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Interim Report of the Working Group on Risks of Maritime Activities in the Baltic Sea (WGMABS)

14–16 April 2015

Helsinki, Finland

ICES CIEM
International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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Contents

Executive summary

The Working Group on Risks of Maritime Activities in the Baltic Sea (WGMABS) met on 14–16 April 2015 in Helsinki, Finland. This was the first meeting of the working group and the aim was to reviews the current work to understand what kind of scientific tools are available for risk management of maritime risks. It was decided already before the meeting that the focus will be on large-scale oil accidents, as it was considered that this is an area where ICES has not had much activities even though the impact on nature can be very large in large-scale oil spills. For example other ICES working groups have already studied the introduction of new species in ballast waters of vessels, but large-scale oil spills are not.

Governance measures against oil spill risk can be divided into preventive and recovery measures. The ground for these measures is the legislation concerning safety on life at sea and marine pollution prevention.

As conclusion working group agreed to suggest a new advisory approach to be applied in Baltic Sea oil spill management. This included both activities after the accident, but especially it includes a strategic approach to maximize interests to avoid accidents. It was agreed that a proactive approach would be useful in improving maritime safety. (Haapasaari *et al.* 2015). This means that adjustments are made before accidents occur rather than after, and it requires anticipating events or conditions that could lead to accidents. Proactive policy making means that the approach is based on a formal process of identifying, assessing, and evaluating risks, and focusing adjustments on those risks that are evaluated unacceptable. Proactive approaches to decision making are predominant *inter alia* in the nuclear sector and in fisheries management. A proactive approach enables creating a holistic picture of a socio-ecological or a socio-technological system, its failure modes and uncertainties, and taking decisions based on that.

In the maritime field, proactive risk governance should take place at the regional level, to complement the current national and international level prescriptive policy making. This is because maritime risks are to a great extent of a local or regional nature. Environmental conditions (waterways, marine weather, visibility, traffic density/volume), in addition to human and technical factors, are major causes of maritime accidents. A regional governance framework would enable viewing maritime safety as a holistic system, and assessing the risks using scientific methods. A risk assessment would require a committed scientific body for conducting the work. In addition, state-of-the-art methods, and available up-to-date information of the regional risks would be needed. A regional risk governance framework can improve safety by focusing on actual regional risks, designing tailor-made safety measures to control them, enhancing a positive safety culture in the shipping industry, and by increasing trust among all involved.

Obtaining useful estimates of species distribution by traditional observational means is demanding because surveys are expensive and time-consuming. However, wide scale high resolution models that quantify the relationship between a species occurrence and environmental characteristics may be used to complement the survey work, and improve the information content of future surveys.

1 Administrative details

Working Group name

Working Group on Risks of Maritime Activities in the Baltic Sea (WGMABS)

Year of Appointment

2015

Reporting year within current cycle (1, 2 or 3)

1

Chair(s)

Sakari Kuikka, Finland

Meeting venue

Helsinki, Finland

Meeting dates

14–16 April 2015

2 Terms of Reference a) – z)

Terms of reference in 2015

a) Review the recent studies carried out for ecological risks of maritime activities and to plan ToRs for future group meetings

Background:

- Science requirements: The oil spill risks have increased during the years, but scientific support for the decision making in this activity has not followed the intensity of shipping, especially that of oil transportation. The scientific support for oil spill decision making offers a useful knowledge base for Baltic Sea studies.
- Advisory requirements: there is a need to develop advisory system for the Baltic Sea. The discussion of this is in the key role in 2016 meeting

Deliverable: This WG document and the papers reviewed in Annex 2

b) Review the science of maritime risk analysis in the Baltic Sea

- Science requirement: There has been significant amount of work in the Gulf of Finland for oil spill risk analysis. Similar analyses are missing in other Baltic Sea analysis.

Deliverable: as for ToR a) above

c) Plan the ToRs of future WG meetings

- Science requirement: The need to consider the need of having an advisory system for Baltic Sea must be discussed in 2016 meeting. In connection to 2017 there could be a preliminary test of risk communication between key stakeholder groups.

Deliverable: report in 2016.

3 Summary of Work plan

Year 1

- Further review of existing relevant literature in the Baltic area and other sea areas
- Plan and hold an experimental workshop together with stakeholders in 2017

4 List of Outcomes and Achievements of the WG in this delivery period

1) Publications in WGMABS sharepoint: Background documents folder

2) First advisory document published in Helsingin Sanomat, 15th Aprfil, made by the chair of WGMABS and reviewed in the meeting.

3) Given presentations and developed models (WGMABS sharepoint). See developed models in Annex 3.

4) Report 2015 (this document)

5) Discussion material from WGMABS discussions, including the following contacts and persons:

   a) Video of the talk given by Heli Haapasaari, official from Pollution Risk Unit, SYKE (a legally responsible response unit in Finland, acts currently under Ministry of Environment);

   b) Discussion notes with Chief Adviser Dr Anita Mäkinen (TRAFI Finnish Transport Safety Agency, Finland), former Baltic Sea expert in WWF Finland;

   c) Slides and discussion notes from discussions with Hermanni Becker, HELCOM representative on oil risk management themes. This includes information needs in policy design;

   d) Talk, slides and notes from discussions with Dr Laura Uusitalo, SYKE, Finland: Work in Baltic Integrative Ecosystem Group (WGIAB);

   e) Talk given by Dr Jani Luoto, University of Helsinki: Bayesian time series modelling and the possibility to evaluate theoretical model structures by environmental and fleet data sets (short notes);

   f) Dr, civil engineering Ari Jolma, Biwatec ltd, Finland: spatial software and methods in oil spill risk analysis;

g) Raw discussion notes available on the SharePoint under Working documents.

