a number of scientific, science policy and stakeholder conferences (such as the Baltic Sea Day, the International Coastal Symposium, the Baltic Sea Science Congress, Future of Operational Oceanography, among others, see Appendix 2); also far outside the Baltic Sea region (e.g., in the Australian scientific and maritime engineering community, see statistics below). Further challenges in the implementation and possible extensions of the proposed technology in various marine activities have been formulated both on the level of scientific R&D foresights (Soomere 2011) and several popular publications (see Appendix 4).

Perhaps most importantly, an R&D proposal concerning the practical implementation of the developed technology for sea areas surrounding Estonia has been formulated and funding has

been granted for 2012–2014. The necessity of relevant activities has also been included into the key topics of the international Gulf of Finland Year 2014.

Key progress in 2011: Introduction of new measures (based on line integral techniques) to unambiguously estimate the potential gain of the proposed technology; introduction of several more sophisticated algorithms for the construction of the optimum fairway.

- (7.1, 7.2) The practical usage, the economic cost and environmental gain of the developed four-step optimum fairway design systematically estimated using an existing classical ship routing system (DMI); novel evaluation technique based on a line integral approach implemented and tested for several underlying ocean models (DMI, IoC, SYKE).
- (7.1, 7.2, 7.3) The impact of local met-ocean conditions on the resulting optimum fairway estimated for the Gulf of Finland; substantial seasonal variation of the optimum solution discovered (DMI).
- (7.2, 7.3) Prototype for the fairway design implemented for the south-western Baltic Sea and the Danish Straits (ICR, DMI, IoC).
- (7.2, 7.3) The necessary preconditions for the further development and implementation of the developed technology presented and discussed in a number of scientific, science policy and stakeholder conferences (see the list of statistics) (IoC, all partners on occasion).
- (7.2) The implementation plan for prospective regions, incl. a description of legal and political aspects, composed as a technical report (ICR); straightforward methods to estimate the applicability of the entire approach developed and published in the scientific literature (SYKE, IoC).
- (7.3) A sketch of further challenges in the implementation and possible extensions of the proposed technology in various marine activities published as part of a foresight paper in the edited collection "Research in Estonia," and in several popular publications (IoC).
- (7.3) The necessity of relevant activities included into the key topics of the international activity "The Gulf of Finland Year 2014" (SYKE).
- (7.3) Formulating and winning a national follow-up R&D project for 2012–2014 (awarded by the Archimedes Foundation in the framework of its R&D program in environmental technology, financed from EU structural funds) towards practical implementation of the developed technology for sea areas surrounding Estonia (IoC).

Future plans. The ultimate goal is of course to use the technology in a new generation of fairway and ship routing services in the whole Baltic Sea. We think that this is a proper way of integrating marine ecosystem management with other needs of society, and linking scientists, stakeholders and decision-makers in elaborating a scientific base for political decisions. This clearly is a long-time endeavour, especially because of legal and political issues but the work has been initialized in the project, future directions have been mapped (the foresight study in Research in Estonia, Soomere 2011) and follow-up actions are forthcoming (the national Estonian project in 2012–2014 and as part of "The Gulf of Finland Year 2014" managed by SYKE). Another extremely promising direction is to use the proposed technology for tracking the plumes of turbidity created by breaking large-scale internal waves in certain areas of the Baltic Sea (Kurkina et al. 2011; 2012).

Work Package 8 – Management and dissemination: IoC

- Task 8.1 *Integration and harmonisation of the activities*, PM 1–36
- Task 8.2 *Management and overall quality control*, PM 1–36
- Task 8.3 *Dissemination and public awareness, exploitation and IPR management*, PM 1–36
- Task 8.4 *Organisation of an Advanced Study School.*

Overall appraisal: The WP ran more or less as planned, with small modifications to the timetable of tasks and deliverables caused by external issues. The success of the dissemination efforts was far beyond the most optimistic expectations.

The BalticWay kick-off meeting was held in January 2009 in Helsinki, where the obligations between partners had to be redistributed to match the inhomogeneous budget cuts.

An external issue beyond the teams' control was an initial delay of the financing, which created problems in starting the project properly in Estonia. This issue was mitigated by moving the coordinator's activities from IoC to partner LDI for the year 2009 and by obtaining the acceptance from the Estonian Science Foundation (ESF) to temporarily use some funds from other grants to cover urgent expenses of the project.

After the actual start of the financing in mid-2009, successful coordination of partner efforts was established in all aspects, especially concerning simulations, analysis, validation experiments, effective data flow and competence transfer (begun by a two-week intensive course in the TRACMASS trajectory simulation system held on July 14–24, 2009 in Tallinn).

In July 2009, a first basic version of the project web portal was also set up (http://wavelab.ioc.ee/bonus-balticway), which was subsequently expanded considerably. It is hosted by the Wave Engineering Laboratory at IoC (and will remain on line after the project). It provides information about the project, its partners, BONUS as the sponsoring organization, the project research plan, the project activities and events, presentations at conferences as well as annual reports and public deliverables.

The first annual BalticWay meeting was held in March 2010 on Cyprus, starting in conjunction with the "Water Day" workshop organized on March 18 by the EU FP7 Future and Emerging Technologies network "GSD – Global Systems Dynamics and Policies". This was followed by technical meetings on March 19&20, where partners presented their on-going work and synchronized their future project activities. Especially important were the decisions taken by the Project Council that resulted in successful validation experiments (see WP5).

The Consortium Agreement was finalised and signed by all partners in the second project year.

In the beginning of the third project year, temporary issues in the management of Deliverable D1.1 were effectively resolved. Though the submission was delayed, a much larger database than originally planned was created as a result.

The second annual BalticWay meeting was held April 10–13, 2011 in Sicily as the workshop "The smart use of marine currents for environmental management" in collaboration with the University of Palermo. Presenting project findings was combined with planning the activities for the remainder of the project and beyond.

One of these still on-going activities is the preparation of a book of tutorials presenting the BalticWay results with the title *Preventive Methods for Coastal Protection: The Use of*

Ocean Dynamics for Pollution Control, with contributed chapters by all partners, and publication expected in late 2012 (see Appendix 1).

The final event organized by the project was the summer school "Preventive methods for coastal protection" in Klaipeda, Lithuania, September 18–20, 2011, in collaboration with the Geophysical Sciences Department of the University of Klaipeda. The school was dedicated to the novel methods for coastal protection and maritime spatial planning developed within the BalticWay project. The event attracted more than 50 participants, among those 45 trainees, mostly PhD students and post-doctoral researchers but also a few well-prepared MSc students. Most of the lecturers were senior scientists of the BalticWay consortium.

Dissemination of the results to the scientific community speeded up simultaneously with substantial progress. In 2010, 14 public lectures and presentations addressing different aspects of the project were given to both the scientific and engineering community (incl. presentations to 10 international conferences). Seven research papers were published in peer-reviewed scientific journals. One PhD promotion in Civil and Environmental Engineering, Tallinn University of Technology (IoC), was largely based on the project results and nine more PhD theses are in progress. In 2011, 22 peer-reviewed papers were published (among those 18 indexed by ISI Web of Science) and 57 presentations and lectures given to 14 different events. The total number of peer-reviewed papers published based on the project results is 34 on January 30, 2012 whereas >20 contributions are in progress.

Cooperation and dissemination extended well beyond the Baltic Sea region: the workshops at the annual meetings were organized together with Mediterranean institutions, the first one together with an FP7 FET coordination action, and the principles of the entire technology were even presented to the scientific and marine community in Australia.

Dissemination of the results to stakeholders was launched very successfully from the very beginning of the project, especially through the exploitation of the project's ideas and first results for the Gulf of Finland within consultations concerning the scientific basis of the environmental impact assessment of the Nord Stream pipeline.

In 2009 and 2010 there were 6+2 appearances at political and public stakeholder events, incl. an extraordinary plenary session of the Estonian Parliament and Finnish-Estonian expert panels. Also 19 (2009) + 15 (2010) interviews were given to different media channels for national TV, radio, and newspapers (incl. one interview to the Finnish leading daily newspaper Helsingin Sanomat). In 2010 six popular papers (incl. two explicitly addressing the results of the project) were published (4+3 in 2009+2010). In 2011, two appearances at high-level political events were complemented with 17 interviews and nine popular papers.

Key progress in 2011:

- Massive dissemination of the results to the scientific community in leading scholarly journals, invited and plenary presentations to high-level conferences, invited presentations to science policy conferences.
- Great success in the demonstration of the importance of cutting edge science in the political decision-making process (Nord Stream consultations), followed by public distinctions of the team members.
- Annual meeting scientific event in cooperation with the University of Palermo.
- Summer school in Klaipeda with over 50 participants.
- The BalticWay book in progress, agreements with the publisher Springer Verlag pending; most of the chapters already in review.

Future plans. More than 20 manuscripts of research papers based on the results of the BalticWay activities are either in the production pipeline or in the preparation stage. Several other texts are in the planning stage.

The plan for a tutorial book (suitable for teaching purposes) on the interdisciplinary approach of the project has been favourably received by the publisher Springer Verlag; several of its chapters are already under review, while some others can only be finished when the majority of chapters have been finalized. The IoC team (especially the Coordinator and the Dissemination Manager) will carry on the editorial work, with the goal to have the book published in autumn 2012.

We expect the tight cooperation between the consortium partners to continue so that the major outcomes of all the scientific publications will also be reflected in science policy fora and popular publications in a holistic manner.

Appendices

Appendix 1. Peer-reviewed publications based on the BalticWay project

Submitted manuscripts:

1. T. Soomere, R. Weisse, A. Behrens 2012. Wave climatology in the Arkona basin, the Baltic Sea, submitted to *Ocean Science*.

2. X. Lu, T. Soomere, E. Stanev, J. Murawski 2012. Event driven approach for the identification of the environmentally safe fairway in the south-western Baltic Sea and Kattegat, submitted to *Ocean Dynamics*.

3. T. Soomere, A. Räämet 2012. Decadal changes in the Baltic Sea wave heights, submitted to *Journal of Marine Systems*.

4. J. Kalda, T. Soomere, A. Giudici 2012. On the compressibility of the surface currents in the Gulf of Finland, the Baltic Sea, submitted to *Journal of Marine Systems*.

5. T. Soomere, M. Viška 2012. Simulated sediment transport along the eastern coast of the Baltic Sea, submitted to *Journal of Marine Systems*.

6. J. Kjellsson, K. Döös 2012. Surface drifters and model trajectories in the Baltic Sea, submitted to *Boreal Environment Research*.

7. B. Viikmäe, T. Soomere 2012. Spatial pattern of hits to the nearshore from a major marine highway in the Gulf of Finland, submitted to *Journal of Marine Systems*.

8. A. Höglund, H.E.M. Meier 2012. Environmentally safe areas and routes in the Baltic proper using Eulerian tracers, submitted to *Marine Pollution Bulletin*.

Tutorial book (peer-reviewed collection) in preparation: *Preventive Methods for Coastal Protection: The Use of Ocean Dynamics for Pollution Control*, T. Soomere and E. Quak (eds.), foreseen publication by Springer in autumn 2012.

Chapters already submitted for review or in preparation:

9. T. Soomere 2012. Towards mitigation of environmental risks, submitted.

10. A. Lehmann, K. Myrberg 2012. Hydrography, functioning, circulation and currents of the Baltic Sea, submitted.

11. K. Myrberg, A. Lehmann 2012. Gulf of Finland, its hydrography and circulation dynamics, submitted.

12. T. Torsvik 2012. Introduction to computational fluid dynamics and ocean modelling, submitted.

13. E. Stanev, L. Xi 2012. European semi-enclosed seas: basic physical processes and their numerical modelling, submitted.

14. K. Döös, J. Kjellsson 2012. TRACMASS – A Lagrangian trajectory model, submitted.

15. J. Kjellsson, K. Döös, T. Soomere, M. Viidebaum 2012. Evaluation and tuning of model trajectories in the Baltic Sea using surface-drifter observations, submitted.

16. H.E.M. Meier, A. Höglund 2012. Tracing water masses in the Baltic Sea using an Eulerian model approach, in preparation.

17. T. Soomere (lead author) 2012a, Lagrangian transport and inverse modelling, in preparation.

18. T. Soomere (lead author) 2012b, Optimisation of offshore activities, in preparation.

19. J. Murawski, J.W. Nielsen 2012. Oil drift modeling and its application for sea way designs, in preparation.

20. S. Babitchenko (lead author) 2012. Technologies for remote measurements of location, Lagrangian transport and internal structure of adverse impacts on sea surfaces, in preparation.

Manuscripts in preparation for research journals:

21. J. Murawski, J.W. Nielsen, T. Soomere 2012. Oil drift model applications for sea way design studies in the Gulf of Finland, in preparation for *Ocean Science*.

22. O. Andrejev, A. Sokolov, K. Myrberg, T. Soomere 2012a. Areas of reduced risk and optimum fairways for subsurface transport in the Gulf of Finland, in preparation

23. O. Andrejev, T. Soomere, A. Sokolov, K. Myrberg 2012b. Application of the Dijkstra algorithm for environmental optimisation of fairways, in preparation for *Journal of Atmospheric and Oceanic Technology*.

24. L. Xi, E. Stanev 2012. Inflow events in the Baltic Sea: Numerical study of the physical process in the transition zone, in preparation.

Published in 2012:

25. O.E. Kurkina, A.A. Kurkin, E.A. Ruvinskaya, E.N. Pelinovsky, T. Soomere 2012. Dynamics of solitons in non-integrable version of the modified Korteweg-de Vries equation, *JETP Letters*, **95** (2), 98–103 (in Russian).

Published in 2011:

26. K. Döös, V. Rupolo, L. Brodeau 2011. Dispersion of surface drifters and model-simulated trajectories, *Ocean Modelling*, **39** (3-4), 301–310. doi:10.1016/j.ocemod.2011.05.005

27. B. Jönsson, K. Döös, K. Myrberg, P.A. Lundberg 2011. A Lagrangian-trajectory study of a gradually mixed estuary, *Continental Shelf Research*, **31** (17), 1811–1817.

28. J. Kalda 2011. *k*-spectrum of decaying, aging and growing passive scalars in Lagrangian chaotic fluid flows, *Journal of Physics: Conference Series*, **318**, Art. No. 052045.

29. T. Soomere, A. Räämet 2011. Long-term spatial variations in the Baltic Sea wave fields, *Ocean Science*, **7** (1), 141–150.

30. T. Soomere, N. Delpeche, B. Viikmäe, E. Quak, H.E.M. Meier, K. Döös 2011a. Patterns of current-induced transport in the surface layer of the Gulf of Finland, *Boreal Environment Research*, **16** (Supplement A), 49–63.

31. T. Soomere, I. Zaitseva-Pärnaste, A. Räämet 2011b. Variations in wave conditions in Estonian coastal waters from weekly to decadal scales, *Boreal Environment Research*, **16** (Supplement A), 175–190.

32. L. Kelpšaite, I. Dailidiene, T. Soomere 2011. Changes in wave dynamics at the south-eastern coast of the Baltic Proper during 1993–2008, *Boreal Environment Research*, **16** (Supplement A), 220–232.

33. A. Räämet, T. Soomere 2011. Spatial variations in the wave climate change in the Baltic Sea, *Journal of Coastal Research*, Special Issue 64, 240–244.

34. T. Soomere, O. Andrejev, A. Sokolov, E. Quak 2011c. Management of coastal pollution by means of smart placement of human activities, *Journal of Coastal Research*, Special Issue 64, 951–955.

35. B. Viikmäe, T. Soomere, K.E. Parnell, N. Delpeche 2011. Spatial planning of shipping and offshore activities in the Baltic Sea using Lagrangian trajectories, *Journal of Coastal Research*, Special Issue 64, 956–960.

36. O. Andrejev, T. Soomere, A. Sokolov, K. Myrberg 2011. The role of spatial resolution of a three-dimensional hydrodynamic model for marine transport risk assessment, *Oceanologia*, **53** (1-TI), 309–334.

37. T. Soomere, A. Räämet 2011. Spatial patterns of the wave climate in the Baltic Proper and the Gulf of Finland, *Oceanologia*, **53** (1-TI), 335–371.

