COASTAL & MARINE

# Systems Approach Framework - Baltic Sea Application

Volume 27 • No. 1 2018

# Editorial

Dear Reader,
There is a growing trend to include stakeholders from early on in the decision making process within coastal planning and development to enhance transparency and increase citizen support for management decisions. Developments within Integrated Coastal Management (ICM) involve the process of including evidence-based advice in management decisions. However, how often do these decisions reflect integration of knowledge from natural, economic and social sciences? How much does science actually matter in the political process and decision-making? How and when are the stakeholders engaged? Does stakeholder engagement influence decision/policy making? If "integration" and "stakeholder engagement" are not just to be buzzwords, there is a need for a systematic framework to guide ICM processes to ensure sustainability, equity and fairness of solution. The Systems Approach Framework does just that by providing a step-wise approach from the early phase of identifying the problem(s) through scenario evaluation onto the final phase of implementation, monitoring and evaluation. This volume of Coastal and Marine explains what the SAF is and what it entails and presents the results of several applications of the SAF to coastal case studies in the Baltic Sea Region as carried out within the BONUS BaltCoast project.

Josianne G. Støttrup and Grete E. Dinesen
Technical University of Denmark

## Coastal & Marine Union (EUCC)

The Coastal & Marine Union is dedicated to conserving and maintaining healthy seas and attractive coasts for both people and nature.
EUCC advocates best practice by developing coastal and marine policies, mobilising experts and stakeholders, providing advice and information, and implementing demonstration projects.

**Membership dues for 2018**
€ 48 (€ 80 / 3 years) for Student and Private Members;
€ 65 (€ 120 / 3 years) for Professional Members and Non-profit NGOs;
€ 300 (€ 500 / 3 years) for Full Member Organisations;
€ 1000 for Communication Partners;
€ 2000 for Programme Partners.
All EUCC members are entitled to a free subscription to 'Coastal&MarinE-News' and our e-letters in Dutch, French, German and Spanish.
For info: www.eucc.net.

**EUCC Coastal & Marine Magazine**
Coastal & Marine is free for EUCC members (except Friends of the Coast).
Conferences and meetings are listed on
www.eucc-d.de/events-conferences.html

**Coastal & Marine Union (EUCC)**
P.O.Box 11232, NL-2301 EE Leiden
Telephone: +31.71.5143719
E-mail: admin@eucc.net, www.eucc.net
Visiting address: Rapenburg 8, 2311 EV Leiden, NL

# Content



## Colophon

**EUCC's magazine 'Coastal & Marine' Special 'Systems Approach Framework – Baltic Sea Application' (volume 2018-1)** , ISSN 1877-7953


**Editors:** Josianne G. Støttrup and Grete E. Dinesen
**Design & Layout:** Tom Will, Germany

Opinions expressed in Coastal & Marine do not necessarily reflect the official views of EUCC.

**Cover photo:** © Ulrike Retzlaff
**Photo cover inserts:** © Katja Hanoldt, © Melanie Rixen, © Anna-Helena Purre
**Back page photo:** © Marco Rank,© Mirko Boy, © Alexander Ritter

**Thanks for support are expressed to:** *Jane Hofmann, Svenja Karstens, Johanna Schumacher, Franziska Stoll, Nardine Stybel and all contributing authors and photographers.*

The pictures on the following pages are contributions to the BONUS BaltCoast photo competition "Me and my Baltic Coast": p. 12-13, top; p. 16

Sole responsibility of this publication lies with the authors, the Commission is not responsible for any use that may be made of the information herein.

*BONUS BALTCOAST project has received funding from BONUS (Art 185), funded jointly by the EU and Baltic Sea national funding institutions.*


## Applying the SAF to the Baltic Sea region

With nine countries having shorelines along the Baltic Sea, and more than 85 million people living around this semi-enclosed inland sea, decision makers are faced with the challenge to resolve complex issues such as environmental protection, sustainable growth and social and cultural uses. The challenge is compounded by the fact that the Baltic Sea is one of the most intensively used seas and most decisions on space allocation, sector development or species protection, are made on a one-sector/single-species basis. Thus, the need for a holistic approach to planning ensuring an optimal balance of resource use and protection.

The Systems Approach Framework (SAF) was tested in six study sites in six Baltic Sea countries within the BONUS BaltCoast project. The aim was to

- Test the SAF at different levels of complexity and for various multiple issues
- Demonstrate its value and applicability
- Aid in the further development of the SAF by providing valuable feedback for improvement of a SAF Handbook
- Deliver knowledge and transferable solutions for highly relevant ICM issues.

**The case studies**

***Eco-technologies & eutrophication in the Szczecin (Oder) Lagoon, Germany/Poland***

The Szczecin (Oder) Lagoon is ecologically, economically and socially important supporting fisheries, tourism and recreation as well as valuable species and habitats. However, as a recipient for several large German and Polish rivers it has a high nutrient load. With the SAF, the study site team were able to address the challenge to integrate knowledge and provide a suitable platform for discussion with stakeholders using scenario simulations of spatial uses and socio-economic consequences of potential management options.

***Shipping and economic development in the Vistula Lagoon***

The Vistula Lagoon is shared by Poland and Russia and the only connection to the Baltic Sea is in the Russian part. Following the transition to market economy, the Polish part became isolated leading to economic decline. The SAF was applied to explore the ecological, social and economic potential using an integrated approach.

***Bathing water quality and tourism in Curonian lagoon and coastal Lithuania***

Curonian spit is a highly popular tourist destination, but has a short bathing season due to the water temperatures in the Baltic Sea. To broaden the bathing season and increase tourism without compromising the identity of the area, the suggestion to open a beach on the lagoon side was explored using the SAF to guide an integrated holistic approach with the inclusion of stakeholders.

***Coastal protection management Pärnu Bay, Estonia***

Situated in the NE corner of the gulf, Pärnu Bay is exposed to winds, waves and storm surges that negatively affect the low-lying city of Pärnu. With the SAF, several options for protection or adaptation measures were explored in an integrated manner and in dialogue with stakeholders. The results showed the main concerns of the citizens and choices of measures to ensure livelihood as well as the safety of citizens.

***Fish distribution and productivity in inner Danish waters, Denmark***

Severe declines in the coastal fisheries, due to decreases in the occurrence of fish in coastal waters, has affected coastal communities both economically and socially. With implementation of the SAF stakeholders were engaged and the nature and causes for these changes were identified. The issue was complicated and required several modeling approaches, including spatial modeling that prolonged the Formulation step.
More detailed descriptions of the SAF processes in the individual case studies are given in the following pages. Enjoy reading!