WGMABS agreed that the share point documents will be made available to all those who are interested. Also the wiki possibility to get feedback on the report should be considered.

5 Progress report on ToRs and workplan

There was a significant progress in each ToR, leading to somewhat updated ToR for years 2016/2017.

The progress in relation to all Tors are as follows:

a) Review the recent studies carried out for ecological risks of maritime activities and to plan ToRs for future group meetings

This ToR was achieved to some extent, but there is still a need to review existing models, especially to learn the required input data and the key outputs. Especially those modelling solutions where decision models are applied are useful for WGMABS.

b) Review the science of maritime risk analysis in the Baltic Sea

This ToR was achieved very well, as WG members included several authors of recent key papers for Gulf of Finland. There is, however, need to better review the analysis carried out for other areas.

Now there is a need to integrate the existing engineering models (grounding and collision accidents, their probabilities, impacts and ways to decrease expected amount of oil in the water) to the existing biological models (impacts on threatened species, impacts on habitats, impacts on fish stocks). There is an obvious need to carry out data analysis and expert knowledge elicitation to be able to do integration. More economic resources are needed from Baltic Sea countries to carry out this task.

Cooperation with Advisory structures: none inside ICES, short advice was given by chair during the meeting on results of recently accepted paper on cost benefit analysis of using money on decreasing accident probabilities or using resources on oil combatting. Need for text was based on the nearby Government of Finland Program that deals with state of ministries and their activities

c) Plan the ToRs of future WG meetings

Bayesian analysis is needed to create learning systems for oil spill risk analysis and to learn from publications, experiments, experts, existing data sets and scientific theory.

Based on this and foreseen development, WGMABS considers essential to start the end user discussions and to obtain feedback on the usefulness and relevancy of the existing models in suggested new risk governance scheme (see Annex 2).

6 Revisions to the work plan and justification

WGMABS agrees that the next terms of references are to be followed in 2016 and 2017:

- 2016: In a 4 days meeting, to have first 2 days for WGMABS inside discussions, and thereafter 2 days interactive workshops with end users on the models and their use, relevance and understand ability, to judge whether tools are ready for first steps of advice. Industry (oil companies, shipping companies, insurance companies) and NGO's (environmental organisations, fisheries organisations, recreational organisations, cottage owners, etc.). From ICES, at least ACOM observer attendance is suggested.
- 2017: To complete the experiences from the workshop on the relevancy, review the steps taken since 2015 (has the integration been successful), and suggest the format of ICES or other advice on maritime risks in the Baltic Sea. In the views expressed in meeting 2015, the role of HELCOM is seen important, but also a purely scientifically based discussion organisation with industry and NGO involvement is one possibility. In such case, industry must express their interest to support such progress either financially or by taking the responsibility of carrying out the risk analysis with developed methodology, taking into account the openness needs and information interests of other stakeholders. The meeting place is suggested to be Stockholm, Sweden (venue to be decided), 10–13 April 2017.

7 Next meeting

Suggested terms of references for the future years

The agreed terms of references of the WGMABS include the review of existing models in 2015, the review of data in 2016 and the suggested policy advice system for ICES in 2017.

This meeting (April 2015, Helsinki) has already carried out the review of the models, and it will submit a review paper to some scientific journal. This report, as well as the shorter version of the journal manuscript, includes these findings and also the review of data. There is a need to continue the data review, but it is obvious that the data, published papers, theoretically based models and available expert knowledge can, and to large extent has already been, used to populate the required conditional probability tables of existing models.

Annex 1: List of participants

Name	Home Institute/laboratory	Email
Chair professor Sakari Kuikka: interdicplinary Baysian risk and decision analysis, fisheries (STECF member, EU, all time)	University of Helsinki, FEM group, head of environmental and economic group	sakari.kuikka@helsinki.fi
Inari Helle : ecological risk analysis, cost benefit analysis (all time)	University of Helsinki, FEM group	inari.helle@helsinki.fi
Annukka Lehikoinen: fleet risk analysis, effectiveness of oil compantting, large integrated models (not present)	University of Helsinki, FEM group	annukka.lehikoinen@helsinki.fi
Tuuli Parviainen: starting PhD on the industry and citizens to prevent oil disasters (all time)	University of Helsinki, FEM group	tuuli.parviainen@helsinki.fi
Jarno Vanhatalo: spatial Bayesian analysis, Gaussian process models (2 days)	University of Helsinki, FEM group	jarno.vanhatalo@helsinki.fi
Päivi Haapasaari: social sciences, advisory systems	University of Helsinki, FEM group	paivi.haapasaari@helsinki.fi
Riikka Venesjarvi: spatial biodiversity analysis, impacts of oil on populations	University of Helsinki, FEM group	riikka.venesjarvi@helsinki.fi
Prof Samu Mäntyniemi, Bayesian statistics, stock assessments, risk and decision analysis	University of Helsinki, FEM group	samu.mantyniemi@helsinki.fi
Christer Larsson (not present)	Sweden	christer.larsson@havochvatten.se
Floris Goerlandt (2 days)	Aalto University, Helsinki	floris.goerlandt@aalto.fi
Osiris Valdez Banda (not present)	Aalto University, Helsinki	osiris.valdez.banda@aalto.fi
Ari Jolma (3 days)	Biwatec ltd Finland	ari.jolma@gmail.com
Otto Sormunen (1 day)	Aalto University, Helsinki	otto.sormunen@aalto.fi
Pentti Kujala (1 day)	Aalto University, head of engineering group	pentti.kujala@aalto.fi
Risto Jalonen (1 day)	Aalto University, Helsinki	risto.jalonen@aalto.fi