38. T. Soomere. O. Andrejev, A. Sokolov, K. Myrberg 2011d. The use of Lagrangian trajectories for identification the environmentally safe fairway, *Marine Pollution Bulletin*, **62** (7), 1410–1420, doi: 10.1016/j.marpolbul.2011.04.041

39. T. Soomere, M. Berezovski, E. Quak, B. Viikmäe 2011e. Modeling environmentally friendly fairways using Lagrangian trajectories: a case study for the Gulf of Finland, the Baltic Sea, *Ocean Dynamics*, **61** (10), 1669–1680, doi: 10.1007/s10236-011-0439-y

40. O.E. Kurkina, A.A. Kurkin, T. Soomere, E.N. Pelinovsky, E.A. Ruvinskaya 2011. Higher-order (2+4) Korteweg-de Vries - like equation for interfacial waves in a symmetric three-layer fluid, *Physics of Fluids*, **23** (11), Art. No. 116602, doi: 10.1063/1.3657816

41. T. Soomere, R. Weisse, A. Behrens 2011f. Wave climatology in the Arkona basin, the Baltic Sea, *Ocean Science Discussions*, **8** (6), 2237–2270, doi: 10.5194/osd-8-2237-2011

42. T. Soomere, M. Viidebaum, J. Kalda 2011g. On dispersion properties of surface motions in the Gulf of Finland, *Proceedings of the Estonian Academy of Sciences*, **60**, 4, 269–279, doi: 10.3176/proc.2011.4.07

43. T. Soomere, M. Viška, J. Lapinskis, A. Räämet 2011h. Linking wave loads with the intensity of coastal processes along the eastern Baltic Sea coasts, *Estonian Journal of Engineering,* **17** (4), 359–374 doi: 10.3176/eng.2011.4.06

44. T. Soomere, O. Kurkina 2011. Statistics of extreme wave conditions in the south-western Baltic Sea, *Fundamental and Applied Hydrophysics*, **4** (4), 43–57 (in Russian).

45. T. Soomere 2011. Contribution of fundamental research towards solving challenges of changing times in coastal science and management, in: *Research in Estonia* (J. Engelbrecht and G. Varlamova, eds.). Estonian Academy of Sciences, Tallinn, 206–226.

46. A. Lehmann, K. Getzlaff, J. Harlaß 2011. Detailed assessment of climate variability in the Baltic Sea area for the period 1958 to 2009, *Climate Research*, **46**, 185–196.

47. K. Getzlaff, A. Lehmann, J. Harlaß 2011. The repsonse of the general circulation of the Baltic Sea to climate variability. *BALTEX Newsletter* No. 14, 13–16.

Published in 2010:

48. A. Räämet, T. Soomere 2010. The wave climate and its seasonal variability in the northeastern Baltic Sea, *Estonian Journal of Earth Sciences* **59** (1), 100–113.

49. T. Soomere, B. Viikmäe, N. Delpeche, K. Myrberg 2010a. Towards identification of areas of reduced risk in the Gulf of Finland, the Baltic Sea, *Proceedings of the Estonian Academy of Sciences* **59** (2), 156–165.

50. A. Räämet, T. Soomere, I. Zaitseva-Pärnaste 2010. Variations in extreme wave heights and wave directions in the north-eastern Baltic Sea, *Proceedings of the Estonian Academy of Sciences* **59** (2), 182–192.

51. O. Andrejev, A. Sokolov, T. Soomere, R. Värv, B. Viikmäe 2010. The use of high-resolution bathymetry for circulation modelling in the Gulf of Finland, *Estonian Journal of Engineering* **16** (3), 187–210.

52. B. Viikmäe, T. Soomere, M. Viidebaum, M. Berezovski 2010. Temporal scales for transport patterns in the Gulf of Finland, *Estonian Journal of Engineering* **16** (3), 211–227.

53. T. Soomere, A. Räämet 2010. Long-term spatial variations in the Baltic Sea wave fields, *Ocean Science Discussions* **7**, 1889–1912.

54. T. Soomere, I. Zaitseva-Pärnaste, A. Räämet, D. Kurennoy 2010b. О пространственно-временной изменчивости полей волнения Финского залива (Spatio-temporal variations of wave fields in the Gulf of Finland), *Фундаментальная и прикладная гидрофизика* (Fundamental and Applied Hydrophysics) **4**(10), 91–102 (in Russian).

55. S. Keevallik, T. Soomere 2010. Towards quantifying variations in wind parameters across the Gulf of Finland, *Estonian Journal of Earth Sciences* **59** (4), 288–297.

Published in 2009:

56. A. Räämet, Ü. Suursaar, T. Kullas, T. Soomere 2009. Reconsidering uncertainties of wave conditions in the coastal areas of the northern Baltic Sea, *Journal of Coastal Research*, Special Issue 56, 257–261.

57. I. Zaitseva-Pärnaste, Ü. Suursaar, T. Kullas, S. Lapimaa, T. Soomere 2009. Seasonal and long-term variations in wave conditions in the northern Baltic Sea, *Journal of Coastal Research*, Special Issue 56, 277–281.

Appendix 2. Dissemination at conferences

Conference presentations in 2011:

1. Conference, planning and kick-off meeting of the Baltic Assessment Network (ACoast, Assessment of coastal observing systems in the Baltic Sea), Lauenburg, Germany, February 02–03, 2011: oral presentation by T. Soomere *Wind wave climatology on the eastern coast of the Baltic Sea*.
2. Science and policy conference "Building of the Nord Stream pipeline–consequences and potential hazards of the project", The European Parliament's Conservatives and Reformist's Group, Szczecin, Poland, February 22, 2011: invited presentation by T. Soomere *Nord Stream as a challenge and mirror for the Baltic Sea marine science*.
3. International Conference on Fundamentals, Experiments, Numeric and Applications "Particles in turbulence," University of Potsdam, Germany, March 16–18, 2011: oral presentation by B. Viikmäe (co-authors T. Soomere, N. Delpeche-Ellmann) *Technology for finding optimum fairways for environmental management in the Baltic Sea*.

4. European Geosciences Union, General Assembly, Vienna, Austria, April 03–08, 2011, four poster presentations: I. Didenkulova, E. Pelinovsky, T. Soomere, K. Parnell, M.Viška, *Beach response on the interplay of two wave systems: ship wakes and winds waves*; O. Kurkina, T. Talipova, E. Pelinovsky, T. Soomere, A. Giniyatullin, *Prognostic characteristics of internal waves for the Baltic Sea* (Geophysical Research Abstracts, 2011, 13, EGU2011-4559); T. Soomere, O. Andrejev, K. Myrberg, A. Sokolov, *Quantification of the potential of offshore areas in terms of Lagrangian transport of danger to vulnerable regions*, L. Xi, *Numerical Study of the inflow event in the Western Baltic Sea*.
5. Conference "The smart use of marine currents for environmental management" as a part of the BalticWay Annual Meeting, Palermo, Italy, April 11–12, 2011; eleven oral presentations: T. Soomere, *Basic steps of the technology for fairway optimization*; A. Höglund, M. Meier, *Tracing oil with tracers*; A. Lehmann, *Climate variability of the Baltic area and the Baltic Sea response*; A. Sokolov, *On transport patterns in the Gulf of Finland*; J. Murawsky, *Oil drift and fate modeling in the Gulf of Finland*; L. Xi, *The analysis of the trajectories in the Western Baltic Sea*; O. Andrejev, K. Myrberg, *Construction of optimal fairways in fields generated by Lagrangian particles statistics*; B. Viikmäe, *Equiprobability lines in the Gulf of Finland and the Baltic Proper*, K. Döös, *Surface drifters in the Baltic Proper*; J. Kjelsson, *Validating the model simulations with surface drifters*; M. Viidebaum, *Experiments with surface drifters in the Gulf of Finland*.
6. 11th International Coastal Symposium, Szczecin, Poland, May 09–13, 2011, three oral presentations: A. Räämet, T. Soomere, *Spatial variations in the wave climate change in the Baltic Sea*; T. Soomere, O. Andrejev, A. Sokolov, E. Quak, *Management of coastal pollution by means of smart placement of human activities*; B. Viikmäe, T. Soomere, K.E. Parnell, N. Delpeche, *Spatial planning of shipping and offshore activities in the Baltic Sea using Lagrangian trajectories*.
7. BOOS and HIROMB scientific workshop, May 11, 2011, oral presentation L. Xi, E. Stanev, *Numerical study of the inflow events in the Baltic: Focus on the transition zone*.
8. 3rd International Workshop on Modeling the Ocean, Qingdao, China, June 06–09, 2011, oral presentation: B. Viikmäe, *Optimizing fairways for environmental management in the Baltic Sea*.
9. Science and policy conference "Climate, renewable energy and sustainable development: The new geo-energy" organized by the Group of Conservatives and Reformists on the premises of the European Parliament (ASP 7 H 1), Brussels, Belgium, June 21, 2011; invited oral presentation by T. Soomere, *Marine science in research for alternative energy sources*.
10. 8th Baltic Sea Science Congress, Saint Petersburg, Russia, August 22–26, 2011; plenary lecture by T. Soomere, *Towards the use of currents for environmental management of vulnerable sea areas*; eleven oral presentations: R. Hordoir, H.E.M. Meier, *Freshwater fluxes in the Baltic Sea: A model study*; A. Höglund, H.E.M. Meier, *How to make oil stay at sea*; K. Getzlaff, A. Lehmann, H.-H. Hinrichsen, *The response of the Baltic Sea to climate variability*, B. Viikmäe, T. Soomere, N. Delpeche-Ellmann, *Optimizing fairways to reduce environmental risks in the Baltic Sea*; M. Viška, T. Soomere, K. Kartau, A. Räämet, *Patterns of sediment transport along the Latvian and Estonian coasts along the Baltic Proper and the Gulf of Riga*; M. Viidebaum, J. Kalda, T. Soomere, *Dispersion properties of surface currents in the Gulf of Finland*; A. Räämet, T. Soomere, *Decadal changes in significant wave height in the Baltic Sea*; K. Kartau, M. Viška, T. Soomere, *Decadal variations of wave-driven sediment transport processes in the Gulf of Riga*; O. Andrejev, T. Soomere, A. Sokolov,

K. Myrberg, *Environmentally safe fairways over fields generated by Lagrangian particles statistics: an application to the Gulf of Finland*; A. Giudici, J. Kalda, *Compressibility of sea surface created by 3D current field*; two poster presentations: O. Kurkina, A. Kurkin, D. Dorokhov, V. Gorbatsky, E. Morozov, A. Pankratov, *Distribution, vertical structure and seasonal variability of horizontal currents near the Curonian Spit in southeastern Baltic Sea in 2010*; L. Xi, E. Stanev, *Numerical study of the inflow event in the Baltic transition zone*.

11. ICES Annual Science Conference, Gdansk, Poland, September 19–23, 2011, poster presentation: K. Getzlaff, A. Lehmann, H.-H. Hinrichsen, *The response of the Baltic Sea to climate variability*.
12. Summer school "Preventive methods for coastal protection", Klaipeda, September 18–20, 2011; lectures: K. Myrberg, *Introduction to the physical oceanography of the Baltic Sea*; T. Soomere, *Introduction into hydrodynamics of currents and waves*; T. Torsvik, *Introduction into 2D and 3D modelling of ocean currents*; T. Eremina, *Modeling of transport and transformation of pollutants in the marine environment*; K. Döös, *Modelling of Lagrangian trajectories and the TRACMASS code*; E. Quak, *Things that may go wrong*; T. Soomere, *Basic steps of the BalticWay technology for coastal protection*; J. Murawsky, *Oil spill modelling*; K. Döös, *Surface drifters in the Baltic Proper*; J. Murawsky, *Operational oceanography in Denmark*; T. Soomere, *Applications of the smart use of marine currents for environmental management*.
13. International conference “The Future of Operational Oceanography,” Hamburg, Germany, October 25–27, 2011; oral presentation by T. Soomere, *Towards the use of currents in environmentally safer management of maritime activities*.
14. The fall seminar of the Institute of Cybernetics, Viinistu, Estonia, November 12, 2011, two oral presentations: E. Quak, *The Baltic Way project – experiences and results*; A. Giudici, *Compressibility of the surface currents*.

Conference presentations in 2010:

15. The Joint Baltic Sea Research Programme BONUS Annual Conference, January 19–21, 2010, Vilnius, Lithuania; two oral presentations: B. Viikmäe, R. Isotamm, N. Delpeche, *An empirical method to determine patterns of risk of coastal pollution in the Gulf of Finland*; T. Soomere, N. Delpeche, B. Viikmäe, *Semi-persistent patterns of transport in surface layers of the Gulf of Finland*.
16. International workshop "Water Seminar Day", March 18, 2010, Frederick University, Nikosia, Cyprus; two oral presentations: T. Soomere, *Implications of intense fast ferry traffic on nearshore water quality and beach erosion*; K. Döös, *Relative dispersion of surface drifters and model simulated trajectories*.
17. European Geosciences Union, General Assembly, May 02–07, 2010, Vienna, Austria; poster presentation T. Soomere, N. Delpeche, B. Viikmäe, M. Viidebaum, *The use of current-induced transport for coastal protection in the Gulf of Finland, the Baltic Sea*.
18. 15th Biennial Workshop of Joint Numerical Sea Modelling Group (JONSMOD), May 10–12, 2010, Delft, The Netherlands; oral presentation by B. Viikmäe, *The use of Lagrangian trajectories for minimization of the risk of coastal pollution*.
19. 6th Study Conference on BALTEX, June 14–18, 2010, Międzyzdroje, Poland; three oral presentations: A. Räämet, T. Soomere, *A reliability study of wave climate modelling in the Baltic Sea*; B. Viikmäe, T. Soomere, N. Delpeche, H.E.M. Meier, K. Döös, *Utilizing*

Lagrangian trajectories for reducing environmental risks; O. Andrejev, B. Viikmäe, A. Sokolov, T. Soomere, K. Myrberg, *Using multi-year circulation simulations to identify areas of reduced risk for marine transport. Application to the Gulf of Finland*; poster presentation: N. Delpeche, T. Soomere, B. Viikmäe, *Towards a quantification of areas of high and low risk of pollution in the Gulf of Finland, with the application to ecologically sensitive areas*.

20. 2nd conference–school on Dynamics of Coastal Zone of Non-tidal Seas, June 26–30, 2010, Baltiysk, Russia, oral presentation I. Zaitseva-Pärnaste, A. Räämet, T. Soomere, *Comparison between modelled and measured wind wave parameters in Estonian coastal waters*.
21. The ANNiMS Student Conference, Townsville campus, James Cook University, Australia, July 21–22, 2010; invited keynote lecture by T. Soomere, *Towards a future technology of environmental management*.
22. Humboldt Kolleg Ukraine "Mathematics and Life Sciences", August 5–8, 2010, Kiev, Ukraine; oral presentation by E. Quak, *The BalticWay project: The potential of currents for environmental management of the Baltic Sea*.
23. 10th International Marine Geological Conference "The Baltic Sea Geology – 10", August 24–28, 2010, St. Petersburg, Russia; two oral presentations: I. Zaitseva-Pärnaste, T. Soomere, *Long-term variations of wave heights and its comparison with ice conditions in Estonian coastal waters*, B. Viikmäe, T. Soomere, N. Delpeche, *Potential of using Lagrangian trajectories for environmental management in the Gulf of Finland*.
24. 5th International Student Conference on "Biodiversity and Functioning of Aquatic Ecosystems in the Baltic Sea Region", October 6–8, 2010, Palanga, Lithuania; two oral presentations: B. Viikmäe, T. Soomere, N. Delpeche, *Using Lagrangian Trajectories to find areas of reduced risk of coastal pollution in the Gulf of Finland*; M. Viidebaum, B. Viikmäe, N. Delpeche. *Sensitivity study of the Lagrangian trajectory model TRACMASS*; poster presentation: I. Zaitseva-Pärnaste, T. Soomere, *Wave climate in the eastern part of the Baltic Sea*.
25. 6th autumn school of young geologists "Schola Geologica – 6", October 8–10, 2010, Roosta, Estonia; invited lecture by T. Soomere *The changing wave climate of the Baltic Sea*; field trip to the sea coast led by T. Soomere.