Josianne G. Støttrup and Grete E. Dinesen
Technical University of Denmark


## An introduction to the Systems Approach Framework

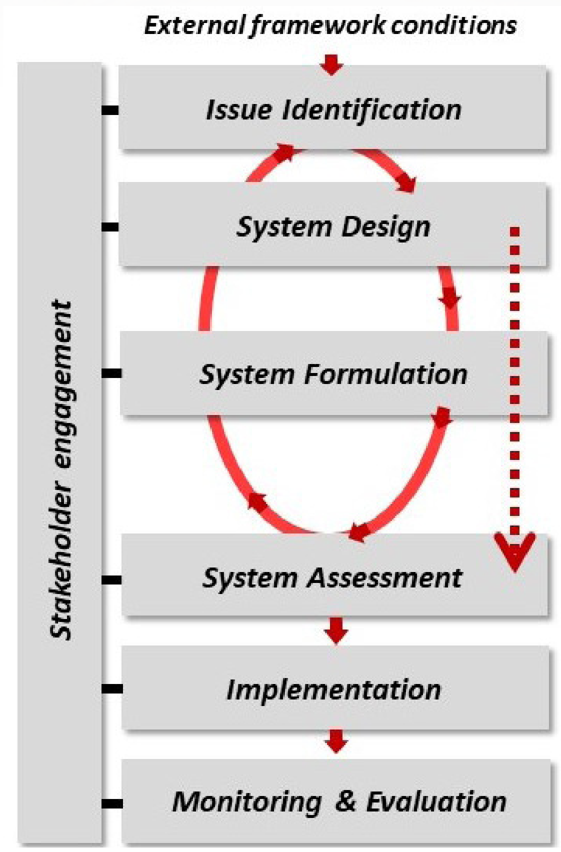
The Systems Approach Framework (SAF) is based on systems theory, which is an interdisciplinary study of systems and is the process of understanding how things influence one another within a whole.

The SAF provides a structured guideline for integrating science into decision making in coastal management processes. It enables managers and policy makers, in collaboration with stakeholders and scientists, to manage the use of coastal systems in a manner that is ecologically sustainable, economically efficient and provides social equity. The latter implies fair and equal access to resources, active participation in political and cultural life, and safeguarding of human rights of all citizens.

In today's world, implementation of international directives and regulations result in changes in human activities. Changes in human activities can also occur due to external forcings, such as economic crises or natural disasters. Irrespective of the drivers for change in human activities, these cause changes of the pressures on the system and may need new regulations to abate negative consequences.
Without an informed process, decisions may give rise to new and unforeseen conflicts. The SAF facilitates science-policy integration as well as results in changes in user relationships, public perception and awareness and increases social capital.

The SAF was developed under the SPICOSA project (EU 6th FP, 2008-2013) and further developed under the BONUS BaltCoast project (2015-2018). The Integrated Coastal Management (ICM) process using SAF requires teamwork with collaboration among policy makers, managers, stakeholders and scientists from different disciplines. Any complex ICM problems with multiple interconnected elements, having high priority and requiring acquisition and integration of information would benefit from the structured guidelines of the SAF. The Ecological-Social-Economic (ESE) assessment ensures that the three pillars of sustainability are evaluated in an integrated, and where possible, quantitative manner.

The SAF comprises six steps: Issue Identification, System Design, System Formulation, System Assessment, Implementation and Monitoring and Evaluation in all of which stakeholders are engaged. Each is briefly described below and further details can be obtained from the BONUS BaltCoast website (www.baltcoast.net).




*The steps of the System Approach Framework within BONUS BaltCoast.*

**Issue Identification**

When a problem is recognised, the SAF is initiated by forming a team of managers and scientists responsible for the process. The process begins with the Issue Identification step. Tasks included listing human activities and mapping ecosystem services, institutions and stakeholders. The stakeholders are invited to an initial meeting where they, together with the SAF team, list and prioritise issues of concern and identify the main issue(s). Relevant environmental, social and economic components and their dependencies are described using the DPSIR and CATWOE tools. Furthermore, stakeholder preferences for future development can be assessed using the Stakeholder Preference Tool.


**System Design**

In this step, the SAF team develops a conceptual model dealing with the issue. The conceptual model is a diagram with graphical symbols and connectors showing the states, processes and key forcings for each of the ESE components. It displays how the real system is perceived to be interconnected and functioning. With a conceptual model at hand, data availability and modelling resources are assessed with the aim of formulating an ESE model.

IF sufficient data is available administrative and virtual system boundaries can be defined and ESE linkages and external hazards identified. At this point, success criteria and indicators need to be identified and system state assessed based on indicators of ecosystem services and sustainability. Potential scenarios and management options are discussed with stakeholders in preparation for the Formulation step. If no data is available new information can be procured. If the new data is sufficient for ESE modelling the above tasks can be carried out. If not, potential scenarios are discussed and selected with stakeholders based on qualitative information and expert opinion and the SAF team can progress directly to the System Assessment step.

**System Formulation**

Data input is assembled for all variables and equations are formulated for each ESE model component and auxiliary models. The model is tested and calibrated and validated using hindcast simulations. During this process stakeholders are consulted to assess whether model components reflect their real world and, where needed, integrate their knowledge to consolidate the model. The ESE model components are then linked into a system model whereupon sensitivity testing is carried out and the full ESE model validated. The scenarios can then be simulated and prepared for deliberation.

**System Assessment**

Scenario results visualising consequences of the different management options are presented to and discussed with stakeholders. Discussions should reflect potential system impacts and consequences of management options, including contribution to sustainability and effects on ecosystem services. At this point, stakeholder preferences can be revisited to assess if and how they have changed throughout the SAF application.

**Implementation**

This is critical step for the completion of the SAF with the implementation of the selected management options. The legal, administrative and financial requirements are important elements for the implementation and need to be in place within a short timeframe. Mitigation measures need to be identified in consultation with stakeholders to reduce offset or eliminate negative impacts of the plans. Regular information to the public is required to ensure citizens are being heard and taken seriously. Validation of the ICM process ensures accountability and averts consultation fatigue. It provides the stakeholders an opportunity to observe how their input has influenced the decision and how the decision has been implemented.

**Monitoring and Evaluation**

A monitoring programme should be designed based on predefined success criteria for ecosystem goods and services and sustainability targets. Monitoring intensity and duration needs to be adapted to provide adequate basis for the evaluation and to inform the public of the progress.

Josianne G. Støttrup, Grete E. Dinesen, Johanna Schumacher,
Christine Gillgren, Gerald Schernewski
Technical University of Denmark
Leibniz Institute for Baltic Sea Research Warnemünde, Germany
Gillgren and Associates, Australia

## Eco-technologies & eutrophication in the Szczecin (Oder) Lagoon, Germany/Poland

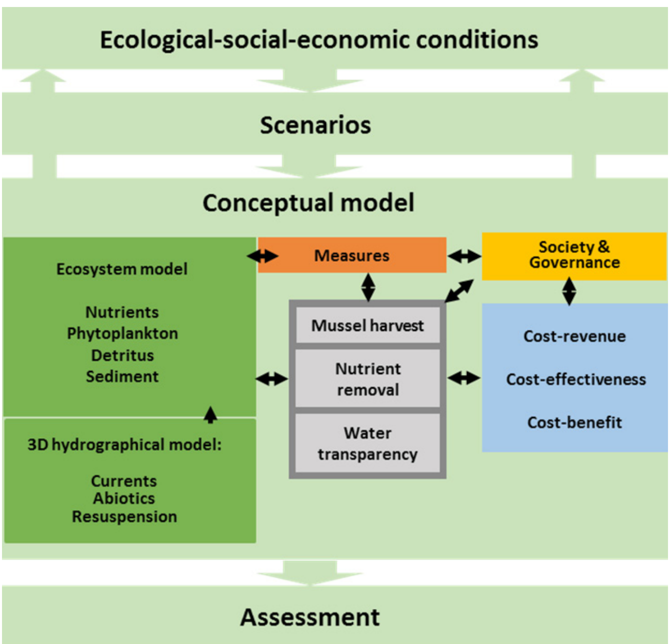
Szczecin Lagoon with its central parts, the Great Lagoon (Polish territory) and Small Lagoon (mainly on German side), is one of the most important coastal lagoons for fisheries, tourism and recreation in the Baltic Sea. It plays an important ecological role, supporting valuable species and habitats and is part of several European conservation-orientated programs, like Natura2000. At the same time, it is heavily polluted by nutrients, brought into the system over the last century.