Tuomas Routa (not present)	TRAFI, Maritime director	tuomas.routa@trafi.fi
Valtteri Laine	TRAFI, Helsinki	ville.autero@trafi.fi
Jakub Montewka (3 days)	Aalto University, Helsinki	jakub.montewka@aalto.fi
Hermanni Backer (2 days)	HELCOM, Professional Secretary (Maritime, Response, MSP)	hermanni.backer@helcom.fi

Annex 2 Review of litterature

1. Introduction

Due to the ever-increasing interest raise after natural resources, humans are expanding their interests to even more challenging areas like arctic oceans. The steps of science and international policy make a feeling of acceptable safety, which justifies the activities to find oil and gas from arctic areas and also to look after new vessel routes from Pacific around the northern Russia to Arctic Ocean and further to Atlantic. There is obviously a need to utilize the knowledge of all such areas that have similar features like Arctic Ocean. While Bayesian inference can utilize information in the form of prior information, it helps in such between-areas learning.

The recent increase in oil transportation in the Gulf of Finland has aroused an urgent need to find measures to decrease risks related to oil accidents. In principle, risks can be reduced either by decreasing the probability of accidents or by mitigating the harmful consequences after the accident (Helle *et al.* 2015). When the aim is to find the "best" alternative, comprehensive decision-making typically needs to consider also economic aspects, as society's resources that can be allocated to reducing risks are limited.

In this review of risk methodology applied in Gulf of Finland, Baltic Sea, we use the lessons learned from the highly studied, well managed Baltic Sea area, but having the additional risk of collision risks due to the rocky coastal and even open sea areas and ice, which create challenges to the tankers and other visiting vessels. For example crews from tropical area potentially meet circumstances they have never experienced in their life before.

In addition to be likely the most scientifically measured sea area in the world, the Baltic Sea is surrounded by highly modern societies where legislation is developed and agreed international co-operations exists, based on national, EU level and international legislation. Gulf of Finland is currently one of the most important areas of exportation of Russian crude oil to western markets, but at the same time, it has for example 3 nuclear power stations that were built well before the time of Russian exports. This combination currently creates a risk as the heavy oil can be taken into the cooling system. Now GoF, as one of the world's densest areas of high technology, cities and high populations, offers a lesson to learn for other developing sea areas in the world.

In this text we review the international and national governance of the GoF, the scientific needs to support such policies, the existing scientific methods and practices to estimate non observable but existing risks, and the modern ways to learn from existing scientific documents, large international data sets, existing theories and models describing them, and from the support of decision theory to say what should be known for safe policy before starting new risky activities. Even though review is focusing on the Gulf of Finland, we believe that the experiences are useful for other areas in the Baltic Sea and especially in the arctic sea areas.

2. Current national risk governance: example from Finland

Governance measures against oil spill risk in the Gulf of Finland can be divided into preventive and recovery measures. The ground for these measures is the legislation concerning safety on life at sea and marine pollution prevention. The legislative tasks of Finnish Transport Safety Agency are basically related to preventive measures such as making the rules and regulation and controlling that shipping companies and vessels comply with them. Some of these control tasks are outsourced to private international classification societies. The role of Finnish Transport Agency is also mainly preventive since the agency is responsible of e.g. vessel traffic services, ship reporting system GOFREP and defining places of refuge to vessels in distress. Maritime pilotage and icebreaking services are conducted by state owned companies. It should be highlighted that to comply with legislative requirements is more like a baseline for safe maritime operations than guarantee of them.

Recovery measures in case of oil spill are legislative tasks of Finnish Environment Institute. When human lives are threatened in maritime accidents, Finnish Border Guard leads the rescue operation. Agencies in Finland and countries around the Gulf of Finland do lot of co-operation related to both of these measures that aim to minimize the consequences of maritime accidents. The current risk evaluations related minor oil spills can be considered quite reliably, but as they are approaching to catastrophic type of events, such as disastrous oil accidents, they become more and more unreliable: experts are not able to estimate accidents frequency anymore, the amount of different scenarios is high and they might go beyond imagination. Having said that, well recommended strategies against these black swan type of events (Taleb 2007) are general strategies, such as practicing of oil combating, delegating decision making to the operational stage and flexible and trained measures to increase resources during the crisis.

2.1 Role of stakeholders in increasing the interest for best practises in industry and governance

The MIMIC report outlines the need for stakeholder participation in maritime safety policymaking (Haapasaari *et al.* 2014). Maritime safety risks can be considered as public systemic risks, where the risks cross boundaries between environment, society and human health, as well as the international, national and regional scales, and can have both factual and socio-cultural dimensions. As such, risk definition depends on both the context and values and should therefore be examined by all relevant stakeholders in maritime risk governance (Haapasaari *et al.* 2014).