Conference presentations in 2009:

26. Kick-off meeting of the BONUS BalticWay project, Helsinki, Finland, January 12, 2009; oral presentation: T. Soomere, E. Quak, *Towards using the potential of currents for the benefit of society*.
27. Kick-off meeting and conference of the Baltic Sea Research Programme BONUS, Dipoli Conference Centre, Espoo, Finland, January 13–15 January, 2009; oral presentation: T. Soomere, E. Quak, Baltic Way: *Towards using the potential of currents for the benefit of society*.
28. 7th Baltic Sea Science Congress, Tallinn, Estonia, August 17–21, 2009; three oral presentations: E. Quak, T. Soomere, *The BalticWay project: The use of currents for environmental management of the Baltic Sea coasts*; I. Zaitseva-Pärnaste, *Seasonal and long-term variations of wave conditions in Estonian coastal waters*, A. Räämet, *Simulating long-term changes of wave conditions in the northern Baltic Sea*.

29. International conference "Lithodynamics of bottom contact zone of the ocean," Moscow, Russia, September 14–17, 2009; oral presentation by L. Kelpsaite, T. Soomere, *The relative importance of wind-waves and ship-wakes on longshore drift in Tallinn Bay, the Baltic Sea* and poster presentation by I. Zaitseva-Pärnaste *Long term variation in wave fields in the Baltic Proper*.
30. Australasian Coasts and Ports Conference, Wellington, New Zealand, September 16–18, 2009; invited keynote lecture by T. Soomere *Using wave and current dynamics to find solutions to the challenges of environmental change*.
31. 4th International student conference "Biodiversity and functioning of Aquatic Ecosystems in the Baltic Sea Region" Dubingiai, Lithuania, October, 2–4, 2009; oral presentation by A. Räämet *Wave climate changes in the Baltic Proper 1978–2007*.
32. Conference dedicated to the 90 years of the Estonian Marine Academy, Tallinn, October 23, 2009, keynote lecture by T. Soomere *Marine science in Estonia in the present, past and future*, reflecting also the BalticWay ideas.
33. International conference "Coping with Uncertainty," Sigtuna, Stockholm, Sweden, November 15–17, 2009; three oral presentations: T. Soomere, *Towards the use of currents for reducing anthropogenic risks for the Baltic Sea coasts*, R. Isotamm, B. Viikmäe, T. Soomere, *Application of a trajectory model to select areas of high risk of pollution* and R. Isotamm, N. Delpeche, *An empirical method to determine a low-risk fairway in the Gulf of Finland*.

Appendix 3. Public lectures and presentations

2011

1. T. Soomere. *New possibilities for handling marine coastal hazards*. Hotel Palmse, Palmse, Estonia, 14.01.2011.
2. T. Soomere. *Contribution of marine science to the protection of Estonian coasts*. National Library, Tallinn, 24.01.2011.
3. T. Soomere. *New aspects of the meaning of extreme waves in maritime engineering design*. University of Palermo, 08.04.2011.
4. T. Soomere. *The possibilities of contemporary marine science for understanding and protection of Estonian coasts*. Estonian Naturalists' Society, Tartu, 26.05.2011.
5. T. Soomere. *The use of currents for environmental management of offshore activities*. Institute for Baltic Sea Research (Institut für Ostseeforschung), Warnemünde, 16.08.2011.
6. T. Soomere. *The smart use of currents for environmental management of offshore activities*. Institute of Coastal Research, Helmholtz-Zentrum Geesthacht, 13.09.2011.
7. T. Soomere. *Spatio-temporal patterns in the Baltic Sea wave climate*. Dept. of Data Analysis and Data Assimilation, Institute of Coastal Research, Helmholtz-Zentrum Geesthacht, 14.09.2011.
8. M. Viška, T. Soomere. *Patterns of sediment transport along the Eastern Baltic Sea coast*. Dept. of Data Analysis and Data Assimilation, Institute of Coastal Research, Helmholtz-Zentrum Geesthacht, 14.09.2011.

2010

9. T. Soomere. *Nord Stream as a challenge for the society*. Annual meeting of the Estonian Water Society, 05.02.2010.
10. T. Soomere. *Nord Stream as a challenge for the Baltic Sea marine science*. Tallinn House of Teachers, 07.02.2010.
11. Dr. Urmas Raudsepp (Marine Systems Institute at Tallinn University of Technology) presented an overview of recent developments of the Baltic Way team to the East Estonian crisis regulation committee, Kohtla-Järve, 26.03.2010.
12. T. Soomere. *Offshore secrets: sea waves and currents*. Open University of the Tallinn University of Technology, 14.05.2010.
13. T. Soomere. *The Baltic Sea in development: surprises for maritime spatial planning (On new ways of treatment of marine-induced hazards)*, Seminar on spatial planning of coastal areas, Vihula, Lääne-Virumaa, 20.05.2010.
14. T. Soomere. *Towards a future technology of environmental management: the use of properties of currents for minimizing coastal pollution*. Institute of Marine and Antarctic Studies (IMAS), University of Tasmania, Hobart, 17.08.2010.
15. T. Soomere. *Are regional wave climates changing*? Technical Meeting Series of the Tasmanian Divisions of RINA (Royal Institute of Naval Architects) and IMarEST (Institute of Marine Engineering, Science and Technology), Australian Maritime College, University of Tasmania, Launceston, 18.08.2010.
16. T. Soomere. *New aspects of the meaning of extreme waves in maritime engineering design*. Australian Maritime College, University of Tasmania, Launceston, 18.08.2010.
17. T. Soomere. *Patterns of changes to the regional wave climate*. School of Earth and Environmental Sciences, James Cook University, Townsville, Australia, 02.11.2010.
18. T. Soomere. *Towards the use of properties of currents for environmental management, with applications to ship-caused pollution*. Institute of Marine Engineering, Science and Technology (IMarEST), Queensland Branch, Townsville Marine Museum, Australia, 11.11.2010.
19. T. Soomere. *Contribution of fundamental research towards solving challenges of changing times*. Oceans Institute, University of Western Australia, Perth, 24.11.2010.
20. T. Soomere. *Patterns of changes to the regional wave climate*, School of Environmental Systems Engineering, University of Western Australia, Perth, 25.11.2010.
21. E. Quak. *The Baltic Way project: The potential of currents for environmental management of the Baltic Sea*. Universität Ulm, Germany, 17.12.2010.

2009

22. T. Soomere. *Marine hazards for Estonian large cities*. Seminar organised by the Lions Club on the premises of the Estonian Academy of Sciences, 25.02.2009.
23. T. Soomere. *Transport patterns in the surface layer of the Gulf of Finland*. BalticWay seminar in the Finnish Environmental Institute (SYKE), Helsinki, Finland, 03.12.2009.

Appendix 4. Popular papers addressing or using the results of the BalticWay project

2011:

1. T. Soomere. Kuidas mõõta randade tervist (How to measure the health of beaches). *Loodusesõber* (*The Friend of Nature*, a popular science journal), 2011, 2, 22–26 (in Estonian).
2. I. Puura, T. Soomere. Влияние на окружающую среду и потенциальные риски в результате прокладки газового трубопровода „Северный поток" (Environmental impact and potential risks stemming from the Nord Stream pipeline), *Горизонты Эстонии* (*Horizons of Estonia*) 2011, 68–75 (in Russian).
3. T. Soomere. BALTICWAY – The potential of currents for environmental management of the Baltic Sea maritime industry. *BONUS in Brief*, November 2011, p. 7.
4. T. Soomere. Läänemere lainekliima Eesti ranniku kontekstis (The Baltic Sea wave climate in the context of the Estonian coast). In: *Teadusmõte Eestis VII. Meri. Järved. Rannik* (edited collection of popular papers about developments in oceanography, limonology and coastal sciences in Estonia) (T. Soomere, T. Nõges, eds.). Eesti Teaduste Akadeemia, 2011, Tallinn, 69–82 (in Estonian).
5. I. Didenkulova. Lainepõhised ohud rannavööndis (Wave-induced hazards in the nearshore). In: *Teadusmõte Eestis VII. Meri. Järved. Rannik* (T. Soomere, T. Nõges, eds.). Eesti Teaduste Akadeemia, 2011, Tallinn, 103–115 (in Estonian).
6. T. Soomere. Preventiivsed meetodid ranniku kaitseks mere sisemise dünaamika abil (Preventive methods for the coastal protection). In: *Teadusmõte Eestis VII. Meri. Järved. Rannik* (T. Soomere, T. Nõges, eds.). Eesti Teaduste Akadeemia, 2011, Tallinn, 197–211 (in Estonian).

2010:

7. T. Soomere 2010. Tugev tuul puhub saarerahvale merel meelehärmi (Strong wind affects the life of island people), *Maaleht* (weekly newspaper targeted to countryside people), 3(1163), 21.01.2010, p. 10–11 (in Estonian).
8. T. Soomere, Nord Stream eirab tundliku Läänemere eripära (Nord Stream ignores the specific features of the vulnerable Baltic Sea), In: *Tallinna Tehnikaülikooli aastaraamat 2009* (Yearbook of the Tallinn University of Technology 2009), TTÜ Kirjastus 2010, 243–249 (in Estonian).
9. T. Soomere, Läänemere lainekliima muutuste keerises (Changing wave climate in the Baltic Sea). Preeden, U., Laumets, L. (eds.), *Globaalsed muutused* (*Global Changes*). Schola Geologica VI. Eesti Looduseuurijate Selts, Tartu Ülikooli Ökoloogia ja Maateaduste Instituut, Tallinna Tehnikaülikooli Geoloogia Instituut, Tallinna Tehnikaülikooli Mäeinstituut. Sulemees, Tartu 2010, 59–73 (in Estonian).
10. CENS-CMA: Coastal research on the crest of a wave, Marie Curie Actions: Inspiring Researchers, European Commission, Directorate-General for Research, 2010, 232–235.

2009:

11. T. Soomere. Sea currents bring pollution to the Estonian coasts. *Postimees* (*The Postman*, the leading daily newspaper), 57(5537), March 11, 2009, 5.

12. Anonymous, Scientists think the gas pipeline may be dangerous to the sea. Editorial based on comments by T. Soomere, Postimees, 57 (5537), March 11, p. 1 (in Estonian).

13. T. Soomere. What would think Andres and Pearu about a gas pipeline at the border of their land sections? Maaülikool (newspaper of the Estonian University of Life Sciences), 161, March 23, 2009, 2 (in Estonian).

14. T. Soomere. Nord Stream ignores the specific features of the vulnerable Baltic Sea, Text of the presentation to the Estonian Parliament on October 27, 2009. Postimees 249 (5729), October 28, 2009, 12–13 (in Estonian).

15. T. Soomere. Marine science in Estonia and in the Baltic Sea region: past, present and future. Meremees (The Mariner), 4/2009 (in Estonian).

Before the start of the Project:

16. M. Filippov. Estonian scientists will put the Baltic Sea under careful scrutiny (paper about the ideas of the BONUS BalticWay project, Postimees, 12.07.2008, p. 8–9 (in Estonian).

Appendix 5. Distinctions

- Olga Tribštok received an award in the student research competition of the Estonian Academy of Sciences for the master thesis „Comparison of wave regimes along Estonian and Lithuanian coasts“ partially reflecting wave calculations under the BalticWay project (supervisor T.Soomere) (08.11.2011).
- The BalticWay team was awarded a special mention in the BONUS+ Award 2011 competition for the best public engagement activity or product, for an outstanding public engagement effort and high level key stakeholder involvement related to the topic of the environmental impact assessment of the Nord Stream pipeline (24.10.2011).
- T. Soomere was awarded the title of the best scientist (journalist or teacher), that communicates science and technology for explaining actual problems of marine physics in popular-scientific papers and at public appearances at the distribution of 2011 Estonian Science Communication Awards (11.11.2011).
- I. Didenkulova was awarded a Humboldt foundation fellowship (2012–2014) for experienced researchers to perform research in Germany (2011).
- T. Soomere received a thank-you letter from the Estonian Society for Nature Protection for informing the public and the leaders of Estonia, and for urging them to protect the Baltic Sea (2009).
- The Estonian Council of Environmental NGOs chose the 2009 Environmental Deed in Estonia to be Tarmo Soomere's and Ivar Puura's initiative to draw attention to the possible negative environmental influence of the future Nord Stream pipeline.

Appendix 6. PhD theses fully or partially based on the BalticWay developments

Promoted:

A. Räämet, Spatio-temporal variability of the Baltic Sea wave fields in changing climate conditions, June 22, 2010 (Tallinn University of Technology, supervisor T. Soomere).

In progress:

L. Xi (ICR), Study of the Baltic Sea dynamics: a contribution to designing environmentally safe fairways (supervisor E. Stanev), promotion expected 2012.

O. Kurkina (IoC), Nonlinear dynamics of internal gravity waves in the Baltic Sea (supervisor T. Soomere), promotion expected 2012.

I. Zaitseva-Pärnaste (IoC), Wave climate changes of the Baltic Sea and their economical consequences (supervisor T. Soomere), promotion expected 2013.

N. Delpeche-Ellmann (IoC), Using improved understanding of the circulation pattern in the Gulf of Finland to minimize coastal pollution (supervisor T.Soomere), promotion expected 2013.

J. Kjellsson (University of Stockholm), Drift and dispersal properties of the Baltic Sea – Model and observational perspectives (supervisor K. Döös), promotion expected February 2014.

M. Viška (IoC), Evolution and forecast of open sedimentary coasts in the Baltic Sea conditions (supervisor T. Soomere), promotion expected 2014.

A. Rodin (IoC), Evolution, runup and breaking of strongly nonlinear sea waves in the nearshore (supervisors I. Didenkulova and T. Soomere), promotion expected 2015.

A. Giudici (IoC), Quantification and visualisation of current-induced risk of coastal pollution (supervisor T. Soomere), promotion expected 2015.

B. Viikmäe (IoC), Optimizing fairways in the Baltic Sea using patterns of surface currents (supervisor T. Soomere), promotion expected 2015.