High nutrient loads especially in the second part of the 20th century led to impoverished water quality characterised by a low Secchi Depth and the decline of submerged macrophytes.
Subsequent management plans including the catchment were (and are) developed and implemented, accompanied by the demands and nutrient load reduction targets defined by the EU Water Framework Directive (WFD) or the HELCOM Baltic Sea Action Plan. Within the project SPICOSA, a first SAF cycle including an enlarged DPSIR-application took place, addressing the need of an integrated management of the lagoon and its catchment to improve the water quality. Since the absolute peak of nutrient loads at the end of 1980s, the nutrient loads were reduced by up to 70% (TP), resp. 30% (TN). This was accompanied by a water quality improvement in the eastern part, while in Small Lagoon nearly no improving trend is visible.

Within the project BONUS BaltCoast, a revised SAF cycle was conducted, focusing not only on measures to improve the water quality in the western part of Szczecin Lagoon, but also on the question how the region can contribute to the "Blue Growth" strategy. The latter addresses the increased anthropogenic demand of food, feed and recreation supplied by coastal waters. For instance, mussel farms can be used as mitigation measure that combines nutrient retention with a non-interfering aquaculture of the naturally occurring Zebra mussel (*Dreissena polymorpha*).

The first and second SAF application were accompanied by a widely spread group of stakeholders, ranging from local stakeholders, like the mayor of Ueckermünde or the local fishery cooperative, to regional authorities or organisations, like the Tourism Association Vorpommern. We conducted between 2013 and 2017 three workshops. From the first two workshops we learned that: (i) there is a strong wish to boost the regional sustainable development; (ii) many stakeholders were open for the idea to implement supportive measures to achieve an improved water quality, but were afraid that mussel farms could have larger impacts on the flora and fauna, especially the main commercial fish species (e.g. zander or pikeperch, both preferring turbid waters) and; (iii) abstract discussion like "mussel farms – yes or no" or "do you prefer small scale mussel farms nearshore or larger ones offshore" are hardly productive.

Acknowledging the need for detailed scenarios addressing most of the key issues of the stakeholder group, we developed a tailor-made conceptual model, which was the backbone for the ESE assessment and the third stakeholder workshop. The conceptual model combines the framework conditions with an ecological, economic and a social mode.




*Conceptual model for the case study*

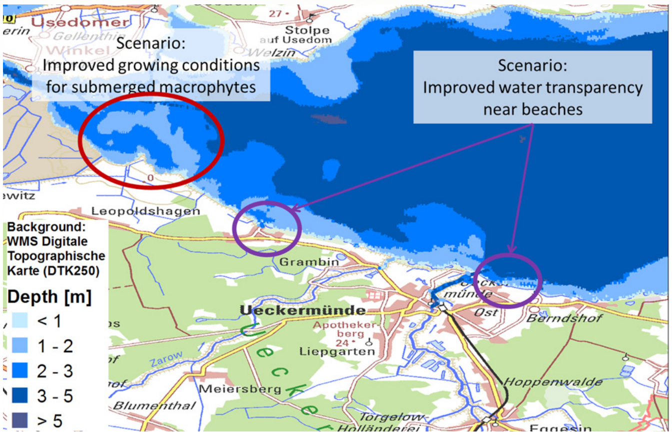

A supplementary 3d-simulation model of Szczecin Lagoon allowed us to estimate the impact of different scenarios, varying in the mussel farm´s intention, its location or the mussel density. The necessary background data (e.g. clearance rates) for this simulation model were gained from tailor-made experiments, e.g. by estimating the clearance rate of Dreissena under natural conditions in Szczecin Lagoon. These experiments were supplemented by a test farm in a small bay (Lake Usedom), underlying the strong reduction of phytoplankton due to filtration.

We grouped the scenarios into four guiding lines varying strongly in the key intentions.

The first scenario family aimed at improving the growth conditions for submerged macrophytes, which were widely spread in Szczecin Lagoon, but vanished nearly everywhere over the last 50 years. Because Secchi Depth was strongly reduced during this period, we assumed that macrophyte growth was light-limited. We made a scenario simulation including low-density mussel farms located in a fish nursery area and could show that implementing a mussel farm could increase the available light reaching the bottom up to 45%. We predicted such a farm as a supportive measure to improve the growth conditions for a starting period, after which the macrophytes should be able to re-occur without further external aid. While the economic benefit of such a farm would be negligible, it could boost the sustainable and self-maintaining development, and support additionally the implementation of the WFD. Hence, this scenario was favoured by most stakeholders in the third workshop, as a long-term and sustainable water quality improvement could be achieved.

The other three scenarios address much stronger the economic prospects arising from an improved water quality and mussel mitigation measures. Therefore production costs and potential sales were analysed, resulting in a mussel farm scenario, located close to an industrial harbour, which could be economically profitable, if the nutrient retention (with respect to N and P) is included as a cost-compensation. This scenario got a low response from the stakeholders and was perceived as crucial, as it would be an "end of the line" retention measure not executed by the main polluters.

The third pre-defined scenario addressed the placement of a mussel




*Tailor-made scenarios focusing on different key issues and locations were developed to serve as backbone for the stakeholder involvement*

farm near to beaches, assuming that a higher water transparency would lead to an increasing number of bathers, balancing the farm´s costs by a rising touristic revenue. The stakeholder´s response was mixed to this, as many workshop attendees suspected the potential implementation due to a high probability of spatial conflicts. Others saw the potential revenues of this scenario and tried immediately during the workshop to make a plan, how to design a mussel farm to reduce the spatial conflicts. Nevertheless, one of the stakeholders' key issues cannot be answered, as neither the development of fish and bird populations, nor the resulting economic situation of the local fishermen due to the increased mussel biomass or water transparency could be predicted. However, the SAF provides a good structure to address these issues as well as potential spatial conflicts of an internal measure.

René Friedland and Gerald Schernewski
Leibniz Institute for Baltic Sea Research Warnemünde
Germany

## Systems Approach Framework Case Study Vistula Lagoon

The Vistula Lagoon is located in the Baltic Sea and is shared by Poland and Russia. Roughly 91 km long, 6.8 to 13 km wide and 2.7 m deep, it is separated from the Baltic Sea by the Vistula Spit. Recent history features economic decline after transition to a market economy and isolation of the Polish part from the sea, as the only access is located in the Russian part. The recovery of the Vistula Lagoon economy requires integrated management including multiple ecological, social and economic interactions. For this purpose the SAF framework was applied.