Stakeholder participation has already been widely acknowledged in environmental management elsewhere, and the MIMIC report (Haapasaari *et al.*, 2014) draws upon three different examples: safety management in nuclear industry, fisheries management in the EU, as well as an practical example from the maritime sector: the establishing of risk governance procedures in the aftermath of the grounding accident of the oil tanker Exxon Valdez in the Prince William Sound, Alaska, 1989. The steering committee established in the Prince William Sound was formed to represent all stakeholders; for agreeing and defining the objectives and scope of risk management; and to build trust and increase knowledge and understanding of risks related to oil transportation among all the stakeholders (Haapasaari *et al.* 2015).

In order to enhance the role of stakeholders in maritime safety policymaking in the Gulf of Finland, Haapasaari *et al.* (2015) suggest the need for a permanent stakeholder committee including a broad scale of stakeholders (such as ship companies, crews, maritime safety authorities, pilots, oil industry, port employees, environmental authorities and non-governmental organizations, local citizens and scientists); (Haapasaari *et al.* 2015, Haapasaari *et al.* 2014). A permanent stakeholder committee enables bringing in different types of knowledge for the comprehensive identification of risks and risk control options, as well as enhancing discussion on the relevant values for the evaluation of the risks and the need for actions to reduce them (Haapasaari *et al.* 2015; Haapasaari *et al.*, 2014).

For example, an important topic to be discussed by the stakeholders is how to share the costs of decreasing the risks between the public and the private sector: in who carries the risks and/or the costs, and who benefits and who is responsible for paying for the costs related to the risks, the public or private sector? At the moment, the shipping companies have insurances in case of accidents, but only to a certain limit, after which the taxpayers are responsible for paying the bill. Furthermore, the environmental impacts of an oil spill are difficult, and sometimes impossible, to value in monetary terms. It can be considered, that the insurance policy is likely an effective way to manage the risks, and insurance legislation is in the hands of societies. Therefore it is essential to include insurance companies to such open processes what is suggested in this report.

The MIMIC report suggests that involving the private sector in policy processes can be seen as a way to increase the commitment of the industry to the regulations and to develop safety culture. Based on the view of Finnish maritime experts interviewed for the MIMIC report, in order to ensure maritime safety in the Gulf of Finland, instead of new regulatory policy instruments, the effectiveness and cost-effectiveness of current policy instruments should be improved, as well as supporting shipping companies to voluntarily improve their safety performance (Haapasaari *et al.* 2014).

The concept of corporate social responsibility and safety culture were seen to emphasize safety by reducing human errors and by increasing commitment to regulations. Corporate social responsibility refers to the responsibilities of businesses for their societal impacts, whereas safety culture consists of the shared values, attitudes and behaviour of a shipping company and its crew, related to its safety performance (Haapasaari *et al.* 2014). In addition, transparency, no-blame culture, open communication, enrolment of third parties (such as scientists), incident and near-miss reporting practices and open data base and publicity of the data can contribute towards enhanced safety in shipping. However, more research is needed on the different best practices and measures for motivating the companies to voluntarily improve their safety performance (Haapasaari *et al.*, 2014).

One of the methods could be Bayesian network modelling or participatory modelling. For example in the case of fisheries management, Bayesian participatory modelling can help in facilitating discussion between scientists and stakeholders uncertainties and contribute to increasing legitimacy of policymaking (Röckmann *et al.*, 2012). Bayesian networks can be made interactive in web, i.e. to learn the knowledge of the users, and even carry out analysis where the questionnaire is made such that so many questions are made that the objective function is informative enough to identify preferred policies. Then we speak about learning databases (Pulkkinen *et al.* 2011).

Finally, further research is needed in how stakeholder participation can enhance maritime safety policymaking among policymakers as well as the different NGOs and citizens. Recent social science theories, such as political ecology, suggest that participation should be seen as the core value and foundation of environmentally and socially justified policies (Adams, 2010; Gaillard and Mercer, 2012), and it is important to examine if participation of stakeholders can both enhance safer maritime policymaking as well as promote social and environmental justice. The environmental justice approach focuses on the stakeholders', such as the local inhabitants', right to take part in defining risk levels and the potential impact of participation in promoting policymaking based on participation, transparency and equity. In addition, further research is needed in examining the role of IMO in maritime safety governance, as well as the role of national and regional scale governance, and how bridging the gap and improving the communication between the actors on different scales can enhance maritime safety policymaking.

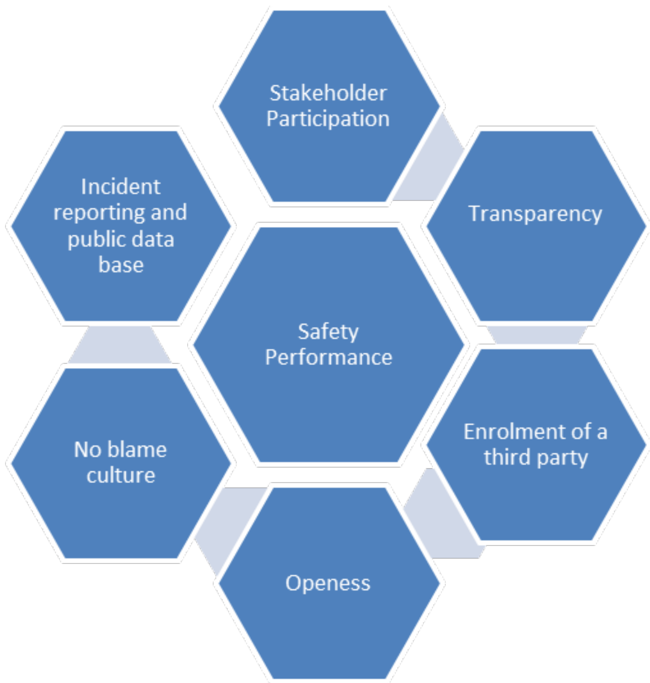

Figure 1. Some of the different human factors contributing towards enhancing safety performance in shipping industry, discussed in the of the WGMAB meeting.