Appendix 7. Meetings and events

2011:

- January 26, Tallinn — Visit of German Ambassador Dr. Martin Hanz to the IoC Baltic Way team
- February 02–03, Lauenburg — Conference and planning meeting of the Baltic Assessment Network (ACoast, Assessment of coastal observing systems in the Baltic Sea); organised by ICR, attended by IoC, SYKE, DMI
- February 22, Szczecin — Conference "Building of the Nord Stream pipeline – consequences and potential hazards of the project" organised by the European Parliament's Conservatives and Reformist's Group, attended by IoC
- March 16–18, Potsdam — International Conference on Fundamentals, Experiments, Numeric and Applications "Particles in turbulence", attended by IoC
- March 21–23, St. Petersburg — International symposium „Baltic Sea Day," co-organised by SYKE, attended by IoC

- April 03–08, Vienna EGU General Assembly 2011, attended by IoC, SYKE, ICR, DMI
- April 11–13, Palermo Project annual meeting, attended by all partners
- May 09–13, Szczecin 11th International Coastal Symposium, attended by IoC & ICR
- May 10–11, Tallinn Plenary Meeting of the European Science Foundation Marine Board; organised by IoC
- May 11, Hamburg BOOS and HIROMB scientific workshop, attended by ICR
- June 06–09, Qingdao, China 3rd International Workshop on Modeling the Ocean, attended by IoC
- June 15, Helsinki BONUS Forum, attended by IoC & SMHI
- June 16, Zürich Kick-off meeting of the network "FuturICT's Interconnected Observatories of Society for a Resilient and Sustainable Future," attended by IoC
- June 21, Brussels Conference "Climate, renewable energy and sustainable development: The new geo-energy" organized by the Group of Conservatives and Reformists on the premises of the European Parliament, attended by IoC
- June 27–29, Berlin Annual meeting of the Alexander von Humboldt Foundation, attended by IoC
- June 27–July 1, Helsinki Project discussion meeting, attended by SYKE & IFM-GEOMAR
- June 28, Zürich Meeting of national coordinators of the FuturICT Flagship project, attended by IoC
- June 28–July 07 International Union of Geodesy and Geophysics (IUGG) General Assembly 2011, attended by IoC
- August 22–26, St. Petersburg 8th Baltic Sea Science Conference, attended by IFM-GEOMAR, SYKE, ICR, IoC, MISU, SMHI, DMI; project meeting within the event
- September 05–09, Salzburg International Association for Mathematical Geosciences (IAMG) conference „Mathematical Geosciencs at the Crossroads of Theory and Practice," attended by IoC
- September 11, Vienna Meeting of national coordinators of the FuturICT flagship, attended by IoC
- September 12, Vienna European Conference on Complex Systems ECCS'11, attended by IoC
- September 18–20, Klaipeda International BalticWay summer school "Preventive methods for coastal protection", attended by IoC, SYKE, MISU, ICR, DMI
- September 19–23 Gdansk ICES Annual Science Conference, attended by SYKE & IFM-GEOMAR
- September 29–30 BALTEX Science Steering Group related to BONUS Phase II, attended by IFM-GEOMAR
- October 13–14, Madrid Plenary Meeting of the European Science Foundation Marine Board, attended by IoC

- October 24, Gdansk BONUS Forum, attended by IoC & SMHI
- October 25–27, Hamburg Conference "The Future of Operational Oceanography," attended by IoC & ICR
- November 11, Brussels Joint meeting of the European Academies Scientific Advisory Council (EASAC) Environment Steering Panel and Energy Steering Panel, attended by IoC
- December 20, Tallinn Public presentation of the edited popular science volume "Science in Estonia (VII)" in the Estonian Academy of Sciences, co-organised by IoC

2010:

- January 19–21, Vilnius BONUS Annual Conference, attended by all partners
- February 9, Helsinki International workshop Bonus Day 2010, attended by IoC
- March 18, Nikosia International workshop „Water Seminar Day", attended by IoC & MISU
- March 18–20, Cyprus Project annual meeting and international workshop, attended by all partners
- April 14, Helsinki Project discussion meeting, attended by SYKE & IFM-GEOMAR
- April 14–15, Brussels International conference BIG-STEP (Business, Industry and Government – Science and new Technologies for Enhancing Policy), attended by IoC
- May 06–08, Tallinn Workshop targeted at the formulation of the basic steps of the technology for environmental management, attended by IoC & SYKE
- May 10–12, Delft 15th Biennial Workshop of Joint Numerical Sea Modelling Group (JONSMOD), attended by IoC
- May 11, Copenhagen HIROMB-BOOS scientific workshop, attended by DMI & ICR
- May 24–25, Helsinki Project discussion meeting, attended by SYKE & SMHI
- June 8, Helsinki The BONUS Coordinators' Forum, attended by IoC
- June 9, Helsinki The BONUS Advisory Board meeting, attended by IoC
- June 14–18, Międzyzdroje 6th BALTEX Study Conference, attended by IoC, SYKE, SMHI, IFM-GEOMAR
- June 20–24, Tallinn Discussion of the abilities and limitations of the WAM model for wave calculation in the Baltic Sea, attended by ICR & IoC
- June 21–25, Tallinn Training in the TRACMASS code, attended by IoC & ICR
- June 26–29, Tsinghua U 2nd international conference „Nonlinear Waves: Theory and Applications", attended by IoC
- June 26–30, Baltiysk 2nd school on Dynamics of Coastal Zone of Non-tidal Seas, attended by IoC
- June, Geesthacht Project discussion meeting, attended by DMI & ICR
- July 21–22, Townsville The ANNiMS Student Conference, attended by IoC
- August 5–8, 2010, Kiev Humboldt Kolleg Ukraine "Mathematics and Life Sciences", attended by IoC

- August 24–28, St. Petersburg
  10th International Marine Geological Conference „The Baltic Sea Geology – 10", attended by IoC
- September 2–4, Tallinn Finnish-Estonian Humboldt Kolleg "The Baltic Sea as a Bridge", including discussions of the project status and future steps, attended by IoC, SYKE, IFM-GEOMAR and the BONUS Executive Director
- September 20–24, Nantes ICES Annual Science Conference, attended by IFM-GEOMAR
- October 6–8, Palanga 5th International Student Conference on „Biodiversity and Functioning of Aquatic Ecosystems in the Baltic Sea Region", attended by IoC
- October 18–22, Kiel Project discussion meeting, attended by SYKE & IFM-GEOMAR
- November 24–25, Gothenburg
  BALTEX Scientific Steering Group meeting, related to BONUS Phase II, attended by IFM-GEOMAR

2009:

- January 12, Helsinki Project kick-off meeting, attended by all partners
- January 13–14, Helsinki BONUS+ kick-off meeting, attended by all partners
- March 6, Stockholm Planning meeting of the Swedish partners, attended by MISU, SMHI & IoC
- May 14, Tvärminne Discussion of model calculations, attended by SYKE, IFM-GEOMAR, LDI & IoC
- May 4-8, Lund RCM-Workshop: 21st century challenges in regional-scale climate modelling, Lund University, attended by IFM-GEOMAR
- May 5, Liège Discussion of model calculations, attended by IoC, LDI & ICR
- May 25-28, Szczecin Climate change: the environmental and socio-economic response in the southern Baltic Region
- June 5, Kiel Discussion of model calculations, attended by SYKE & IFM-GEOMAR
- June 15–16, Helsinki BONUS+ coordinators' meeting, attended by IoC & SMHI
- August 17–21, Tallinn Baltic Sea Science Congress, including a project status meeting attended by IoC, SYKE, SMHI, IFM-GEOMAR, LDI
- October 12–14, Helsinki Discussion of drift modelling and circulation in the north-eastern Baltic Sea, attended by SYKE & IFM-GEOMAR
- October 15, Norrköping Modelling cluster meeting, attended by SMHI, ICR
- December 3, Helsinki BalticWay regional meeting and seminar with presentation of first results and discussion of upcoming simulations, attended by SYKE, IoC & LDI.
- December 15, Kiel Presentation of the drift experiments from the Gulf of Finland (SYKE) and the southern Baltic (IFM-GEOMAR), and discussion of potential differences in trajectory modelling and data exchange, attended by SYKE & IFM-GEOMAR)

Practical implementation: performance statistics 1–4

Contributions to consultations carried out by the European Commission

Total contributions in 2009–2011: 5

2011: 3

- T. Soomere twice contributed to consultations carried out by the European Commission through input created jointly by the European Science Foundation Marine Board on its Plenary Meetings (Spring Meeting, Tallinn, May 10–11, 2011 and Fall Meeting, Madrid, October 13–14, 2011), using suggestions based on the output of the BalticWay project on both occasions.
- T. Soomere contributed to working documents of the Environmental Steering Panel and Energy Steering Panel of the European Academies Scientific Advisory Council on the joint meeting of these panels (Brussels, November 11, 2011).

2010: 1

- T. Soomere participated in the marine science policy conference EurOCEAN2011 (Oostende, Belgium, October 12–13, 2010) where the Oostende (Ostend) Declaration "The Seas and Oceans are one of the Grand Challenges for the 21st Century" was adopted by the representatives of the European marine and maritime research community. The contribution based on the outcome of the BalticWay project was incorporated into the recommendations of the European Science Foundation Marine Board, discussed during the Spring Plenary Meeting (Istanbul, June 03–04, 2010).

2009: 1

- T. Soomere participated in the Plenary Meeting of the European Science Foundation Marine Board with suggestions based on the ideas of the BalticWay project (Rome, May 18–19, 2009).

Participation in stakeholder and scientific committees

Total 2009–2011: 106 activities (calculated on annual basis, overlapping items possible).

2011: 54
2010: 29 (updated from 26 reported in Annual Report Year 2)
2009: 23 (updated from 16 reported in Annual Report Year 2)

2011: 50

Tarmo Soomere (IoC):

1. Estonian representative in the Marine Board of the European Science Foundation
2. EASAC Environmental Steering Panel, founding member, Estonian representative
3. Member of the Board of the Estonian Academy of Sciences
4. Chair of the Committee on Marine Sciences of the Estonian Academy of Sciences (since 2007)
5. Member of the Estonian national maritime commission
6. Chief organiser of the conference „The smart use of marine currents for environmental management"(Palermo)
7. Member of the CBO (Conference of Baltic Oceanographers) steering committee
8. Member of the steering committee of the 8th Baltic Sea Science Congress 2011; chair of one plenary session; convener and chair of the thematic session: Interplay of physical, biological and geological processes in various spatial and temporal scales
9. Member of the Scientific Council of the Laboratory of Multiphase Flows at Tallinn University of Technology
10. Member of the Committee on Scientific Research of the Council of the Tallinn University of Technology.
11. Chief organiser of the BalticWay summer school Preventive methods for coastal protection, Klaipeda, Lithuania
12. Member of the PhD examination committee of Irina Nikolkina, University of Antilles and Guayane, Point-a-Pitre, Guadeloupe, France
13. Estonian Journal of Engineering (editor, hydrodynamics and coastal engineering); guest editor of issue 4/2011 „Oceanograpy. Meteorology. Coastal Engineering".
14. Oceanologia, member of the Editorial Board
15. Journal of Marine Systems, member of the Editorial Board.
16. Boreal Environment Research, member of the Editorial Board.

Kai Myrberg (SYKE)

17. ICES Delegate of Finland
18. EUR-OCEANS, member of Council
19. HIROMB, member of Steering Committee
20. BALTEX, member of Steering Committee
21. Co-ordinator of the Gulf of Finland Year 2014
22. Opponent of Mr. Germo Väli, Tallinn Univ. of Technology
23. Boreal Environment Research, editor
24. Geophysica, member of advisory board
25. Estonian Journal of Earth Sciences, member of advisory board
26. Member of the CBO (Conference of Baltic Oceanographers) steering committee
27. Convener of a scientific session on coastal-open sea interactions in BSSC 2011
28. Convener of a session on upwelling in ICES ASC

Ira Didenkulova (IoC)

29. European Geosciences Union, scientific officer of Sea Hazards division
30. International Tsunami Comission, member, Estonian representative
31. Convener and chair of two thematic sessions of EGU General Assembly 2011: NH5.1 "New developments in tsunami science and in mitigation of tsunami risk, including early warning" and NH5.3/NP7.3/OS2.5."Nonlinear Dynamics of the Coastal Zone"
32. Co-convener and chair of the thematic session of the 8th Baltic Sea Science Congress 2011: Interplay of physical, biological and geological processes in various spatial and temporal scales
33. Natural Hazards and Earth System Sciences, guest editor of Special Issues „Sea Hazards" and „New developments in tsunami science: from hazard to risk"
34. Nonlinear Processes in Geophysics, guest editor of Special Issue „Nonlinear waves in the ocean"

Ewald Quak (IoC)

35. Evaluator in the EC evaluation of Integrated Project proposals for the ICT Call 7 in Brussels
36. Co-organiser of the 9th Industry Challenges in CAD, Geometric Modelling and Simulation Workshop, Darmstadt, Germany
37. Vice-chair in the EC evaluation of the call for Marie Curie Industry Academia Fellowships and Pathways in Brussels
38. Co-organiser of the Fall School of the Marie Curie Initial Training Network SAGA (Shapes, Geometry, Algebra) in Vilnius, Lithuania, http://www.sagaschool.lt/
39. Co-organiser of the SIAM/ACM Joint Conference on Geometric and Physical Modeling Orlando, Florida, USA, responsible for a two-part "Forward Looking Minisymposium" on future research challenges and moderator of the "Forward Looking Panel Discussion"
40. Journal of Mathematics in Industry (JMiI), member of the editorial board

Kristofer Döös (MISU)

41. Co-convener of the thematic session of the 8th Baltic Sea Science Congress 2011: Interplay of physical, biological and geological processes in various spatial and temporal scales

Andreas Lehmann (IFM-GEOMAR)

42. Member of the BSSC Scientific Steering Committee
43. Member of the BALTEX Science Steering Group
44. Convener BSSC St. Petersburg Russia: Coastal-offshore exchange processes.
45. Convener of the session Upwelling events, coastal-offshore exchange and links to biogeochemical processes in various parts of the oceans of the ICES Annual Science Conference

Markus Meier (SMHI)

46. Member of the scientific committee of the 8th Baltic Sea Science Congress (BSSC) 2011 "Joint research efforts for sustainable ecosystem management", St.Petersburg, Russia

47. Convener of the theme session ”Impact of changing climate and human-induced pressures on the Baltic Sea Ecosystem" proposed by the BONUS+ program by Markus Meier (Sweden), Joachim Dippner (Germany), Aarno Kotilainen (Finland) at the Baltic Sea Science Congress (BSSC2011), St.Petersburg, Russia
48. Co-Convener of the theme session `”Integration of multidisciplinary knowledge in the Baltic Sea to support science-based management" proposed by the BONUS+ program by Sakari Kuikka (Finland), Michael Gilek (Sweden), Markus Meier (Sweden), Kari Lehtonen (Finland) at the 2011 Annual Science Conference of the International Council for the Exploration of the Sea (ICES), Gdansk, Poland, September 19–23, 2011

Sergey Babichenko (LDI)

49. Member the Board of Stakeholders, European Technology Platform Photonics21, Brussels
50. Member of Scientific Committee and co-chairman of the 5th EARSeL Workshop on Remote Sensing of the Coastal Zone, Prague, Czech Republic

Emil Stanev (ICR)

51. Four occasions in 2011

2010: 32

Tarmo Soomere (IoC):

52. Estonian representative in the Marine Board of the European Science Foundation
53. EASAC Environmental Steering Panel, founding member, Estonian representative
54. Member of the Board of the Estonian Academy of Sciences
55. Chair of the Committee on Marine Sciences of the Estonian Academy of Sciences (since 2007)
56. Member of the expert group of the Estonian Ministry of Environment for estimating the content of the environmental impact assessment of the Nord Stream gas pipeline
57. Member of the Estonian national maritime commission
58. Invited expert to the discussion of the concept and principles of the new legislation of the use and protection of the marine environment by the Estonian Ministry of Environment
59. Co-organiser of the international workshop „Water Seminar Day“(Frederick University, Nikosia, Cyprus), organised jointly by the BalticWay team, the FP7 FET Coordination Action “Global Systems Dynamics and Policies” GSD and Frederick University
60. Organiser of the Estonian-Finnish Humboldt Colloquium “The Baltic Sea as a Bridge” in Tallinn
61. Member of the CBO (Conference of Baltic Oceanographers) steering committee
62. Member of the steering committee of the Baltic Sea Science Congress 2011
63. Member of the steering committee of the international conference „The Baltic Geology – 10”, Saint Petersburg, Russia
64. Member of the Scientific Council of the Laboratory of Multiphase Flows at Tallinn University of Technology

Kai Myrberg (SYKE)

65. HIROMB, member of Steering Committee
66. BALTEX, member of Steering Committee
67. Boreal Environment Research, editor
68. Geophysica, member of advisory board
69. Estonian Journal of Earth Sciences, member of advisory board
70. Member of the CBO (Conference of Baltic Oceanographers) steering committee.

Ewald Quak (IoC)

71. Vice-chair of the Engineering panel for the evaluation of Marie Curie Initial Training Network proposals in the EU FP7 People Programme
72. Evaluator of the ComplexityNet call, representing the Estonian Academy of Sciences
73. Member of the Expert Panel for the ex-post evaluation of 44 Belgian interuniversity networks in the framework of the IAP-VI programme
74. Member of the Program Committee, FOCUS K3D Conference on semantic 3D media and content in Sophia-Antipolis, France
75. Member of the Program Committee, Conference Shape Modeling International 2010 in Aix-en-Provence, France
76. Member of the Program Committee, SAGA Fall School in Kolympari, Greece
77. Member of the Program Committee, Euromed2010 Conference on Digital Heritage in Lemesos, Cyprus
78. Contact point Special Interest Group on Geometric Modeling, CAD, Evolving Interfaces and Surfaces of the European Consortium for Mathematics in Industry (ECMI)

Markus Meier (SMHI)

79. Organizer of the international BONUS+ program workshop “Uncertainties of scenario simulations,” Norrköping, Sweden

Andreas Lehmann (IFM-GEOMAR)

80. Member of the scientific steering committee of BALTEX

2009: 23

Tarmo Soomere (IoC):

81. Member of the expert group of the Estonian Ministry of Environment for estimating the content of the environmental impact assessment of the Nord Stream gas pipeline
82. Member of the Estonian national maritime commission
83. Member of the steering committee of the Baltic Sea Science Congress 2009
84. Member of the CBO (Conference of Baltic Oceanographers) steering committee
85. Member of the Scientific Council of the Laboratory of Multiphase Flows at TUT
86. Member of the Scientific Council of the Institute of Cybernetics at TUT
87. Estonian representative in the Marine Board of the European Science Foundation

88. Chair of the Marine Board of the Estonian Academy of Sciences (since 2007)
89. EASAC Environmental Steering Panel, Estonian representative (since 2008)
90. Co-chair of the international conference „Complexity of Nonlinear Waves" in Tallinn
91. Member of the Board of the Estonian Academy of Sciences

Kai Myrberg (SYKE)

92. HIROMB, member of Steering Committee
93. Boreal Environment Research, editor
94. Geophysica, member of advisory board
95. Estonian Journal of Earth Sciences, member of advisory board
96. Member of PhD Committee, Klaipeda University, Coastal Research and Planning Institute, Mr. Georg Umgiesser
97. Member of the CBO (Conference of Baltic Oceanographers) steering committee
98. Co-ordinator of a Summer School on the Physical Oceanography of the Baltic Sea, Tvärminne, Finland

Ewald Quak (IoC)

99. Vice-chair of the Mathematics-Engineering panel for the evaluation of Marie Curie Industry-Academia Partnerships and Pathways proposals in the EU FP7 People Programme
100. Evaluator of the ComplexityNet call, representing the Estonian Academy of Sciences
101. Member of the Program Committee, FOCUS Workshop on advanced 3D media in gaming and simulation in Amsterdam, The Netherlands
102. Member of the Program Committee, Workshop 3D Physiological Human, Zermatt, Switzerland
103. Contact point Special Interest Group on Geometric Modeling, CAD, Evolving Interfaces and Surfaces of the European Consortium for Mathematics in Industry (ECMI)

Modifications made to policy documents and action plans.