The issue (SAF step 1) was identified by consultations with local authorities, coastal and environmental managers, fishermen and tourist operators using the DPSIR and CATWOE frameworks to pinpoint the inter-connections among society, economy and environment and elaborate the mapping of main stakeholder groups. These activities revealed that the issue (recovery of the Lagoon economy) can be attained by construction of new and rehabilitation of existing harbors, marinas and navigational channels, which lead to increase of tourism, shipping and fishing. In the System Design step, inter-dependencies among activities and states (e.g. tourism vs. water quality) were identified. The identified linkages are presented in Fig. 1 as a virtual system diagram.

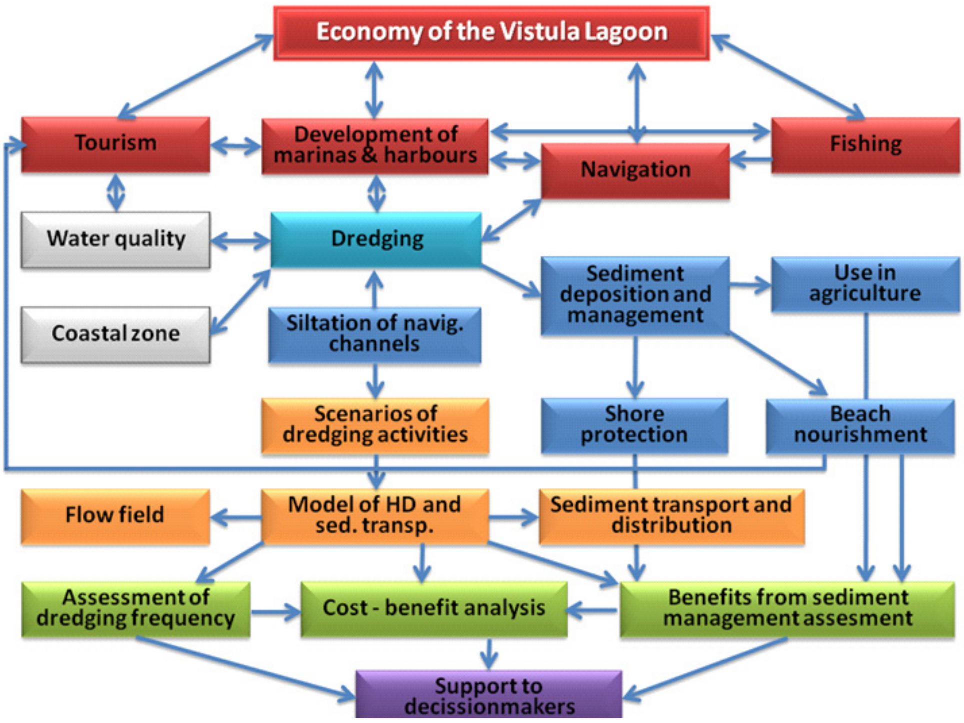



*Fig.1: Conceptual model for the case study.*


During the System Design step, sediment samples were analyzed to assess their toxicity and determine parameters for the modeling of silting-up of navigational channels to be dredged and dug. Processes of the channels' silting up were modeled with the Delft3D suite and a special emphasis was laid on the modeling of siltation of navigational channels by cohesive sediments, whose litho-dynamic characteristics are much more complicated than those of ordinary sandy sediments. Mechanisms such as wave and current-driven sediment transport were modeled with the inclusion of sliding phenomena of submerged slopes of navigational channels, built of cohesive sediments with angle of repose close to zero. Example of modeling results is presented in Fig. 2.

The computed silting-up rates in different scenarios of the layout of channels were then used in the cost-benefit analysis for the evaluation of channels maintenance cost vs. benefits (income) resulting from tourism, navigation and fishery increase thanks to the refurbished network of channels, harbours and marinas. In the System Assessment step the modeling results will be presented to main stakeholder groups for discussing the feasibility of the proposed measures (costs of construction of new and refurbishment of old harbors and marinas and costs of dredging and maintenance of navigational channels vs. economic benefits obtained by expanded tourist infrastructure). The variant(s) accepted by the stakeholder panel will be recommended for implementation.

Grzegorz Różyński, Małgorzata Bielecka and Jan Schönhofer
Institute of Hydroengineering, Polish Academy of Sciences
Poland

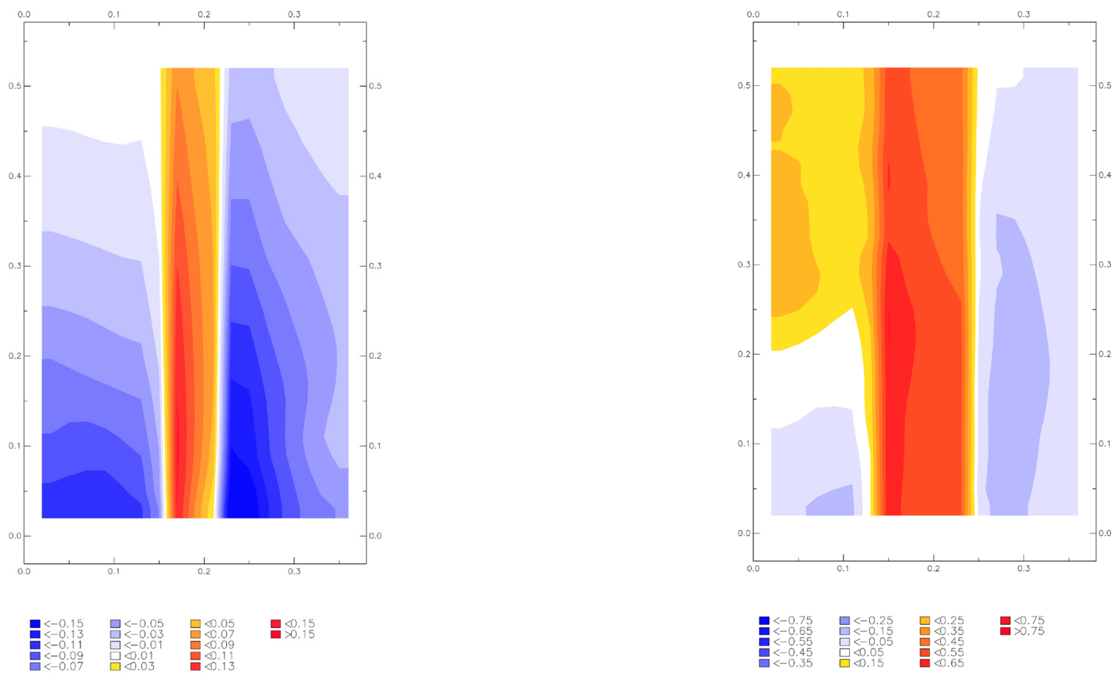
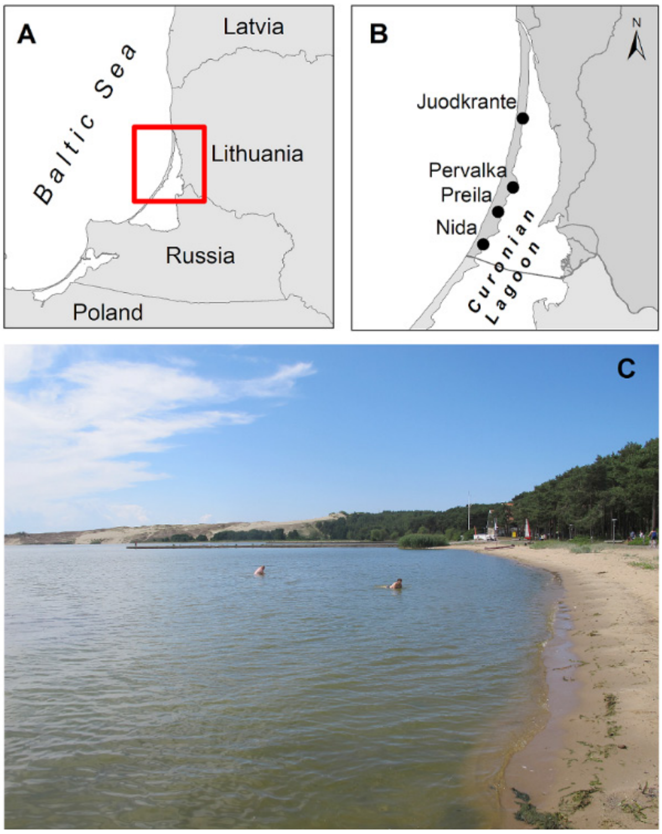