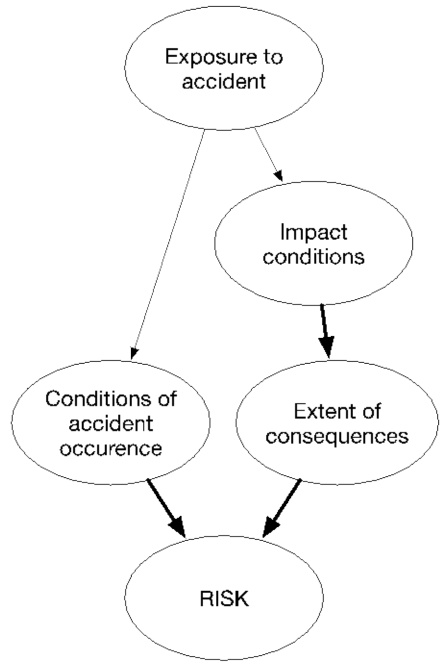

Figure 2. The minimum causal relations existing in maritime transportation risk models.

3. Spatial modelling: Using different data sources in species distribution modelling

3.1 Spatial models in oil spill modelling

Knowledge about the distribution areas of species under danger is vital when assessing the risks posed by possible oil spills to the ecosystem. Obtaining useful estimates of species distribution by traditional observational means is demanding because surveys are expensive and time-consuming. However, wide scale high-resolution models that quantify the relationship between a species occurrence and environmental characteristics may be used to complement the survey work, and improve the capacity of future surveys (Vanhatalo *et al.*, 2012, Juntunen *et al.*, 2012). The model should give predictions at surveyed locations and highlight the environmental variables explaining the occurrence. These can then be used to guide management decisions concerning oil risks.

Current development in the Geographic Information System (GIS) technology provides us increasing amount of data and efficient tools to collect and visualize spatial and spatio-temporal data on environmental variables on thematic maps. However, in many situations of practical interest, especially in marine areas, the available useful data are patchy, sparse or totally missing. In such situations, we need to be able to fuse complementary sources of information, including, e.g., scientific survey and voluntarily collected citizen science data as well as expert information, in order to build useful knowledge for risk assessment. However, the most common species distribution models (SDM), such as the Maximum entropy (MaxEnt) or generalized additive models (Elith and Leathwick, 2009), are rather restrictive on data they can process, for which reason it is hard to combine information from alternative sources. Expert knowledge is especially important in cases, where focus is on rare and threatened species, i.e. cases where the available population observations are sparse. Hence, we need novel probabilistic modelling techniques.

For example, in case of an oil spill the preventive and clean up actions should be planned according to vulnerability, protect-ability and recovery potential of populations at risk (Ihaksi *et al.*, 2011). This leads to a high dimensional decision problem where limited preventive and clean up resources should be allocated so that the loss to the environment (and infrastructure) is minimized. Moreover, these decisions need to be done under great uncertainty due to a lack of detailed information about the environment at risk. By reducing this uncertainty the decisions about, for example, oil booming actions could be planned better, which would reduce the expected ecological loss in case of an accident. Moreover, according to the precautionary principle the management should be the more conservative the more uncertain we are of its consequences (Burgman, 2005). Thus, theoretically sound and efficient risk management requires realistic uncertainty estimates.

When combining different data sets the model should explicitly account for the data collection procedures. Apart from classical well-structured survey setups, this is possible, in theoretically justified manner, only with probabilistic hierarchical model structures (e.g., Gelman *et al.*, 2013; Kuikka *et al.*, 2014). Just recently Juntunen *et al.*, (2012) introduced a hierarchical Bayesian SMD to combine acoustic and trawl survey data and Pagel *et al.* (2014) an SDM that integrates both long term count data and opportunistic occurrence records from a citizen science programme.

However, these recently introduced methodologies need to be developed further to fuse information from different kinds of data, including, e.g., survey, voluntarily collected observational and censored data. Moreover, fusing expert knowledge with various data sets, and to plan future surveys cost efficiently is mandatory in many cases (see Figure 1). Expert elicitation is commonly used in environmental risk management analysis to inform on, typically, small sets of functional model parameters (Lindley 1983, O'Hagan *et al.*, 2006, Mäntyniemi *et al.*, 2013) but not in spatial settings where, e.g., the distribution of a species is continuous spatial plane or, in discretized setting, corresponds to thousands of end variables.