In total three contributions explicitly or implicitly based on the results of the BalticWay project were proposed for policy documents on the national and European level.

1. Contributions based on the outcome of the BalticWay project (especially the importance of fundamental studies into the processes in the seas and oceans) were implicitly included into the Oostende (Ostend) Declaration "The Seas and Oceans are one of the Grand Challenges for the 21st Century" (October 2010) through the input by the European Science Foundation Marine Board.
2. Contribution to the Memorandum for Incoming Members of the European Parliament and Commissioners: Independent advice from the European Academies Science Advisory Council (EASAC).
3. Contribution to the declaration of the Estonian Parliament concerning the environmental impact assessment of the Nord Stream gas pipeline. T. Soomere (IoC) presented the lecture

"Nord Stream in the unique and vulnerable environment of the Baltic Sea", including preliminary results of the BalticWay project, to an extraordinary Plenary Session of the Parliament of Estonia (Riigikogu) and answered questions posed by Members of Parliament (2009).

Suggestions for pertinent public policies and governance

During the entire duration of the BalticWay project, a total of 10 contributions or suggestions were made towards designing, implementing or evaluating the efficacy of pertinent public policies and governance, originating from the work of this project.

2011:

1. Science and policy conference "Building of the Nord Stream pipeline–consequences and potential hazards of the project", European Parliament Conservatives and Reformist's Group, Szczecin, Poland, February 22, 2011: the invited presentation by T. Soomere *Nord Stream as a challenge and mirror for the Baltic Sea marine science* contained several recommendations for the future governance of large-scale interventions into the marine environment.
2. Science and policy conference "Climate, renewable energy and sustainable development: The new geo-energy" organized by the European Patliament Group of Conservatives and Reformists on the premises of the European Parliament (ASP 7 H 1), Brussels, Belgium, June 21, 2011: the invited presentation by T. Soomere, *Marine science in research for alternative energy sources* presented an overview of marine alternative energy sources and suggestions for a potential legal framework for their development.

2010:

3. T. Soomere participated in the discussion of the concept and principles of the new legislation on the use and protection of the marine environment by the Estonian Ministry of Environment and made several suggestions to the concept directly resulting from the BalticWay project and related to the necessity of accounting for the different internal dynamics and patterns of transport in different sea areas, March 30, 2010.
4. *Baltic Conference on Intellectual Cooperation*, November 4–5, Vilnius, Lithuania: T. Soomere was co-author of the oral presention "Science, society and environment: the case of NordStream" presented by Ivar Puura, containing several suggestions based on the results of the BalticWay project.

2009: 6 contributions to the development of the positions of several committees of the Estonian Parliament, the Estonian Ministry of Environment, the Estonian governmental maritime commission, HELCOM and Finnish-Estonian expert panels:

5. Presentation by T. Soomere "Nord Stream: challenges for the Baltic Sea marine sciences" for the joint meeting of the Estonian Parliament Committees on foreign affairs and on environment, including a short overview of the ideas of the BalticWay project, April 6, 2009.
6. Information about the novel concept of protection of valuable sea areas by means of relocating human activities and related suggestions to HELCOM Habitat working group, May 12, 2009.

7. Presentation by T. Soomere “Nord Stream: challenges for the Baltic Sea marine sciences” for the meeting of the Estonian governmental maritime commission, including a short overview of the background and potential outcome of the BalticWay project, May 27, 2009.
8. T. Soomere participated in the official meeting of Estonian experts and official representatives with Finnish representatives and Nord Stream experts, organised by the Finnish Ministry of Environment (Helsinki, Finland), with an explanation of the potential role of anisotropic transport patterns in the Gulf of Finland, based on preliminary results of the BalticWay project, June 25, 2009.
9. T. Soomere presented the lecture “Nord Stream: hard knots of hydrodynamics”, including preliminary results of the BalticWay project, for the joint meeting of the Estonian Parliament’s Environment Committee, Foreign Affairs Committee, and Economic Affairs Committee, October 15, 2009.
10. T. Soomer participated in the official meeting of Estonian experts and official representatives with Finnish representatives, organised by the Finnish Ministry of Environment (Tallinn, Estonia), with comments and explanations partially based on the results of the BalticWay project, October 26, 2009.

Comparison with original research plan

In the first project year the unclear contract and payment situation delayed the start of the project to a certain extent, especially for the Estonian partners IoC and LDI, and for DMI from Denmark. This affected the allocation of existing and the hiring of new personnel as well as the purchase of equipment. Consequently, some of the work undertaken in the first project year did not fully progress as expected.

The delay was mitigated by moving the coordinator's activities from IoC to partner LDI for the year 2009 and by obtaining the acceptance from the Estonian Science Foundation (ESF) to temporarily use some funds from other grants to cover urgent expenses of the project. The necessary measures taken to ensure fulfilling the project goals were agreed with the BONUS Secretariat, described in the Annual Report for the first project year (2009) and further discussed at the BalticWay Annual Meeting in March 2010.

The contractual and financial issues were resolved in the middle of the first project year (2009). Additional staff was hired to ensure a smooth running of the work in 2009 and 2010. The joint efforts of all teams during the second half-year of 2009 and the entire year of 2010 made it possible to complete the majority of activities and plans foreseen for the first two project years.

Due to the delay the work during the first project year was concentrated in the first three work packages. Activities in WP4, WP5 and WP6 only started for full in the second project year. Consequently the timing of the validation experiments in WP5 was changed. An in-depth discussion during the Annual Meeting in March 2010 resulted in several innovative and relatively low-cost solutions for the validation experiments, which actually allowed a much wider scope than originally thought.

An economical technical solution was developed for drifter experiments on the sea surface based on active elements equipped with a GPS and GSM (Soomere et al. 2011g). The purchase of professional active surface drifters (Kjellsson and Döös 2012) and the extensive use of ships of opportunity in the Baltic Proper and small vessels for the experiments in the Gulf of Finland as well as in-kind contributions from the Estonian Border Guard to board drifters that were stuck in Estonian coastal waters altogether made it possible to considerably increase the amount of experiments and to reduce the cost of each single experiment. Consequently the consortium decided to continue with additional validation experiments in the Baltic Proper.

The implemented changes have resulted in a much larger amount of high-quality data. The use of low-cost surface drifters also made it possible to track their drift until very small depths (down to about 1.5 m) and in coastal areas, earlier accessible only by remote sensing. This made it possible to additionally increase the high-quality data stream about local dispersion properties.

Due to the late availability of funds for some partners, also the work in WP6 was carried out to a somewhat lesser extent than originally planned in 2009. The tasks in this WP, however, were largely activities supporting and quantifying the reliability of the results of other WPs. Therefore they were not deemed as critical for the project, and priority was assigned to other WPs in order to make rapid overall progress in those WPs. This policy was successful and substantial progress was obtained in WP6 during the second and third year to make up for the initial delay.

Consequently, while the timing of the activities was indeed changed due to the delayed start, this delay did not affect the work in WP1–4 and WP7, and was mostly resolved during the second project year.

The above changes also affected to some extent the preparation and submission of deliverables. Due to the financing problems involving – among others – the coordinator institution, the launch of Deliverable 8.1 (the Project web portal), originally due in April 2009 (project month 4), was delayed and the web site was set up in a basic version only in July 2009. It was, however, subsequently considerably expanded to provide information about the project, its partners, BONUS as the sponsoring organization, the project research plan, the project activities and events, presentations at conferences as well as annual reports and public deliverables.

Several deliverables (e.g., a test version of Deliverable 2.1 – database of 3D velocity fields) have been released ahead of the schedule. Almost all other deliverables were on time. Moreover, a total of six additional deliverables (already published scientific papers reflecting natural extensions of the original research ideas, with useful output for the entire project), have been added to the pool of results.

Due to the wish of the consortium to provide high-quality output, the nature of several deliverables has been “upgraded” from a technical report to a scientific paper. This of course meant a considerable amount of additional efforts. In agreement with the BONUS EEIG, the deadline of one of these deliverables (D4.3 "The effect of local wind and waves on the areas of reduced risk") was postponed by a few months.

Two data sets, Deliverable 1.1 “Unified pool of initial, boundary and forcing data for the circulation, oil spill, and risk models” and Deliverable 3.1 "Database of trajectories of water particles" grew much larger than originally planned.

Deliverable 1.1 was substantially delayed because of the initial delay of the entire project. Preliminary versions of D1.1 and D3.1 were, however, created in due time and the relevant information made available within the consortium. Wishing to complete the development of the enlarged database D1.1, it was agreed with the BONUS EEIG to postpone the formal submission date to some extent. Doing so made it possible to include into D1.1 the boundary data and results from the high-resolution simulations of the Gulf of Finland as well as the data base of wind wave properties for the entire Baltic Sea.

In order to make the data effectively available for the users, it was decided at the Annual Meeting (2011) to purchase a specialised memory bank. The relevant expenses were made possible because of the much smaller costs of the validation experiments compared to the original plan. Both database deliverables were submitted at the end of the entire project.

Comparison with original financial plan

The amount of overall expenses matches the original financial plan.

Owing to the delay in financing, IoC and LDI applied for a restructuring of their budgets with the central issue being that the coordination costs for the first project year had to be redirected to LDI. The positive response from the BONUS EEIG allowed for a smooth launch of the project and helped in compensating most of delays by the end of the first year.

As the project personnel at IoC, LDI, ICR and DMI only reached full strength in the middle of the first project year and as these teams consequently redistributed their efforts evenly for the remaining 2.5 years, the personnel costs for the first two years were slightly below the foreseen amounts for some partners.

The coordinating partner (IoC) used only about 50% of the foreseen funds during the two first project years. This partially resulted from the structure of the financing of experiments agreed upon. As the distribution of the experiment costs between partners was not known beforehand, the relevant funds were included into the general budget of the coordinator and then distributed between the partners participarting in WP5 according to the actual costs. As no experiments were run in WP5 in the first project year due to the delays in financing, the organisation of the experiments (incl. the corresponding budget for equipment and associated costs for field works) was shifted in time, in part even to the third project year.

As mentioned above, the extensive use of ships of opportunity in the Baltic Proper and of small vessels for the experiments in the Gulf of Finland, and especially the implementation of low-cost surface drifters trackable until very small depths (down to about 1.5 m) and in coastal areas greatly reduced the costs for the entire package of validation experiments and also minimised the necessity for airborne remote measurements. At the same time, the quality, amount and spatio-temporal resolution of the data were much higher than originally planned.

As a consequence it was decided by the project teams to use some of the funds originally foreseen for validation experiments for addional efforts in other work packages. The positive response from the BONUS EEIG to this suggestion made it possible to hire additional personnel (see Appendix 8) for the needs of the project and, finally, to considerably increase the outcome of several WPs (especially WP1 and WP6) compared to the original plan.

Appendix 8. Team composition

1. IoC, Tallinn:
Prof Dr Tarmo Soomere tarmo.soomere@cs.ioc.ee
Dr Ewald Quak ewald.quak@cs.ioc.ee
Dr Mikhail Berezovski (June 01, 2010 – September 16, 2011)
Dr Andrus Räämet andrus.raamet@ttu.ee (from October 1, 2009)
Dr Ira Didenkulova (from March 01, 2011)
Dr Jaan Kalda (April–June and September–November, 2011)
MSc Nicole Delpeche nicole.delpeche@gmail.com
(from June 1, 2009; financed by third sources until October 31, 2009; maternal leave from Sept 2010)
MSc Bert Viikmäe bert@ioc.ee (from July 14, 2009)
MSc Raul Isotamm raul@cens.ioc.ee (July 14 – October 14, 2009)
MSc Mikk Viidebaum mikk@cens.ioc.ee (from February 15, 2010)

PhD and MSc students
Maija Viška (PhD student, from February 01, 2011)
Artem Rodin (PhD student, from May 01, 2011)
Andrea Giudici (MSc student 04 March–13 July 2010, 01–31 January 2011, from 01.02.2012 as a PhD student)
Olga Tribštok (June–August 2010)
Katri Kartau (December 2010 and from May 01, 2011)
Katri Pindsoo (from September 01, 2011)

2. SYKE, Helsinki:
Dr Kai Myrberg kai.myrberg@ymparisto.fi
Dr Oleg Andrejev Oleg.Andrejev@ymparisto.fi

3. MISU, Stockholm:
Prof Kristofer Döös doos@misu.su.se
MSc Joakim Kjellson joakim@misu.su.se
(from September 2009)

4. SMHI, Norrköping
Dr Markus Meier markus.meier@smhi.se
Dr Anders Höglund anders.hoglund@smhi.se

5. DMI, Kopenhagen
Dr Jun She js@dmi.dk
Dr Jens Murawsky jmu@dmi.dk

6. ICR Helmholtz-Zentrum Geesthacht (formerly GKSS)
Prof Dr Emil Stanev emil.stanev@hzg.de
Msc Lu Xi xi.lu@hzg.de (from August 2009)

7. IFM-GEOMAR, Kiel
Dr Andreas Lehmann alehmann@ifm-geomar.de
Dr Klaus Getzlaff kgetzlaff@ifm-geomar.de
MSc Hans-Harald Hinrichsen (as consultant)
hhinrichsen@ifm-geomar.de

8. LDI, Tallinn
Dr Sergey Babitchenko sergeyb@ldi.ee

Appendix 9. Deliverables

Del. no.	Deliverable name	WP no.	Planned and actual nature	Dissemi-nation level	Planned and actual delivery date (project months)	Respon-sible Partner
D1.1	Unified pool of initial, boundary and forcing data for the circulation, oil spill, and risk models	WP1	Database	Public	PM 24 PM 37	ICR
D2.1	Database of three-dimensional (3D) velocity fields	WP2	Database	Public	PM 30 PM 25	SMHI
D3.1	Database of trajectories of water particles	WP3	Database	Public	PM 33 PM 37	MISU
D4.1	Identification of areas of reduced risk from the analysis of trajectories	WP4	Technical Report	Public	PM 30 PM 30	MISU
D4.2	Uncertainties and seasonal and interannual variability of the areas of reduced risk		Technical Report	Public	PM 33 PM 34	IoC
D4.3	The effect of local wind and waves on the areas of reduced risk.		Technical Report	Public	PM 33 PM 37	DMI
D4.4	Areas of reduced risk associated with favourable subsurface current patterns		Technical Report	Public	PM 36 PM 36	SYKE
D5.1	Measurement of current-induced surface drift and its dispersion properties	WP5	Technical Report	Public	PM 36 PM 36	SYKE
D6.1	Mathematical background of the concept of areas of reduced risks	WP6	Scientific Paper	Public	PM 36 PM 36	IoC
D7.1	Development of a simplified prototype for fairway design	WP7	Technical Report	Public	PM 33 PM 33	DMI
D7.2	Implementation plan and estimates of the potential gain from the proposed technology		Technical Report	Public	PM 33 PM 33	ICR
D7.3	Implementation plans for potential applications of the results and description of legal and political aspects		Popular publication	Public	PM 36 PM 36	IoC
D8.1	Project web portal	WP8	Web-based	Public	PM 4 PM 7	IoC
D8.2	Year 1 report		Technical Report	Public	PM 13 PM 13	IoC
D8.3	Year 2 report		Technical Report	Public	PM 25 PM 25	IoC
D8.4	Final report		Technical Report	Public	PM 37 PM 37	IoC
D8.5	Advanced Study School		Training Event	Public	PM 30 PM 33	IoC

Appendix 10. Added deliverables

ID 334: The wave climate and its seasonal variability in the northeastern Baltic Sea, scientific paper by A. Räämet and T. Soomere, *Estonian Journal of Earth Sciences* **59**, 1, 100–113, 2010.