*Fig.2: Exemplary annual change (m/y) in bathymetry of existing and upgraded channel: warm color – accumulation, cold – erosion.*


## SAF application for a new bathing sites establishment at the Curonian Lagoon coast

Curonian spit (Neringa city municipality) is one of the most popular local and foreign tourist destinations in Lithuania. Tourism provides the major income for this region. Due to a short bathing season on the Baltic Sea coast, the highest concentration of tourists is in July and August. The municipality of Neringa has plans to open the bathing places on the Curonian Lagoon coasts which could help to expand the tourism season and could lead to more sustainable tourism. Because of the shallowness of the lagoon, the waters usually warm up to approx. 18°C already in May, providing an opportunity to open a bathing place earlier and end it later, than on the Baltic Sea side. Still, the main concern for the beach or bathing place in the lagoon is the water quality.



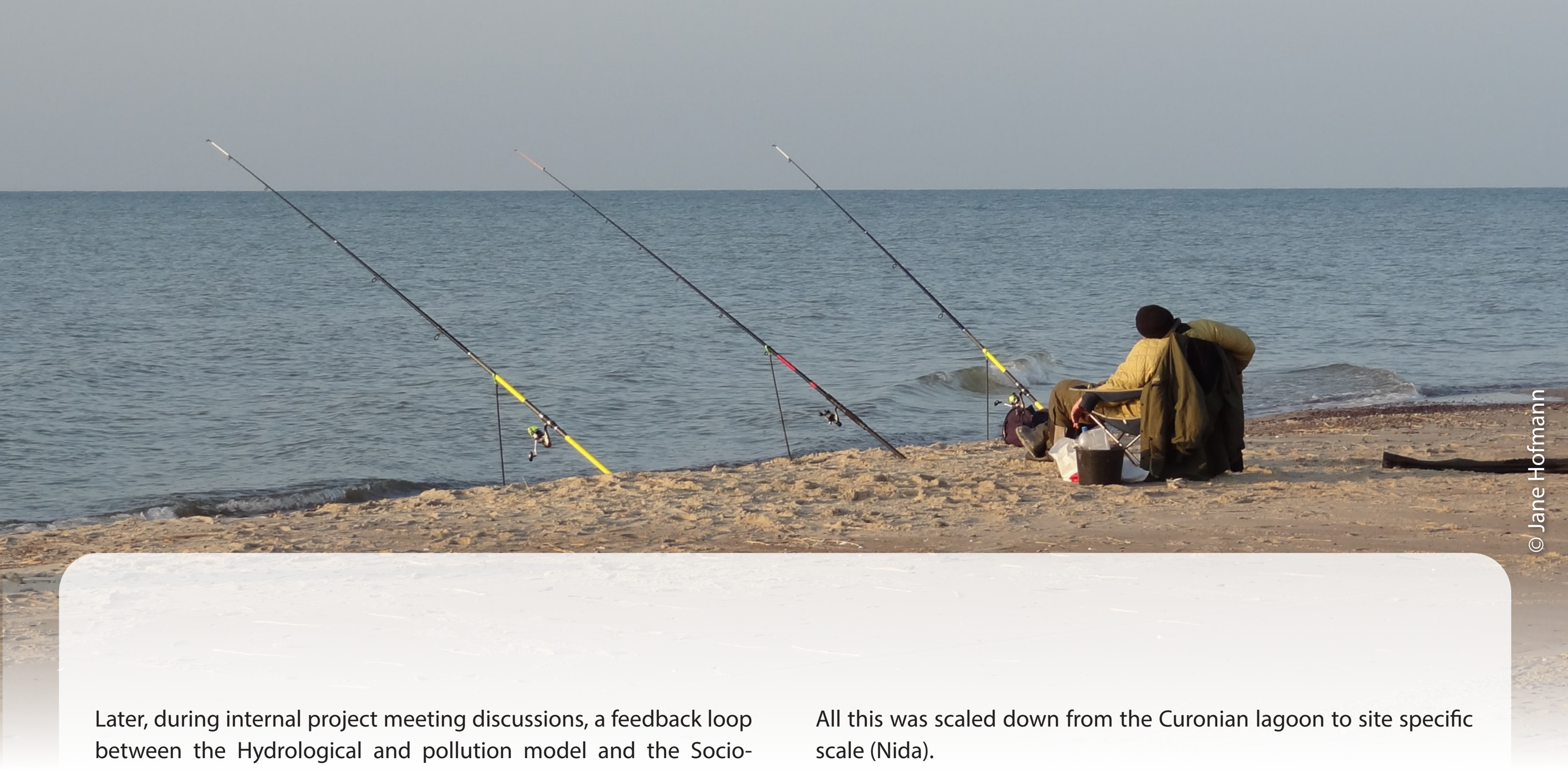

*Potential bathing place in Nida at the Curonian Lagoon site*

A task for our scientific group was to assess the possibility to open the beach using the stepwise, user-friendly SAF approach, which includes an integrated Ecological-Social-Economic (ESE) assessment and a close cooperation with stakeholders. For this, accurate knowledge and experimental information on microbial water pollution, its distribution, effect of new bathing place establishment to social-economic development, and certain scenarios modelling were needed. A team of scientists consisting of technical experts such as ecologists, social scientists, economists, system analysts and modelers were involved for this task.

The issue was identified through DPSIR (Driver-Pressure-State-Impact-Response) and CATWOE (Customers-Actors-Transformational process-Worldview-Owners-Environmental constraints) models, where relevant social, economic and environmental components were identified. The main governance (people or institutions that make or implement laws or policy) and stakeholders (that cause the problem, are affected by the problem or affected by the solution) groups were identified and invited to participate in project meetings.

In the System Design step, we developed a conceptual model that visualised the dependencies within and between the economic and the natural scientific models. Modeling of *E. coli* bacteria (one of the two parameters according to Bathing Water Directive) distribution in the Curonian Lagoon was performed along Curonian spit and as an outcome the sinks and sources and the risks for establishing new beaches were provided.