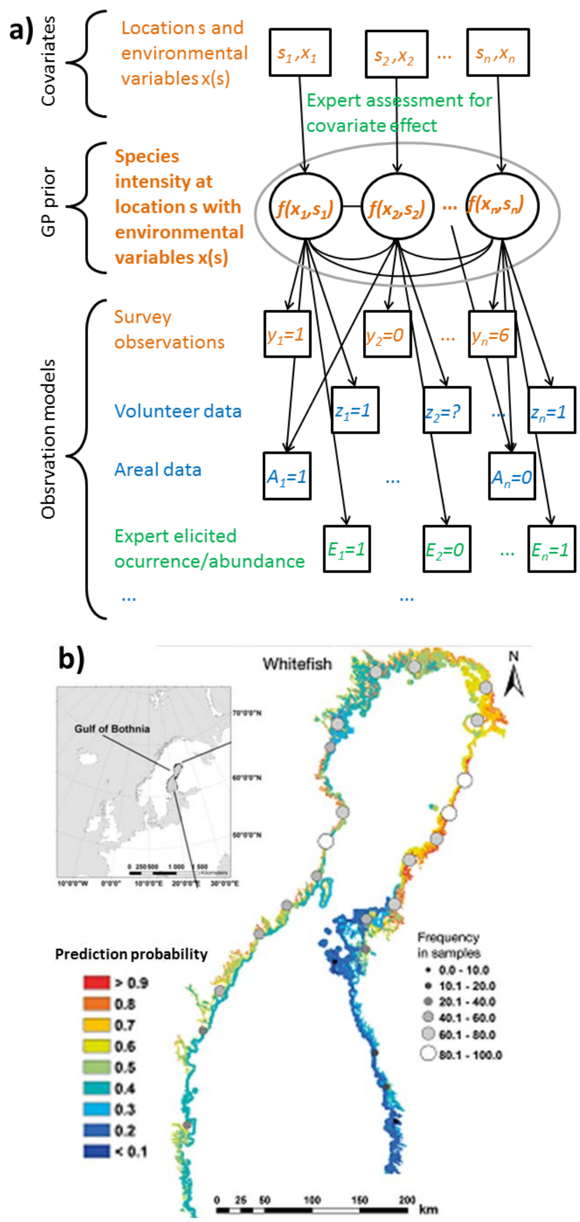

Figure 3. a) A schematic picture of fusing alternative information sources and b) example SDM predictions by Vanhatalo *et al.*, (2012) showing the probability of white fish reproduction area. In the schematic picture, the arrows denote conditional dependence, lines (unconditional) dependence, boxes variables that are treated as observations and circle the species intensity at specific locations. The elements of traditional SDM are denoted by orange. Examples of the new data sets and expert knowledge to be included into the SDM are denoted by blue and green, respectively.

The current state-of-the-art in developing information systems for oil spill management focuses on situation awareness and common operating between multiple agencies (This can be seen for example from the programs of conferences such as Interspill). In essence, the existing systems are more targeted towards operational use and supporting operative decisions with information. The current systems are also rather indifferent to the risk that oil spills pose to coastal biota. They include, at most, map layers of sensitivity of coast to oil spills (Venesjärvi et al, submitted).

Our analysis results indicate that the operational policy must be based on risk assessment done in the context of contingency planning, where the spatial probability of oil spills is analysed together with spatially distributed ecological values. Also, the valuation of coastal biota under the threat of oil spills, and taking into account their protect ability with oil spill combating equipment and other issues, is a complex task. The ecological value at one location is a relative value, usable only in comparison to other locations in regional analysis.

Carrying out a spatial risk assessment in oil spill contingency planning requires the estimation of the risk of each piece of coastline to become oiled and the estimation of its relative ecological value (Ihaksi 2011). Such an assessment sets several requirements for information systems, which can only be satisfied with a complex set up of databases, analytical tools and models. In our case the main tool for estimating the spatial probability of becoming oiled was a physically based oil drift simulation model. The set of initial conditions (location, type of oil, spill size, etc) that were used was based on analysis of accident data and expert judgement and they were developed into a Bayesian network (Lehikoinen *et al.*, 2015). Data exchange between the simulation model that was used and the rest of the information system was based on files and in any case the time required for running the simulations was considerable. Our estimation of the relative ecological values along the coast was based on a database that was compiled from nine source databases. Each source database is maintained and updated in different agency or NGO. The estimation comprised several complex steps, which each required expert knowledge: deciding what data to use and how, and deciding how to compute the relative ecological value. So far we have based out estimation solely on observations and not used any species distribution models.

An information system aimed at supporting decisions is commonly called a decision support system (DSS). The theory and practice of developing DSS is large, but typically a DSS attempts to combine the use of models or analytic techniques, data access, and interactive use for solving decisions.

3.2 Information needs of spatial models

Several experiments have been carried out in GoF to develop DSS for oil spill risk management. These are the elements that have been used in the tools:

- possible locations of accidents:
  - points, selected by expert judgement supported by accident databases; need to be points because these were used as spill locations in the simulation models
- probability of accidents of various types at the locations:
  - modelled with a Bayesian network (BN), essential variables in BN link to simulation model parameters
- fate of oil spills:
  - physically-based simulation model run many times with historical weather data

- assessment of spatial probability of becoming oiled:
  - simulation model data averaged and result output to a ~ 3km x 3km grid cells
- use of combating equipment:
  - not in any integrated tool (that we developed); analysed using separate tools using oil spill trajectories
- values to be protected
  - IUCN endangered species that are vulnerable to oil spills
- locations and existence of values
  - observation database (species and habitats) compiled from nine original databases, which are maintained by different agencies or NGOs
  - no modelling so far
- dynamics of the values (migratory birds etc)
  - expert knowledge encoded into the database
- combination and weighing of the values (sensitivity to oil spills, incl. recovery & protectability)
  - expert knowledge encoded into computational tools
- communication of the information and results (visualization etc)
  - desktop or web gis

4. Spatial analysis done in the GOF

In maritime risk management and spatial planning, interdisciplinary approach is necessary. Ecological knowledge based on marine biology and fisheries sciences need to be combined with information of human actions and their pressures. In addition to natural and engineering sciences, these can be analyzed by the means of social sciences and economics. Finally, intelligent and interactive spatial applications are required in communicating this knowledge to stakeholders and decision-makers. Relevant information need to be collected in advance, analyzed, and taken into account for adequate spatial management of maritime risks. This can be divided into spatial risk analysis, preparedness planning and operational phase.