ID 335: Towards identification of areas of reduced risk in the Gulf of Finland, the Baltic Sea, scientific paper by T. Soomere, B. Viikmäe, N. Delpeche, and K. Myrberg, *Proceedings of the Estonian Academy of Sciences* **59**, 2, 156–165, 2010.

ID 336: Temporal scales for transport patterns in the Gulf of Finland, scientific paper by B. Viikmäe, T. Soomere, M. Viidebaum, and M. Berezovski, *Estonian Journal of Engineering* **16** (3), 211–227, 2010.

ID 397: The use of high-resolution bathymetry for circulation modelling in the Gulf of Finland, scientific paper by O. Andrejev, A. Sokolov, T. Soomere, R. Värv, and B. Viikmäe, *Estonian Journal of Engineering* **16** (3), 187–210, 2010.

ID 439: Variations in extreme wave heights and wave directions in the north-eastern Baltic Sea, scientific paper by A. Räämet, T. Soomere, and I. Zaitseva-Pärnaste, *Proceedings of the Estonian Academy of Sciences* **59**, 2, 182–192, 2010.

ID 440: Spatio-temporal variations of wave fields in the Gulf of Finland (title in Russian: О пространственно-временной изменчивости полей волнения Финского залива), scientific paper by T. Soomere, I. Zaitseva-Pärnaste, A. Räämet, and D. Kurennoy, *Фундаментальная и прикладная гидрофизика* (Fundamental and Applied Hydrophysics) **4**(10), 90–101 (in Russian).

Influence of third party results

The discussions about the construction of the Nord Stream pipeline during the beginning phase of the BalticWay project created considerable interest for Baltic Sea matters among politicians and state administrators but also from the general public. This was also reflected by heightened media attention, which provided increased opportunities to inform about the BalticWay project, as well as to get in touch with important stakeholders needed later on for the application in real-life situations of the technology to be developed. This activity was extremely intense in 2009 but continued to some extent also in 2010. This attention made it possible to present preliminary results of the project to a number of meetings with political and public administration stakeholders:

- Presentation by T. Soomere “Nord Stream: challenges for the Baltic Sea marine sciences” for the joint meeting of the Estonian Parliament Committees on foreign affairs and on environment, including a short overview of the ideas of the BalticWay project, April 6, 2009.
- Presentation by T. Soomere “Nord Stream: challenges for the Baltic Sea marine sciences” for the meeting of the Estonian governmental maritime commission, including a short overview of the background and potential outcome of the BalticWay project, May 27, 2009.
- T. Soomere participated in the official meeting of Estonian experts and official representatives with Finnish representatives and Nord Stream experts, organised by the Finnish Ministry of Environment (Helsinki, Finland), with an explanation of the potential role of anisotropic

transport patterns in the Gulf of Finland, based on preliminary results of the BalticWay project, June 25, 2009.

- T. Soomere presented the lecture "Nord Stream: hard knots of hydrodynamics", including preliminary results of the BalticWay project, for the joint meeting of the Estonian Parliament's Environment Committee, Foreign Affairs Committee, and Economic Affairs Committee, October 15, 2009.
- T. Soomere participated in the official meeting of Estonian experts and official representatives with Finnish representatives, organised by the Finnish Ministry of Environment (Tallinn, Estonia), with comments and explanations partially based on the results of the BalticWay project, October 26, 2009.
- T. Soomere presented the lecture "Nord Stream in the unique and vulnerable environment of the Baltic Sea", including preliminary results of the BalticWay project, to an extraordinary Plenary Session of the Parliament of Estonia (Riigikogu) and answered questions posed by Members of Parliament, October 27, 2009.

This all resulted in massive media coverage throughout the project and many invitations to reflect the outcome of the project in popular publications and presentations (see the section on statistics).

During the third year of the project, this attention developed into several invitations to present the results of the project at a more general level and to submit recommendations for changes in the (science) policy, for example:

- T. Soomere participated in the discussion of the concept and principles of the new legislation on the use and protection of the marine environment by the Estonian Ministry of Environment and made several suggestions to the concept directly resulting from the BalticWay project and related to the necessity of accounting for the different internal dynamics and patterns of transport in different sea areas (March 30, 2010).
- *Baltic Conference on Intellectual Cooperation*, November 4–5, 2010, Vilnius, Lithuania: T. Soomere was a co-author of the oral presentation "Science, society and environment: the case of NordStream" presented by Ivar Puura, containing several suggestions based on the results of the BalticWay project.
- T. Soomere was invited to the science and policy conference "Building of the Nord Stream pipeline–consequences and potential hazards of the project", European Parliament Conservatives and Reformist's Group, Szczecin, Poland, February 22, 2011 to present the lecture *Nord Stream as a challenge and mirror for the Baltic Sea marine science* that contained several recommendations for future governance of large-scale interventions into the marine environment.
- T. Soomere was invited to the science and policy conference "Climate, renewable energy and sustainable development: The new geo-energy" organized by the Group of Conservatives and Reformists on the premises of the European Parliament (ASP 7 H 1), Brussels, June 21, 2011 to present the lecture *Marine science in research for alternative energy sources* that contained an overview of marine alternative energy sources and suggestions for a potential legal framework for their development.

Further research and exploitation of the results

The pool of initial and boundary data for wave and circulation models (covering atmospheric forcing, boundary information, river runoff, etc.) together with the output of circulation and wave models is a highly valuable data set in many aspects of ocean modeling. It will be kept open to all partners. The database will be used for follow-up projects and other relevant applications studying the risks of oil spill. Yet the gradually improving atmospheric models and increasing computational power will make it possible to create similar information with much better resolution (e.g., ERA-85 that is currently in progress). Many features of the Baltic Sea wind fields are, however, still not properly represented by existing atmospheric models. This calls for the implementation of new physics into the models and for a proper re-analysis of meteorological forcing in the recent past for the Baltic Sea with a higher resolution. The high-resolution model capacity that was developed during the project activities could be used for other applications, like river plume modelling and riverine pollutant transport studies. This could be an important part of a GMES downstream service. Operational coupled forecasting models for waves and currents are evolving and might be implemented soon. BalticWay has been a step forward in this direction. If continued, the initiative could lead to improved model applications and could also contribute to GMES downstream services.

The database of trajectories calculated off-line (gradually updated by IoC) also has a long-term value. Only a small fraction of its potential for solving different problems of the quantification of environmental risks, for decision support systems and for maritime spatial planning has been exploited so far. This data can be used in a straightforward manner for further analysis and mitigation of anthropogenic pressure based on realistically distributed values of the near shore.

Several outcomes of the risk analysis (e.g., the presence of largely varying gradients in measures of environmental risks in seemingly similar sea areas, or the impact of inflow/outflow conditions on the optimum solution) have important implications for maritime spatial planning and for integrated coastal zone management. Systematic quantification of offshore domains from this point of view is not only highly desirable but has a clear potential to become a standard tool in the relevant decision-making process. The drastic seasonal variation in the location of the reduced risk areas, calculated with realistic met-ocean forcing and oil fate models, suggests that the real gain from the use of optimum solutions may largely exceed the conservative estimates established so far based on climatologically valid solutions.

The experimentally established characteristics of the actual drift regime in the upper layers of the Baltic Sea serve as a key contribution for the improvement of the trajectory models. They are even more important for the development of the next generation scientific and operational circulation models for the Baltic Sea (such as the NEMO model). The data suggests that the dispersion regime in some sub-basins of the Baltic Sea (e.g., the Gulf of Finland) is rather different from that in the Baltic Proper.

The outcomes of the project have also revealed a large number of highly interesting problems in theoretical physical oceanography. The theory of the finite-time compressibility of sea surfaces should be developed further. The potential for gradual generation of sea surface patchiness in small areas hosting high compressibility may reveal some new features of the natural formation of patchiness. It calls for extensive research towards the understanding of its role in the natural variability of different concentration fields on the sea surface.

Although several fit-for-purpose estimates for the applicability and robustness of the proposed approach have been established during the project, there is a clear need for the continuation of the efforts towards rigorous mathematical justification of the entire technology. It is necessary to estimate more precisely the seasonal and inter-annual deviations of the optimum solution from the climatologically valid one. A detailed analysis of the gradients in the 2D fields of quantitative measures of environmental risk is evidently required for implementations of the technique for open ocean coasts.

The ultimate goal is of course to use the technology in a new generation of fairway and ship routing services in the whole Baltic Sea. We think that this is a proper way of integrating marine ecosystem management with other needs of society, and linking scientists, stakeholders and decision-makers in elaborating a scientific base for political decisions. This clearly is a long-time endeavour, especially because of legal and political issues. The work in this direction has been initialized and follow-up actions are forthcoming (the national Estonian project in 2012–2014 and as part of the "The Gulf of Finland Year 2014" managed by SYKE). Another extremely promising direction is to use the proposed technology for tracking the plumes of turbidity created by breaking large-scale internal waves in certain areas of the Baltic Sea (Kurkina et al. 2011; 2012).

The developed technology of approximately solving the inverse problem of pollution propagation using Lagrangian trajectories can be implemented for a much wider range of problems. The described fairway design studies could be extended in a straightforward manner to include drifting objects, marine litter and wastes, which could be harmful for ship traffic (lost containers, drifting boats) or negative for tourism (ship cruises). An important finding of the BalticWay project, namely that the effects of waves on pollutant transport are locally significant, should be extended to studies of other pollutants and marine litter as well. This could also be part of GMES.

Last but not least, a tutorial book on the interdisciplinary approach of the project, planned to be published by Springer Verlag, eventually will summarize the developed technology in a compact way so that it will become portable and transferable to other sea domains.

Background for the statistical information

1. Number of times your project has contributed to consultations carried out by European Commission. (Provide more information in annual and final reports.)

Total: 5 times
2011: 3
2010: 1
2009: 1
See detailed information in the section "Contributions to consultations carried out by European Commission."

2. Number of times the scientists working in your Project have served as members or observers in stakeholder and scientific committees.

Total 2009–2011: 106 activities.
This number is calculated on annual basis; overlapping items are possible.
See details in the section "Participation in stakeholder and scientific committees"
2011: 54
2010: 29 (updated from 26 reported in the Annual Report Year 2)
2009: 23 (updated from 16 reported in the Annual Report Year 1)

3. Number of times the effort of your Project has resulted in modifications made to relevant policy documents and action plans (in particular, Baltic Sea Action Plan).

In total three contributions explicitly or implicitly based on the results of the Baltic Way project were proposed for policy documents on the national and European level. The details of these contributions are presented in the section "Modifications made to policy documents and action plans."

4. Number of suggestions for designing, implementing and evaluating the efficacy of pertinent public policies and governance originating from the work of your Project.

During the BalticWay project, a total of 10 contributions or suggestions were made towards designing, implementing or evaluating the efficacy of pertinent public policies and governance, originating from the work of this project. During the first year six contributions were made whereas both the second and third year resulted in two contributions of this type. The details are presented in the section "Suggestions for pertinent public policies and governance."

5. Number of persons and working days spent by foreign scientists on research vessels participating in the cruises arranged by your Project.

1 person, 1 day
Daniel Gaston (Foreign trainee, postgraduate), University of Navarra – GIS data processing (LDI, 2011).

6. Number of persons and working days spent by foreign scientists using other major facilities involved in your Project.

Total in 2009–2011: 9 persons, 193 days

2011: 5 persons, 184 days

IoC: Oksana Kurkina: total 25 days at IoC; working on internal waves in the Baltic Sea

LDI: Daniel Gaston (Foreign trainee, postgraduate), University of Navarra – GIS data processing: 30 days at LDI

SMHI: 1 person, 9 days: guest scientist Germo Väli (Marine Systems Institute, Tallinn, Estonia) visited SMHI for October 02–10, 2011.

ICR: 2 persons, 2×90=120 days: T. Soomere and M. Viska visited Institute of Coastal Research. The visit was financially supported by the German Alexander von Humboldt Foundation.

2010: 2 persions, 9 days together

IoC: 1 person, 6 working days: Ms Lu Xi (ICR) visited IoC June 20–26 to implement the TRACMASS code for the ICR facilities.

SYKE: 1 person, 3 working days - Dr. Alexander Sokolov has visited SYKE to assist Dr. Oleg Andrejev with the vectorisation of the OAAS model.

7. Number of popular science papers produced by your Project.

Total in 2008–2011: 16 (one before the formal start of the Project in 2008, five in 2009, five in 2010, nine in 2011). See Appendix 4 for details.

8. Number of interviews to media given by members of your Project's consortium.

Total 52 in 2009–2011; mostly for Estonian TV, radio and newspapers but also two interviews for the Finnish leading daily newspaper “Helsingin Sanomat.”
2009: 19
2010: 15
2011: 18

2011:

1. K. Kello. Tervik on suurem kui osade summa (The whole is larger than the sum of the parts; based on interview with T. Soomere). *Õpetajate Leht* (*Teachers Weekly*) 7, p.7, 18.02.2011.
2. K. Kello. Akadeemiline hulkurlus ja ülikoolide edetabel (Academic vagabondism and ranking list of universities; based on interview with T. Soomere). *Õpetajate Leht* (*Teachers Weekly*) 7, p.7, 18.02.2011.
3. TV broadcast about instruments of laser diagnostics developed and used in the Baltic Way team of the Laser Diagnostic Instruments in the series „Püramiidi tipus“ (The top of the pyramid), broadcast by the national TV channel ETV; four times in 2011.
4. TV broadcast about coastal science in the Baltic Way team of the Wave Engineering Laboratory in the series „Püramiidi tipus“ (The top of the pyramid), broadcast by the national TV channel ETV; 16.04.2011; repeated on 17.04 and 20.04; also on 06.11 (ETV2).
5. R. Veskimäe. „Mees nagu mitme tundmatuga võrrand“(The man as an equation with multiple unknowns). In: Põline partituur. Intervjuud akadeemikutega (Interviews with academicians of the Estonian Academy of Sciences). Reves Grupp, Tallinn 2011, 13–29 (in Estonian).
6. Interview with T. Soomere about progress in Estonian marine science and related policy: the role of Estonian marine scientists has considerably increased during the last years. Broadcast twice by Kuku Raadio in Marine Hour, 01.01.2011.
7. Interview with T. Soomere about patterns of climate changes in the Baltic Sea region. Broadcast in news program „Aktuaalne Kaamera“ in the national TV channel ETV, 19.02.2011.
8. Interview with T. Soomere about first news concerning the Sendai (Tohuku) earthquake. Broadcast in radio channel Kuku Raadio at 16:00–16:30, 11.03.2011.
9. Interview with T. Soomere about the major features of the Sendai (Tohuku) earthquake. Broadcast in news program „Aktuaalne Kaamera“ in the national TV channel ETV at 17:00 and 21:00, 11.03.2011.
10. Interview with T. Soomere about the course and consequences of the oil spill at the Gannet Alpha platform in the North Sea. Broadcast in radio channel „Kuku Raadio“, 18.08.2011.
11. M. Filippov. Eksperdid kritiseerivad Nord Streami seirearuannet (Experts comment the Nord Stream monitoring report). *Postimees* (*The Postman*, the leading daily newspaper in Estonia), 226 (6308), p. 6, 29.09.2011.
12. M. Filippov. Nord Streami mõjudest rääkimine tõi auhinna (Talking about impacts of the Nord Stream pipeline brought a distinction). *Postimees*, 250 (6332), 27.10.2011. Also in *Postimees Online* at 14:56, 26.10.2011 and in the morning news of many radio channels on 27.10 2011.
13. Interview with T. Soomere about specific features and impact of autumn storm „Berit“ on 24–28 November in the North Sea and Scandinavia. Broadcast in radio channel Kuku Raadio at 8:15-8:30, 29.11.2011.
14. M. Filippov. Torm Berit üllatas tugevusega mereteadlastki (The Berit storm was surprisingly strong). *Postimees Online* at 16:58, 29.11.2011.
15. M. Filippov. Soomere: Berit oli üllatavalt tugev torm (The Berit storm was surprisingly strong, Soomere says). *Postimees* 279 (6361), p. 7, 30.11.2011.
16. A 1-hour interview with T. Soomere and T. Nõges; Editors of the collection of popular sciences papers "Science in Estonia (VII): Sea. Lakes. Coast" in the broadcast "Kukkuv Õun" of Kuku Raadio about the basic features and messages of this collection, 18.12.2011.