The Conceptual model of the study site was developed in several iterations. The model required an update after the first stakeholder meeting, during which a request was presented to include a “prestige” factor into the socio-economic part of the model.

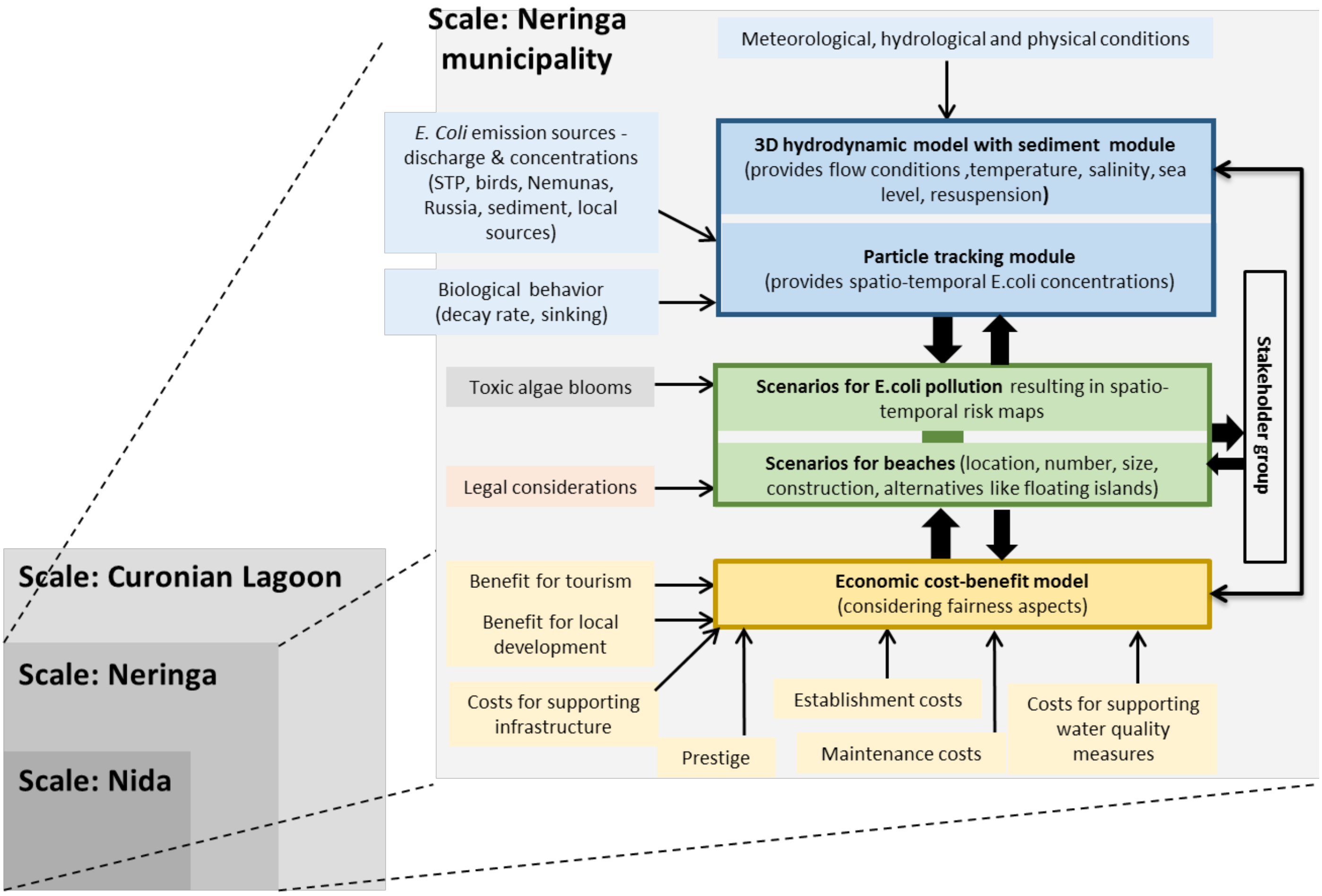



Later, during internal project meeting discussions, a feedback loop between the Hydrological and pollution model and the Socio-Economic one was added. This feedback represents a direct impact of the hydrodynamic (natural) conditions of the system on the socio-economic (derived from human behavior) part of the system. In return, socio-economic factors have an impact on the possible pollution intensity and on other scenarios.

All this was scaled down from the Curonian lagoon to site specific scale (Nida).

The simulated ecological model and socio-economical model scenarios were presented for stakeholders. In close cooperation with municipality and authorities we provided a new bathing water quality evaluation system in the Curonian Lagoon with high practical relevance for end-users.

Marija Kataržytė, Jovita Mėžinė, Natalja Čerkasova and Georg Umgiesser
Klaipėda University
Lithuania

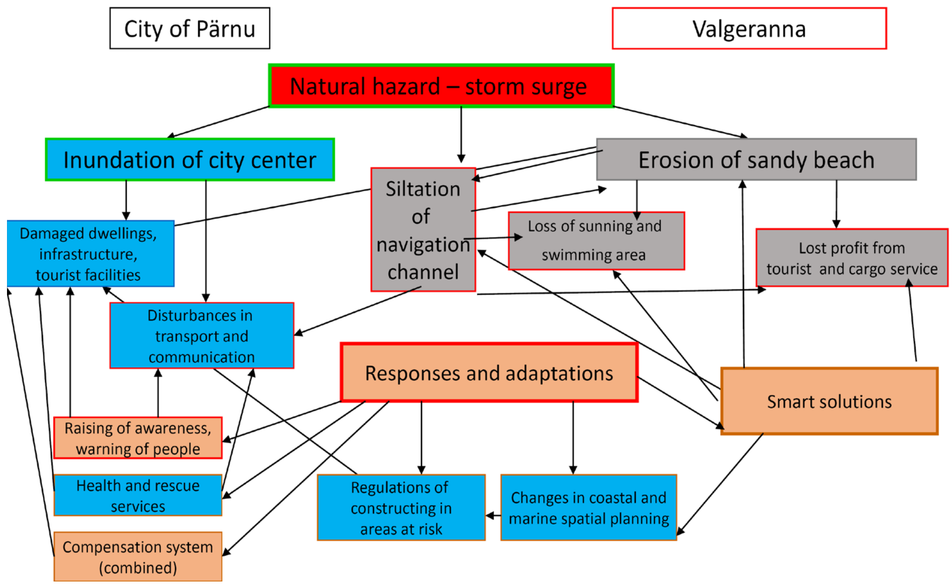



*Conceptual model for new beaches in Curonian lagoon establishment*

## Application of SAF in planning coastal zone management in Pärnu Bay region

Pärnu is located on the coast of the Pärnu Bay, which is a well-defined marine area in the NE corner of the Gulf of Livonia, Baltic Sea. It measures approximately 20x25 km2 and the maximum depth is about 14 m. Pärnu is a popular summer resort with many hotels, spas and excellent sandy beaches but also an important cargo port. The population of Pärnu is about 40 000, but in summer it may double.