Game *et al.* (2013) describe six common mistakes in conservation priority setting, and one of them is not to acknowledge the risk of failure in conservation actions. To overcome this, Kokkonen *et al.* (2010) presented a dynamic mapping application to support decision-making related to the spatial allocation of oil retention booms after an oil accident. Prioritization of coastal ecosystem is based on the OILECO index developed by Ihaksi *et al.* (2011). This index takes into account the conservation values of different occurrences of threatened species in the Gulf of Finland, the oiling probability of species occurrences, and the estimated recovery potential of occurrences after an accident. Furthermore, it considers how effective oil booms are in safeguarding the occurrences of specific species. The system combines the concepts of value-of-information and value-of-control, which are the key concepts in planning any risk-aversely defined management system aiming to manage complex systems like maritime risks in our case.

The most interesting, and also applicable side, of the OILECO index presented by Ihaksi *et al.* (2011) is the fact, that it includes the relative nature value (IUCN status), the technical possibility to safeguard the population by existing methods (in this case oil retention booms) and the recovery potential, that is how likely it is that a lost species will recover locally or move back from some other areas. The genetic methods will likely be able to describe how much the populations mix and how long the populations have been separated. However, such analysis of metapopulation dynamics must be done well in advance of any main spills, to understand how costly it is to restore the populations or get them back from other areas. Such maneuvers are highly expensive, and they could be used as an essential element to increase the interests of insurance companies and industry to avoid catastrophes and thereby support best practices in policy.

Lehikoinen *et al.* (2013) assessed, using Bayesian networks, the recovery efficiency and the optimal disposition of Finnish oil combating vessels in the Gulf of Finland. Graphical probability model includes four different ports, five estimated accident hot spots, and ten vessels. Study indicates that the spatial placement of vessels does not have a significant effect on the recovery efficiency of oil. Instead, the efficiency is more affected by weather and for example wave height. It is noteworthy that the distances between ports and accident hot spots are shorter in the Gulf of Finland than in the Arctic or Antarctic.

Jolma *et al.* (2014) conducted a spatial risk assessment to study the risk that tanker accidents pose to threatened species in the Gulf of Finland. This study combines Bayesian networks describing accident uncertainties, probabilistic maps of drifting oil and a database of species sensitive to oil. Helle *et al.* (2015) further developed the assessment by including updated tanker accident network, new estimated accident hot spots from the Baltic Sea, and also a database of threatened habitat types which are some of those very few elements of ecosystem which have a legal position in Finland, and therefore it can be argued that this decision criteria must be used in operational and strategic oil risk management. These analyses will suggest what types of elements are needed to legislation so that the interests of the society are taken into account. In many existing scientific approaches, those species which have easily an important role in media are used as criteria.

These analyses show the importance of comprehensive risk analysis, which is not based only on one or two factors. Providing this kind of assessment produced by probabilistic methodologies is of interest for stakeholder groups who cope with various types of uncertainties typical for maritime risk management.

A common solution in the oil contingency planning is to create sensitivity maps, which include elements based on the physical characteristics of shoreline, ecological values in the coastal area or the combination of these (Leiger *et al.* 2012, Jensen *et al.* 1998). In practice, the aim of these maps is to demonstrate the locations of most valued nature. However, often the areas presented are too large and difficult to safeguard with current methods. This makes the response actions less efficient.

Altartouri *et al.* (2013) presented an application of geospatial web services developed for responding to the ecological risk posed by oil spills, focusing on the Gulf of Finland and the Finnish Archipelago Sea. By using the on-site OILRISK map application, oil response officers are provided with the knowledge of local nature values. This is a great advantage in in-situ decision-making. The logic of prioritization in the application was partly based on Ihaksi *et al.* (2011) and developed further by Venesjärvi *et al.* (submitted), who included threatened habitat types and improved risk estimates and index calculation. The both index logics suggest that limited oil combating resources should be targeted at areas with a high number of threatened species and habitat types having a low recovery potential. In addition, measures should be used to safeguard species that benefit from protection. The use of oil combating applications requires accurate, up-to-date and usable ecological information. This should be stored and managed in accessible national and international databases. In remote areas such as outer archipelago or even Polar Regions safeguarding actions are difficult to carry out. In these situations, risk assessment and preventive measures are more important than rapid oil spill response.

Ecosystem-based maritime spatial planning perceives multiple usages of oceans and possible contradicting objectives. In planning, risk analytical approach is required and it should have a strong scientific basis. As ecosystems are complicated systems and effects of human pressures uncertain, probability models provide a suitable method for planning tool development. By combing knowledge from experts, field surveys, experiments, data analysis and modelling, probability models and spatial tools can be developed in order to implement risk analytical maritime spatial planning. Venesjärvi *et al.* (submitted) developed a spatial planning tool prototype (TOPCONS), which includes all above-mentioned aspects. The tool is based on a workflow combining Bayesian networks and geographic information systems (GIS). GIS data includes mapped geological and biological survey data, predicted species occurrences and spatial estimations of environmental effects of maritime traffic. Furthermore, the Bayesian networks estimate the quantitative loss caused by human pressures. Successful maritime spatial planning may prevent the maritime risks or at least decrease the harmful effects caused by cumulative effects of maritime traffic and other human activities. For maritime risk management, updated spatial accident probabilities are required. Lehikoinen *et al.* (2015) assessed comprehensively the collision-induced risk of an oil accident in the Gulf of Finland.