17. Introduction and comments by T. Soomere to the documentary "Earth under water"; broadcast in the national TV channel ETV2 on 18.12.2011 and 21.12.2011.
18. An interview with T. Soomere to the national TV channel ETV about the impact of autumn storm Berit on the coasts of Saaremaa and on the potential reaction of the Estonian sedimentary coasts on changes to wind climate in the Baltic Sea basin; broadcast as a part of news about science within the major news program "Aktuaalne Kaamera" 23.12.2011; repeated as a part of news in several radio channels on 24.12.2011.

2010:

19. The TV channel Kanal 2 broadcast a comment by T. Soomere on the case of issuing the permit to the Nord Stream by Finland (12.02.2010).
20. Anonymous, The pipeline construction phase is the most dangerous, *Postimees Online* 12.02.2010; 23:54 (online version of the daily newspaper The Postman), based on comments of T.Soomere to the TV channel Kanal 2 (12.02.2010).
21. Interview with T. Soomere to the state radio channel „Vikerraadio" in the series „Fellows of the Academy of Sciences" (12.03.2010), broadcast also (17.04.2010).
22. Comment by T. Soomere to Radio Kuku Marine Hour about launching construction of the Nord Stream gas pipeline in the Baltic Sea and about the request of the Nord Stream AG for a permission of environmental monitoring in the Estonian Exclusive Economic Zone (10.04.2010).
23. Interview with T. Soomere in the national TV channel ETV broadcast in the series „2020" dedicated to foresights to the future of the Baltic Sea (18.04.2010).
24. Comment by T. Soomere to Radio Kuku morning broadcast about the state-of-the-art and future of the problems caused by ash clouds stemming from the Islandic volcano eruption (21.04.2010).
25. Heli Saavalainen "Hyökyaalto oli vieda hengen Suomenlahdella" (Fast ferries to Tallinn pose a serious threat to boats and yachts in shallow waters off Helsinki: Surge caused by passing ship nearly kills boater in Gulf of Finland), *Helsingin Sanomat* (*Helsinki News*, the leading daily newspaper on Finland), 09.05.2010, pp. A12–A13): the leading daily newspaper in Finland published a story about ship-wave-induced boat accident in the Gulf of Finland, with an expert comment about the possible reasons by T. Soomere; English version:
    http://www.hs.fi/english/article/Fast+ferries+to+Tallinn+pose+a+serious+threat+to+boats+and+yachts+in+shallow+waters+off+Helsinki/1135256773766
26. Tiina Jõgeda, "High-speed ferries excite killer waves" (Kiirlaevad tekitavad tapvaid laineid), full-page article largely based on the research into ship wakes performed in the Wave Engineering Laboratory, *Eesti Ekspress* (the leading Estonian weekly), 10(1087), 20.05.2010, p. 4).
27. Comment by T. Soomere to Radio Kuku about studies into killer waves performed in the Wave Dynamics Laboratory (20.05.2010).
28. A 'live on air' interview of T. Soomere to TV channel TV3 focusing on the properties of ship waves in Tallinn Bay and their potential for studies into killer waves (20.05.2010).
29. An interview of T. Soomere to the Reporter's Hour, state radio channel Vikerraadio, about the meaning and potential consequences of the oil pollution in the Gulf of Mexico (by phone from Istanbul, 04.06.2010).

30. Interview with T. Soomere about the Alexander von Humboldt Colloquium „The Baltic Sea as a Bridge" was broadcast by the state radio channel Vikerraadio (03.09.2010).
31. Interview with T. Soomere about the key ideas of the Alexander von Humboldt Colloquium „The Baltic Sea as a Bridge" was broadcast twice by Kuku Raadio in Marine Hour (04.09.2010).
32. Interview with I. Didenkulova to TV channel ETV reflecting common features of ship waves in Tallinn Bay and tsunamis (12.09.2010).
33. Ulvar Käärt, The central government should clean up the sea, say Tallinn City officers (Linn haisvast Pirita tee äärest: riik koristagu merest roisukraam), reflects an interview with T. Soomere *Eesti Päevaleht* (*Estonian Daily*), No. 223, 28.09.2010, p. 8, in Estonian).

2009:

34. Interview of T. Soomere to the leading radio channel Kuku Raadio in Estonia about breaking developments in the process of the Environmental Impact Assessment of the planned Nord Stream pipeline in the Baltic Sea, broadcast in Meretund (Marine Hour), February 21.
35. A comment by T. Soomere about topics discussed on the extended meeting of the Commission of Marine Sciences of the Estonian Academy of Sciences, broadcast in the Kuku Raadio Meretund, February 28.
36. Madis Filippov, "The environmental impact assessment of the Nord Stream pipeline ignores specific features of the Baltic Sea", based on an interview with T. Soomere (IoC) about the potential threats of the planned Nord Stream pipeline, including anisotropic current patterns to be considered in the BalticWay project in the Gulf of Finland, *Postimees* (The Postman, the leading Estonian daily newspaper), 57 (5537), March 11, p. 4.
37. A longer comment by T. Soomere about potential risks to Estonia connected with the construction and operation of the planned Nord Stream pipeline and about possibilities of their mitigation, including a short overview of the BalticWay project, Estonian state radio channel Vikerraadio, Huvitaja (a series of popular science broadcasts), March 12.
38. A longer comment by T. Soomere about potential environmental risks to Estonia connected with the planned Nord Stream pipeline, including a short overview of the ideas and potential results of the BalticWay project, Estonian radio channel Kuku Raadio, within a series of popular science broadcasts "Kukkuv Õun", April 12
39. Interview with T. Soomere: Research into the Baltic Sea may teach the entire world. *Mente et Manu* (newspaper of the Estonian University of Technology) 7(1764), April 17, p. 3 and 8(1765), May 8, p. 3.
40. Kristjan Kaljund, Tarmo Soomere and his black box of waves, *Tarkade Klubi* (*The Club of Smarts*, the popular science journal), 4(28), April 2009, 44–47.
41. Madis Filippov, Nord Stream environmental reports are extremely superficial, reflects an interview with T. Soomere, *Postimees* (*The Postman*), June 17, p. 6.
42. A longer comment by T. Soomere about the outcomes of the 7th Baltic Sea Science Congress held in Tallinn on August 17–21, Estonian radio channel Kuku Raadio Meretund (Marine Hour), August 22.
43. Interview with T. Soomere by J. Holvandus. Nord Stream is the challenge for society. *Eesti Kirik* (*Estonian Church*, weekly newspaper of the Estonian Lutheran Church), 33(989), September 9, 2009, 4–5.

44. Comment of T. Soomere in the framework of discussions of the environmental impact assessment of Nord Stream, including preliminary results of the BalticWay project, Estonian national TV program "Aeg luubis" (for extended news and comments), October 25.
45. Madis Filippov, Finland tends to say "yes" to the Nord Stream pipeline, reflects on an interview with T. Soomere, *Postimees*, 247(5727), October 26, p. 6.
46. Comments of T. Soomere on the presentation of the lecture "Nord Stream in the unique and vulnerable environment of the Baltic Sea" (with one of the central arguments based on preliminary results of the BalticWay project) about the Nord Stream environmental impact assessment to the extraordinary Plenary Session of the Parliament of Estonia (Riigikogu), October 27. Broadcast in all Estonian national and private TV channels (TV2, TV3, Russian TV news, etc.), and in radio channels, October 27–28.
47. Phone interview of T. Soomere with comments to the answers of the Nord Stream research team to critics of the environment impact assessment, Estonian national TV channel, "Aktuaalne Kaamera" (main nightly news program), October 28;
48. A citation from the presentation of T. Soomere to the extraordinary Plenary Session of the Parliament of Estonia (27.10.2009) appeared as "the word of the day" of the leading daily newspaper *The Postman* (*Postimees*), 250(5730), 29.10.2009, p. 13.
49. Broadcast of almost the full version of the presentation of T. Soomere (IoC) to the extraordinary Plenary Session of the Parliament of Estonia, Estonian national radio channel, program "Reporteritund" (Reporter's Hour, broadcast twice), October 30.
50. A longer comment by T. Soomere reflecting the basic message of the address given on the occasion of 90th anniversary of the Estonian Marine Academy; broadcast by the Kuku Raadio Meretund (Marine Hour) October 31.
51. K. Kunnas, Tutkija: Vaikutukset on selvitetty heikosti (based on comments of T. Soomere about the environmental impact report of Nord Stream gas pipeline). *Helsingin Sanomat* (the leading daily newspaper on Finland), November 2 (in Finnish).
52. Interview of T. Soomere by phone about co-operation of Estonian and Italian (Venice) scientists in the framework of tsunami studies and about problems connected with climate, December 11.

9. Number of multi-media products and TV episodes produced by your Project with dissemination purposes.

Total in 2009–2011: 2.

1. TV broadcast about instruments of laser diagnostics developed and used in the Baltic Way team of the Laser Diagnostic Instruments in the series „Püramiidi tipus" (The top of the pyramid), broadcast by the national TV channel ETV; four times in 2011.
2. TV broadcast about coastal science in the Baltic Way IoC team (Wave Engineering Laboratory) in the series „Püramiidi tipus" (The top of the pyramid), broadcast by the national TV channel ETV; 16.04.2011; repeated on 17.04 and 20.04; also on 06.11 (ETV2).

10. Number of other dissemination products produced by your Project.

Total 2009–2011: 3

1. LIF sensor presentation for the exhibition at the conference "Broadening the Base of Europe´s Space Community, opportunities and challenges in space field for Estonia, Latvia, Lithuania and Poland (ELLP)", February 1–3, 2012, Tallinn, Estonia.
2. SFS sensor demonstration at 5th EARSeL Workshop on Remote Sensing of the Coastal Zone, Prague, Czech Republic, June 1–3, 2011.
3. Oral presentation at the Workshop "Methods for Oil Spill Evaluation", Instituto Hidrográfico (Lisbon, Portugal), June 29, 2011.

11. Number of times your Project team has issued a recommendation how to improve general public's comprehension and priorities regarding the Baltic Sea.

None in explicit form (cf. #4).

12. Number of times your project has contributed to dissemination products/events addressed to general public concerning coupling between marine environmental quality and human health and well-being.

Total in 2009–2011: 35.

Note that a part of items overlap with activities reported under #8
2009: 10
2010: 13
2011: 12

2011:

1. TV broadcast about instruments of laser diagnostics developed and used in the Baltic Way team of the Laser Diagnostic Instruments in the series „Püramiidi tipus" (The top of the pyramid), broadcast by the national TV channel ETV; four times in 2011
2. TV broadcast about coastal science in the Baltic Way team of the Wave Engineering Laboratory in the series „Püramiidi tipus" (The top of the pyramid), broadcast by the national TV channel ETV; 16.04.2011; repeated on 17.04 and 20.04; also on 06.11 (ETV2).
3. Interview with T. Soomere about progress in Estonian marine science and related policy: the role of Estonian marine scientists has considerably increased during the last years. Broadcast twice by Kuku Raadio in Marine Hour, 01.01.2011.
4. Interview with T. Soomere about patterns of climate changes in the Baltic Sea region. Broadcast in news program „Aktuaalne Kaamera" in the national TV channel ETV, 19.02.2011.
5. Interview with T. Soomere about the course and consequences of the oil spill at the Gannet Alpha platform in the North Sea. Broadcast in radio channel „Kuku Raadio", 18.08.2011.

6. M. Filippov. Eksperdid kritiseerivad Nord Streami seirearuannet (Experts comment the Nord Stream monitoring report). *Postimees* (*The Postman*, the leading daily newspaper in Estonia), 226 (6308), p. 6, 29.09.2011.
7. Interview with T. Soomere about specific features and impact of autumn storm „Berit“ on 24–28 November in the North Sea and Scandinavia. Broadcast in radio channel Kuku Raadio at 8:15-8:30, 29.11.2011.
8. M. Filippov. Torm Berit üllatas tugevusega mereteadlastki (The Berit storm was surprisingly strong). *Postimees Online* at 16:58, 29.11.2011.
9. M. Filippov. Soomere: Berit oli üllatavalt tugev torm (The Berit storm was surprisingly strong, Soomere says). *Postimees* 279 (6361), p. 7, 30.11.2011.
10. A 1-hour interview with T. Soomere and T. Nõges; Editors of the collection of popular sciences papers "Science in Estonia (VII): Sea. Lakes. Coast" in the broadcast "Kukkuv Õun" of Kuku Raadio about the basic features and messages of this collection, 18.12.2011.
11. Introduction and comments by T. Soomere to the documentary "Earth under water"; broadcast in the national TV channel ETV2 on 18.12.2011 and 21.12.2011.
12. An interview with T. Soomere to the national TV channel ETV about the impact of autumn storm Berit on the coasts of Saaremaa and on the potential reaction of the Estonian sedimentary coasts on changes to wind climate in the Baltic Sea basin; broadcast as a part of news about science within the major news program "Aktuaalne Kaamera" 23.12.2011; repeated as a part of news in several radio channels on 24.12.2011.

2010:

13. Anonymous, Scientist from TUT receives the Environmental Deed 2009 (Keskkonnateo tiitel TTÜsse), *Mente et Manu*, No 2(1776), 29.01.2010, p. 1 (in Estonian).
14. Margus Maidla, The scientist riding the ninth wave (Tarmo Soomere, mees üheksanda lainega, interview with T.Soomere), *Kultuuri KesKus* (monthly journal focusing on various aspects of culture), May 2010, p. 48–49 (07.05.2010) (in Estonian).
15. T. Soomere. Nord Stream as a challenge for the society, public lecture to the annual meeting of the Estonian Water Society, February 5, 2010.
16. T. Soomere. Nord Stream as a challenge for the Baltic Sea marine science, public lecture to geography teachers, Tallinn House of Teachers, February 7, 2010.
17. T. Soomere. Towards a future technology of environmental management: the use of properties of currents for minimizing coastal pollution, public lecture to the Institute of Marine and Antarctic Studies (IMAS), University of Tasmania, Hobart, August 17, 2010.
18. T. Soomere. Are regional wave climates changing? Public lecture in the framework of Technical Meeting Series of the Tasmanian Divisions of RINA (Royal Institute of Naval Architects) and IMarEST (Institute of Marine Engineering, Science and Technology), Australian Maritime College, University of Tasmania, Launceston, August 18, 2010.
19. T. Soomere. New aspects of the meaning of extreme waves in maritime engineering design, public lecture to the Australian Maritime College, University of Tasmania, Launceston, August 18, 2010.
20. T. Soomere. The changing wave climate of the Baltic Sea. Invited lecture to the 6th autumn school of young geologists “Schola Geologica – 6”, Roosta, October 8–10, 2010.

21. T. Soomere, Patterns of changes to the regional wave climate. School of Earth and Environmental Sciences, James Cook University, Townsville, Australia, 02 November 2010.
22. T. Soomere, Towards the use of properties of currents for environmental management, with applications to ship-caused pollution, public lecture to the Institute of Marine Engineering, Science and Technology (IMarEST), Queensland Branch, Townsville Marine Museum, Australia, 11 November 2010.
23. T. Soomere, Contribution of fundamental research towards solving challenges of changing times, Oceans Institute, University of Western Australia, Perth, 24 November 2010.
24. T. Soomere, Patterns of changes to the regional wave climate, School of Environmental Systems Engineering, University of Western Australia, Perth, 25 November 2010.
25. E. Quak, The Baltic Way project: The potential of currents for environmental management of the Baltic Sea. Universität Ulm, Germany, 17 December, 2010.