The sea level regime is mostly influenced by frequent cyclones passing from west to east along the North Atlantic storm-track. Strong storms may create considerable fluctuations in sea level and wave conditions. During the last 50 years, Pärnu has suffered from two record-high storm surges and consequent inundations – in 1967 (2.53 m) and 2005 (2.75 m above mean). About 8 $km^2$ of the city was inundated and much damage caused by the storm Gudrun in January, 2005. Due to changes in atmospheric circulation and warmer winters, the frequency of strong westerly storms associated with high sea level in ice-free sea conditions has increased over the last half-century and is expected to further increase on the western coast of Estonia. Considering the low-lying coast and virtual absence of tides, the local residents are not always sufficiently prepared for such rare events. There is a strong need for increasing their awareness and to find reasonable solutions for adapting to the extreme climatic events.




*Conceptual model for Pärnu region*

The Pärnu Bay is well exposed to south-westerly winds and waves making it vulnerable to strong coastal erosion on both sides of the bay. At the same time, the prevailing longshore sediment transport takes the eroded material towards the Pärnu River outlet and the port, which is located at the river mouth. To prevent the ship channel from frequent siltation, the river mouth is protected by two 2.2-km long jetties. Coastal sediments are accumulating in the vicinity of the jetties. This material originates mainly from the surrounding coasts that suffer from sediment starvation. The situation is getting worse due to climate change and wrong management leading to the disappearance of sandy beaches together with valuable ecosystem services as has happened in Valgeranna. As a result, people tend to concentrate on the central beach in Pärnu posing more pressure there.

SAF application was applied in the frames of the BaltCoast project and the above-mentioned problems were identified among the most critical ones for sustainable development. The main question was how to minimize the negative effects of extreme climatic events (floods, rapid erosion) on the ecology, economy and society in the coastal zone of the area.
It is clear that extreme events cannot be avoided in Pärnu.

Therefore, a number of protection and adaptation options have been proposed:

- Building a dam;
- Dissipating storm surge water;
- Adaptation;
- Retreat;
- Beach nourishment.

© Anna-Helena Purre

The archived dam project from the 1980s was used for calculating the total cost of building according to the current prices. The results showed that the dam would be too expensive exceeding many times the predicted losses over the next 100 years. The local inhabitants and researchers were also concerned about the loss of identity as a summer resort. Furthermore, the dam would destroy a number of valuable habitats, that are today protected within restrictive legislation.

Dissipating storm surge water over the uninhabited low-lying wetlands behind the dune ridges would only have a minor effect reducing the high water level by 4-5 cm. As the effect of this measure is too low, it was not further considered.

The retreat scenario was not accepted by the local people. The concern for losing the identity of the region was high. Excellent sandy beaches high in recreation value, the relevant infrastructure and the hotels with exclusive sea view are too valuable for the local community and its economy. The retreat option would lead to an overall failure of the tourism industry.

*Popular beach among families with children*

Finally, two parallel scenarios were chosen – raising awareness and applying adaptation in case of storm surges and developing beach nourishment in areas of erosion. The calculations showed that developing reasonable adaptation measures and raising awareness among the residents of Pärnu would be the most cost-effective options in case of catastrophic inundations reducing the costs at least twice.

Raising awareness and developing adaptation include a number of actions:

- Drawing inundation levels on the local pedestrian roads, walls, etc. This activity would be supported by the local government;
- Putting stickers on the traffic lights, street signs and electric poles indicating different inundation levels would be supported also by many stakeholders;
- Voluntary "lifting service" to help elderly or disabled people in case of storm surge warning;
- Serious role-play games at schools and in mobile phones that help react to and escape from extreme storms and reduce losses. These would give a chance to practice emergency situations.

The beach nourishment measure can be applied on two popular beaches near Pärnu. One is fronting Lotemaa theme park (around 100 000 visitors each year), south of Pärnu and the other - Valgeranna beach, north-west of Pärnu. The sand that is accumulating at the harbour jetties can be transported back to the beaches. This would reduce the volume of sand reaching the navigation channel during extreme events and helps to feed the eroded beaches in the cheapest way. However, some aspects in legislation are not clear enough for such kind of activity needing discussion and updating.

We may conclude that SAF application has allowed us to choose the most suitable scenarios for the Pärnu region. The stakeholder involvement has helped to refine those scenarios and finally, our discussions have reached the state level.

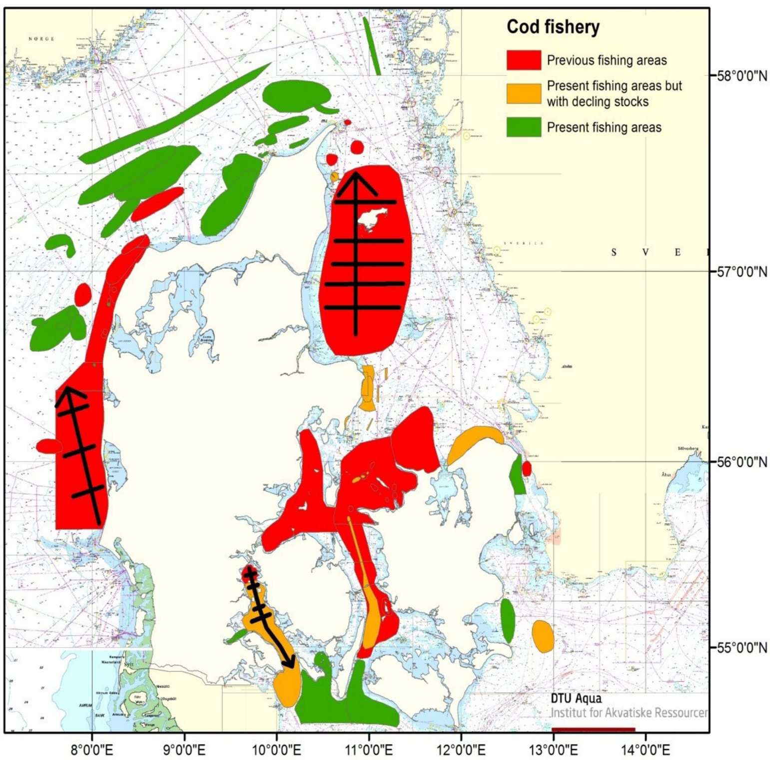
Kaarel Orviku, Valdeko Palginõmm, Hannes Tõnisson and Are Kont
Tallinn University
Estonia

## Fish distribution and productivity in Danish waters

The inner Danish waters have supported coastal commercial fisheries for many generations. In recent years, however, coastal fishermen have experienced severe decline in their catches of several commercially important fish species. Especially in the eastern North Sea, Kattegat and Belt seas fishermen were forced to fish further offshore or unable to sustain a living on the resources available coastally.

In this study, we focused on the decline of cod fishery in the Kattegat using this as a case study. Fishery was only viable in the Skagerrak and south western Baltic Sea.

This case study was thus generated from a stakeholder insistence on uncovering the causes for the decline in coastal stocks of commercially important species, endorsed by management prioritization to resolve the problem and find sustainable solutions. The Systems Approach Framework (SAF) was applied to investigate this rather complex issue of declining fish stocks in coastal areas. As the first part of the SAF, Issue Identification, interviews with 74 coastal fishermen provided the key main concern among stakeholders, declining catches in coastal waters. This became a high priority within government which provided the necessary financial backing to start the SAF process which was taken up as a case study within the BONUS BaltCoast project.

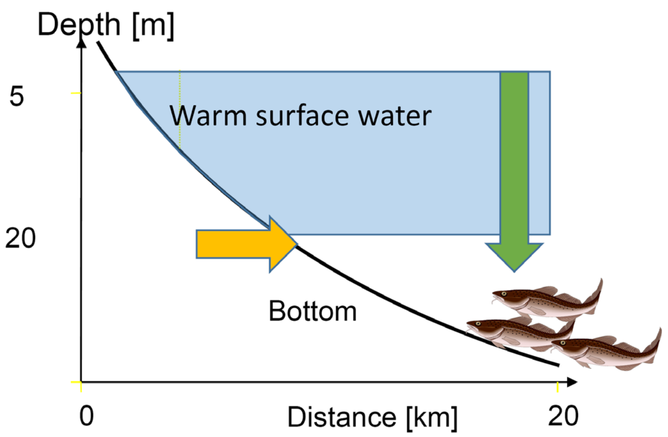



*Results from interviews with 74 coastal fishermen regarding where they have experienced declines in cod fishery. The lines denote step-wise (5-10 year intervals) declines in the direction of the arrow.*

© Katja Hanoldt

The complexity of the ecological elements for this Issue caused the Formulation step to last longer than anticipated. Preliminary analyses of available data indicated changes in the distribution of cod in shallow and deeper areas. However, diverse attempts to quantitatively model these changes in cod distribution on a sufficiently detailed spatial scale, revealed the paucity of data in the near-shore areas. This was due to low coverage of scientific fish surveys, making it practically impossible to explore potential causal relationships. A new approach was needed.

The generation of a high resolution hydrodynamic model from another BONUS project, INSPIRE, combined with in-house information from data storage tags using cod provided a new opportunity. With this combined information, we were able to explore the available habitat for cod in the inner Danish waters including temporal and seasonal changes in habitat caused by climate warming and/or increased eutrophication. The results showed an effect of climate change on the potential cod habitat, further exacerbated by oxygen depletion events.

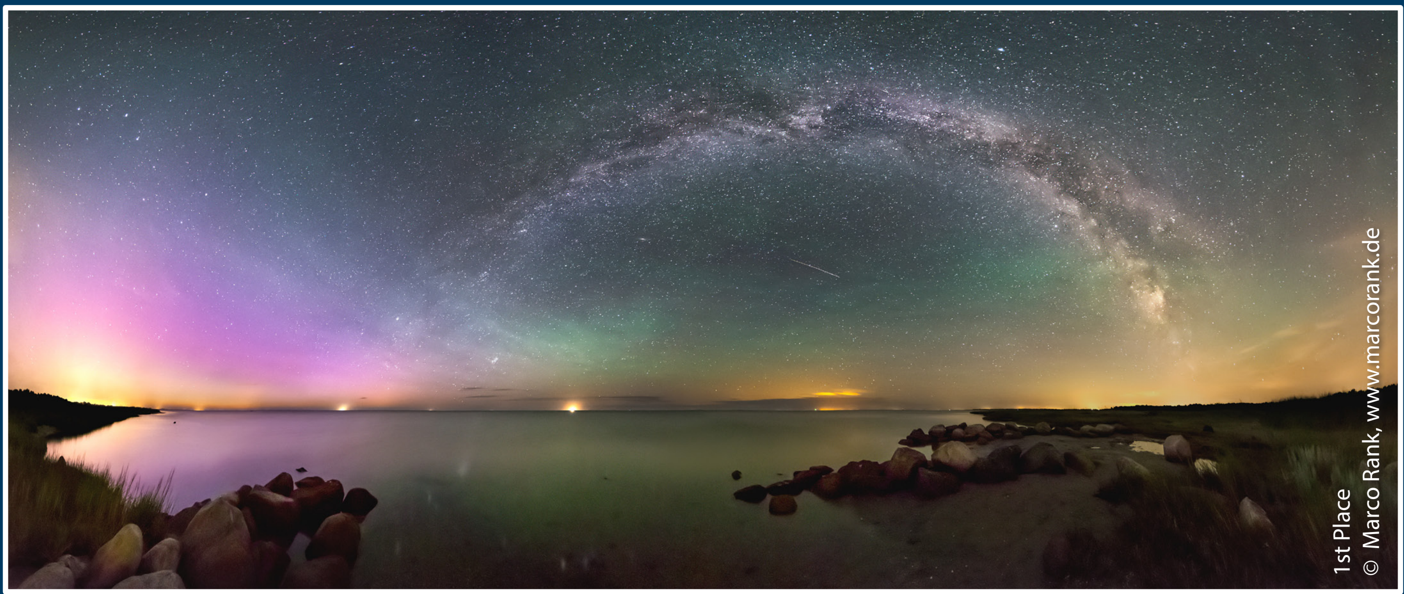



*A schematic diagram showing how climate change combined with eutrophication potentially can alter the magnitude of cod habitat in time and place. The vertical expansion of higher surface water temperature "pushes" cod away from the coast. This change in habitat may be exacerbated by periodic oxygen depletion events.*

With this breakthrough in the ecological component of the ESE assessment, it was then possible to bring in the socio-economic component for this issue and explore potential management options through scenario simulations. However, meetings with managers and the affected fishermen were needed to identify potential management options with these stakeholders, once this new information was disseminated.
This now directed our focus on another challenge with our SAF application; that of a highly changeable governance structure. During the BONUS BaltCoast project, several ministerial changes took place, including both institutional structure and staff responsible for specific areas. The fisheries and environmental management were merged in 2015. A minister shift just a year later, was shortly followed by the separation of the fisheries from the environmental ministry in 2017. The fisheries agency, only recently reconstructed in November 2017, is now under the Ministry of Foreign Affairs. These re-organizations caused delays and even cancellation of meetings necessary for the dialogue between the science team and management.

Despite these set-backs, the science team is positive about the potential completion of the SAF application. Following a recent meeting with managers, already several ideas for management options have emerged and the economic elements of the ESE assessment is being formulated and subsequently implemented in scenario simulations. These scenarios provide a basis for discussion of potential management options with, and among, a wider group of stakeholders. Further meetings are planned including a meeting to discuss the results as potential inputs to the implementation of the Maritime Spatial Planning Directive. Thus, the science team expects to be able to move to System Assessment and the Implementation step within or shortly after the project termination.


Grete E. Dinesen and Josianne G. Støttrup
Technical University of Denmark






**The winning pictures of the BONUS BaltCoast Photo Competition are part of the touring exhibition „Me and my Baltic Coast“. Information about the exhibition as well as all BONUS BaltCoast project results can be found on www.baltcoast.net and**

BaltCoast

BONUS SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

LEIBNIZ INSTITUTE FOR BALTIC SEA RESEARCH WARNEMÜNDE IOW

DTU Aqua
National Institute of Aquatic Resources

KLAIPĖDOS UNIVERSITETAS

TLÜ ÖKOLOOGIA KESKUS INSTITUTE OF ECOLOGY Tallinn University

LATVIJAS UNIVERSITĀTE ANNO 1919 UNIVERSITY OF LATVIA

IBW PAN

SLU

BONUS BALTCOAST project has received funding from BONUS (Art 185), funded jointly by the EU and Baltic Sea national funding institutions.