2009:

26. Interview of T. Soomere to the leading radio channel Kuku Raadio in Estonia about breaking developments in the process of the Environmental Impact Assessment of the planned Nord Stream pipeline in the Baltic Sea, broadcast in Meretund (Marine Hour), February 21, 2009.
27. Madis Filippov, The environmental impact assessment of the Nord Stream pipeline ignores the specific features of the Baltic Sea, based on the interview with T. Soomere, Postimees, 57 (5537), March 11, p. 4, 2009.
28. A longer comment by T. Soomere about potential risks to Estonia connected with the construction and operation of the planned Nord Stream pipeline and about possibilities of their mitigation, including a short overview of the BalticWay project, Estonian state radio channel Vikerraadio, Huvitaja (a series of popular science broadcasts), March 12, 2009.
29. A longer comment by T. Soomere about potential environmental risks to Estonia connected with the planned Nord Stream pipeline, including a short overview of the ideas and potential results of the BalticWay project, Estonian radio channel Kuku Raadio, within a series of popular science broadcasts "Kukkuv Õun", April 12, 2009.
30. Madis Filippov, Nord Stream environmental reports are extremely superficial, reflects an interview with T. Soomere, *Postimees* (*The Postman*), June 17, p. 6, 2009.
31. Comment of T. Soomere in the framework of discussions of the environmental impact assessment of Nord Stream, including preliminary results of the BalticWay project, Estonian national TV program “Aeg luubis” (for extended news and comments), October 25, 2009.
32. Madis Filippov, Finland tends to say “yes” to the Nord Stream pipeline, reflects on an interview with T. Soomere, *Postimees*, 247(5727), October 26, p. 6, 2009.
33. Broadcast of almost the full version of the presentation of T. Soomere to the extraordinary Plenary Session of the Parliament of Estonia, Estonian national radio channel, program “Reporteritund” (Reporter’s Hour, broadcast twice), October 30, 2009.

34. A longer comment by T. Soomere reflecting the basic message of the address given on the occasion of the 90th anniversary of the Estonian Marine Academy; broadcast by the Kuku Raadio Meretund (Marine Hour), October 31, 2009.
35. Kaja Kunnas, Tutkija: Vaikutukset on selvitetty heikosti (based on comments of T. Soomere about the environmental impact report of Nord Stream gas pipeline). *Helsingin Sanomat* (the leading daily newspaper ion Finland), November 2 (in Finnish), 2009.

13. Number of datasets your project has delivered to the common metadata base of the Programme.

Total in 2009–2011: 5

2011: 2
Metadata reflecting Deliverable 1.1
Metadata reflecting Delivarable 3.1

2010: none

2009:
SMHI: 3 datasets

14. Number of scientists that attended international workshops, WG meetings, conferences, intercalibration exercises, etc. paid by BONUS+

Total in 2009–2011: 121 cases

2011: Total 61 cases (23 persons)
2010: Total 42 cases (17 persons)
2009: Total 18 cases, 8 persons

2011: total 61 cases (23 persons)
IoC: 35 times (12 persons)

Katri Kartau	Germany, Geesthacht	2011-02-01	2011-02-03
Maija Viška	Germany, Geesthacht	2011-02-01	2011-02-03
Tarmo Soomere	Germany, Geesthacht	2011-02-01	2011-02-03
Tarmo Soomere	Poland, Szczecin	2011-02-21	2011-02-23
Bert Viikmäe	Germany, Potsdam	2011-03-15	2011-03-18
Tarmo Soomere	Russia, St. Petersburg	2011-03-21	2011-03-24
Tarmo Soomere	Italy, Palermo	2011-04-06	2011-04-14
Andrea Giudici	Italy, Palermo	2011-04-09	2011-04-13
Ewald Quak	Italy, Palermo	2011-04-09	2011-04-14

Bert Viikmäe	Italy, Palermo	2011-04-10	2011-04-13
Mikk Viidebaum	Italy, Palermo	2011-04-10	2011-04-13
Andrus Räämet	Poland, Szczecin	2011-05-09	2011-05-14
Bert Viikmäe	Poland, Szczecin	2011-05-09	2011-05-14
Maija Viška	Poland, Szczecin	2011-05-09	2011-05-15
Tarmo Soomere	Poland, Szczecin	2011-05-11	2011-05-15
Bert Viikmäe	China, Qingdao	2011-06-04	2011-06-10
Tarmo Soomere	Finland, Helsinki ...	2011-06-15	2011-06-16
Maija Viška	Germany, Geesthacht	2011-06-17	2011-09-20
Tarmo Soomere	Germany, Geesthacht	2011-06-18	2011-08-20
Artem Rodin	Finland, Helsinki	2011-06-20	2011-06-20
Andrea Giudici	Russia, St.Petersburg	2011-08-21	2011-08-26
Bert Viikmäe	Russia, St.Petersburg	2011-08-21	2011-08-27
Tarmo Soomere	Russia, St.Petersburg	2011-08-21	2011-09-21
Andrus Räämet	Russia, St.Petersburg	2011-08-22	2011-08-26
Artem Rodin	Russia, St. Petersburg	2011-08-22	2011-08-26
Andrea Giudici	Austria, Salzburg	2011-09-04	2011-09-09
Andrea Giudici	Lithuania, Klaipeda	2011-09-17	2011-09-21
Artem Rodin	Lithuania, Klaipeda	2011-09-17	2011-09-21
Bert Viikmäe	Lithuania, Klaipeda	2011-09-17	2011-09-21
Ewald Quak	Lithuania, Klaipeda	2011-09-17	2011-09-20
Katri Pindsoo	Lithuania, Klaipeda	2011-09-17	2011-09-21
Mikk Viidebaum	Lithuania, Klaipeda	2011-09-17	2011-09-20
Tomas Torsvik	Lithuania, Klaipeda	2011-09-17	2011-09-20
Tarmo Soomere	Poland, Gdansk + Hamburg, Germany	2011-10-23	2011-10-28
Rain Männikus	Finland, Helsinki	2011-11-07	2011-11-07

SMHI: 10 cases (5 persons)

Robinson Hordoir	Stockholm	2011-02-11	
Markus Meier	Italy, Palermo	2011-04-10	2011-04-13
Anders Höglund	Italy, Palermo	2011-04-10	2011-04-13
Markus Meier	Russia, St. Petersburg	2011-08-21	2011-08-26
Anders Höglund	Russia, St. Petersburg	2011-08-21	2011-08-26
Ivan Kuznetsov	Stockholm	2011-09-20	

Markus Meier	Stockholm	2011-09-20	
Markus Meier	Poland, Gdansk	2011-10-23	2011-10-26
Christian Dietrich	Germany,Hamburg	2011-11-15	2011-11-19
Anders Höglund	Stockholm	2011-11-29	

MISU: 8 cases (3 persons)

Kristofer Döös	Italy, Palermo	2011-04-10	2011-04-13
Joakim Kjellsson	Italy, Palermo	2011-04-10	2011-04-13
Kristofer Döös	Latvia, Riga	2011-06-09	2011-06-11
Peter Lundberg	Latvia, Riga	2011-06-09	2011-06-1
Kristofer Döös	Latvia, Riga	2011-08-10	2011-08-12
Kristofer Döös	Russia, St. Petersburg	2011-08-21	2011-08-25
Joakim Kjellsson	Russia, St. Petersburg	2011-08-21	2011-08-25
Kristofer Döös	Lithuania, Klaipeda	2011-09-18	2011-09-20

LDI: 1 case
DMI: 2 cases (J. Murawski, presentations at BSSC2011 and the BalticWay summer school in Klaipeda)
ICR reports 5 cases

2010: Total 42 cases (17 persons)

IoC: 25 cases, 9 persons

Tarmo Soomere	Lithuania, Vilnius	2010-01-18	2010-01-21
Bert Viikmäe	Lithuania, Vilnius	2010-01-19	2010-01-21
Tarmo Soomere	Finland, Helsinki	2010-02-08	2010-02-09
Nicole Delpeche	Cyprus	2010-03-15	2010-03-22
Bert Viikmäe	Cyprus	2010-03-16	2010-03-22
Tarmo Soomere	Cyprus	2010-03-16	2010-03-22
Ewald Quak	Cyprus	2010-03-18	2010-03-21
Tarmo Soomere	Turkey, Istanbul	2010-04-20	2010-04-24
Bert Viikmäe	The Netherlands, Delft	2010-05-09	2010-05-13
Tarmo Soomere	Belgium, Brussels	2010-05-10	2010-05-11
Tarmo Soomere	Turkey, Istanbul	2010-06-01	2010-06-05
Tarmo Soomere	Finland, Helsinki	2010-06-08	2010-06-09
Andrus Räämet	Poland, Miedzyzdroje	2010-06-13	2010-06-18
Bert Viikmäe	Poland, Miedzyzdroje	2010-06-13	2010-06-19

Tarmo Soomere	Australia, Townsville, Hobart	2010-06-24	2010-08-22
Andrea Giudici	Russia, Baltiysk	2010-06-26	2010-07-01
Ewald Quak	Ukraina, Kyiv	2010-08-04	2010-08-08
Anna Terentjeva	Russia, Sankt Peterburg	2010-08-22	2010-08-29
Olga Tribštok	Russia, Sankt Peterburg	2010-08-22	2010-08-29
Bert Viikmäe	Russia, Sankt Peterburg	2010-08-23	2010-08-29
Tarmo Soomere	Russia, Sankt Peterburg	2010-08-23	2010-08-29
Bert Viikmäe	Lithuania, Palanga	2010-10-05	2010-10-09
Katri Kartau	Lithuania, Palanga	2010-10-05	2010-10-08
Mikk Viidebaum	Lithuania, Palanga	2010-10-05	2010-10-09
Tarmo Soomere	Belgium, Oostende + Australia	2010-10-12	2010-12-10

SMHI: 1 case, 1 person (Markus Meier to visit SYKE, 24 May 2010)

LDI: 1 case, 1 person (presentations in Australia, part of costs)

SYKE: 9 cases (2 persons)
March 2010 Kai Myrberg and Oleg Andrejev, BalticWay Annual meeting, Cyprus, 4 days
June 2010 Kai Myrberg and Oleg Andrejev, BALTEX workshop Poland, 4 days
June 2010, Oleg Andrejev, workshop in IoC, 2 days
October 2010 Kai Myrberg, negotiations with A Lehmann, Kiel, 5 days
November 2010 Oleg Andrejev, St.Petersburg, consultations with Russian colleagues, 2 days
November 2010 Kai Myrberg, Stockholm, consultations with A. Sokolov
December 2010 Kai Myrberg, Stockholm, consultations with A. Sokolov

MISU: 6 cases (4 persons)

Kristofer Döös	Cyprus	2010-03-17	2010-03-21
Joakim Kjellsson	Italy, Palermo	2010-03-17	2010-03-21
Kristofer Döös	Latvia, Riga	2010-07-14	2010-07-16
Anders Engqvist	Latvia, Riga	2010-07-14	2010-07-16
Kristofer Döös	Latvia, Riga	2010-08-17	2010-08-19
Joakim Kjellsson	Latvia, Riga	2010-08-17	2010-08-19

2009: Total 18 cases, 8 persons

IoC: Total in 2009: 14 cases (4 persons)

Ewald Quak	Finland, Helsinki	2009-01-12	2009-01-14
Tarmo Soomere	Finland, Helsinki	2009-01-12	2009-01-15
Ewald Quak	Sweden, Stockholm	2009-03-05	2009-03-07

Tarmo Soomere	Sweden, Stockholm	2009-03-05	2009-03-06
Tarmo Soomere	Finland, Kotka, Tvärminne	2009-05-11	2009-05-15
Tarmo Soomere	Italy, Rome	2009-05-16	2009-05-21
Nicole Delpeche	Sweden, Stockholm	2009-05-28	2009-05-29
Tarmo Soomere	Finland, Helsinki	2009-06-15	2009-06-16
Tarmo Soomere	Finland, Helsinki	2009-06-25	2009-06-25
Bert Viikmäe	Sweden, Sigtuna	2009-11-16	2009-11-17
Nicole Delpeche	Sweden, Sigtuna	2009-11-16	2009-11-17
Tarmo Soomere	Sweden, Sigtuna	2009-11-16	2009-11-17
Nicole Delpeche	Finland, Helsinki	2009-12-01	2009-12-01
Tarmo Soomere	Helsinki	2009-12-03	2009-12-03

SYKE: 2 persons: participation in ICES ASC 2009, BSSC 2009

IFM-GEOMAR: 2 persons

15. Number of PhD courses (above) organized by your Project and persons participating (below).

1 event in 2011: international summer school in Klaipeda, Lithuania; 45 trainees; total number of participants 56.

1 event in 2009: TRACMASS training event in Tallinn; 7 participants

16. Number of modifications made to current PhD course programmes that resulted from the work of your Project.

None

17. Number of student visits (persons above, visit days below) from your Project to other BONUS projects.

None

Use of infrastructure

2011:

IFM-GEOMAR:
Supercomputer facilities NEC-SX9 CAU Kiel, Germany
Purpose: BSIOM-model simulations, Drift-model simulations:
CPU hours: 32,000
In-kind contribution: 177,000€

SMHI:
Supercomputer facilities and disk space for data storage
Purpose: Simulation of oil spill with Eulerian tracers in the RCO model
Amount of use: 580,000 CPU hours
In-kind contribution: 50,000 €

LDI:
Lidar system
Purpose: Remote measurements of dissolved organic matter and surface pollution in sea water
Amount of use: 10 hours (test regime)
In-kind contribution (approximate) 2,000 €

MISU:
Supercomputer at the Swedish National Supercomputer Centre NSC, Linköping University (Gimle, Vagn, Tornado) and at the Centre for High Performance Computing PDC, Royal Institute of Technology, Stockholm (Ekman).

IoC:
Cluster of 98 Opteron CPU
Pur*p*ose: Performing calculation of Lagrangian trajectories with the use of the TRACMASS code, intermediate storage of trajectory data
Amount of use: 5,000 CPU hours
In-kind contribution (approximate): 2,500 €

2010:

SMHI:
Supercomputer facilities and disk space for data storage
Purpose: Production and storage of forcing data sets and RCO model
simulations (cpu time, disk and tape storage).
Amount of use: 600,000 CPU hours
In-kind contribution: 50,000 €

IoC:
Cluster of 98 Opteron CPU

Purpose: Performing calculation of Lagrangian trajectories with the use of the TRACMASS code, intermediate storage of trajectory data
Amount of use: 5,000 CPU hours
In-kind contribution (approximate): 2,500 €
3-D Graphics Workstation
Purpose: Three-dimensional visualisation of simulation results
Amount of use: 200 working hours
In-kind contribution (approximate) 2,000 €

LDI:
Lidar system
Purpose: Remote measurements of dissolved organic matter and surface pollution in sea water
Amount of use: 20 hours (test regime) + 20 hours (measurements in the Gulf of Finland)
In-kind contribution (approximate) 10,000 €

2009:

IFM-GEOMAR:
HPC facilities at Kiel University, NEC SX9
Purpose: performing of model runs of the general circulation model of the Baltic Sea, running Lagrangian drift tracking model
Amout of use: 240 CPU hours
Approximate costs as in-kind contribution: 2,000 €

SMHI:
Supercomputer at the Swedish National Supercomputer Centre NSC, Linköping University (Gimle, Vagn, Tornado) and at the Centre for High Performance Computing PDC, Royal Institute of Technology, Stockholm (Ekman).
Purpose: Production and storage of forcing data sets and RCO model simulations (cpu time, disk and tape storage).
Amount of use: 1,100,000 CPU hours
In-kind contribution: 100,000 EUR.

The climate computing resources Tornado, Ekman and Vagn are funded by grants from the Knut and Alice Wallenberg foundation

IoC:
Cluster of 98 Opteron CPU
Purpose: Performing calculation of Lagrangian trajectories with the use of the TRACMASS code, intermediate storage of trajectory data
Amount of use: 10,000 CPU hours
In-kind contribution (approximate): 5,000 €