In future, need for scientific improvements exist in spatial risk analysis. Geological and biological survey data could be described as abundance probabilities, not as classes or presence observations. Thus, the information is more representative. Moreover, spatial modelling of the other effects than oil spills of maritime traffic should advance to traffic-based instead of ship-based. In addition, common ecosystem interactions and cascade effects should be considered. This recalls for the combination of oil spill environmental risk assessments with ecosystem models.

5. Cost benefit models for planning management actions

Two common approaches to assess economic viability of a specific project are cost-effective analysis (CEA) or cost-benefit analysis (CBA). The main aim of CEA is to find a way to achieve a given target with minimum costs or the maximum effect with a given budget, whereas CBA compares monetized costs and benefits. Although the basic idea of both approaches is fairly simple, the irregular occurrence of maritime accidents and high uncertainty related to subsequent consequences pose additional challenges to analyses. Furthermore, in CBA we need to describe costs and benefits in monetary terms, which can be a difficult task especially if non-market goods like biodiversity are involved. In these cases e.g. contingency valuation methods can be used.

In the Gulf of Finland the economic aspects of oil spill management have not been studied extensively, yet some studies and national reports exist. For instance, Ahtiainen (2007) conducted a contingency valuation survey, which estimated the Finnish citizens willingness-to-pay (WTP) for the improvements in oil combating capacity. Montewka *et al.* (2013) published estimates on oil combating and clean-up costs in the Gulf of Finland, and the costs were re-estimated and complemented with waste treatment costs and environmental losses by Helle *et al.* (2015). Haapasaari *et al.* (2014) have published preliminary results related to cost-effectiveness of selected management measures capable of reducing oil spill risks.

In order to assess the economic viability of one preventive and one post-spill measure, Helle *et al.* (2015) conducted a probabilistic CBA using Bayesian Networks (e.g. Jensen 1996, see also e.g. Kuikka *et al.* 1999) as a modelling approach that enables causal description of the problem, explicit handling of uncertainty and the incorporation of different kinds of knowledge in a single framework. The preventive measure in the analysis was a hypothetical alarm system to be incorporated into the VTS (Vessel Traffic Services) system, which would give an alarm when two vessels were in a collision course and which would thus affect the probability of a spill (Lehikoinen *et al.* 2015). The post-spill measure was a new oil-combating vessel capable of recovering oil independently at open sea. The model covered tanker grounding and collisions with other vessels, and included oil leaks from cargo tanks.

The benefits of management resulted from the expected decreases in the costs of offshore and shoreline oil combating, waste treatment operations and environmental losses. The latter were estimated by using data from a contingency valuation survey (Ahtiainen 2007). The costs of management included purchase and maintenance costs of the studied measures.

Various sources of information were employed in the model. These include e.g. models concerning accident frequencies in the Gulf of Finland and the efficiency of the oil combating fleet with and without the new vessel, wave height statistics, expert estimates on future traffic volumes and purchase cost of the alarm system.

The approach seems a promising way to conduct CBAs and CEAs in situations where uncertainty plays a major role. The model can also be linked to other Bayesian Network models (see other sections of the report) to provide economic understanding to the modelling approach applied by the Merikotka research unit in Finland. However, there is still need to improve the knowledge and fill information gaps related to many aspects of the issue. For instance, the analyses would benefit from better accident frequencies estimates, and there is also a clear need for a comprehensive analysis of various kinds of socio-economic and environmental consequences (e.g. the effects on recreation, fisheries, tourism and other livelihoods).

6. Developing biodiversity-based utility functions

Selecting an appropriate approach to value the environment in the risk analyses is not a simple task. Also the harm (i.e. the loss element of the risk) caused by an oil accident can be evaluated having divergent objectives in mind (Lehikoinen *et al.* 2015). A notable question here is whose loss should be taken into account (Burgman, 2005). Even within one objective, numerous alternative perspectives can be taken. On the other hand, in the long run it is often difficult to separate the utility of human society from the well-being of ecosystem (Laurila-Punt *et al.*, 2015).

Biodiversity is recognised as a cornerstone of healthy ecosystems (Kremen, 2005; Worm *et al.*, 2006; Pinto *et al.*, 2014) and preventing the loss of biodiversity is becoming one of the important aims of environmental management. When the potential losses in terms of biodiversity are expressed, there is a need to assign a quantitative value of biodiversity. From a decision-analytic viewpoint, there are three perspectives of biodiversity valuation: socio-cultural, economic, and ecological indicator approaches (Laurila-Pant *et al.*, 2015). The socio-cultural values of biodiversity can serve as a tool to provide information of the most relevant ecological characteristics for the society (Cárcamo *et al.*, 2014). The monetary valuation approach aims to quantify the impact of a change in biodiversity on our economy or human welfare (Martín-López *et al.*, 2007).

The two main classes for valuing biodiversity in monetary terms are the use values (e.g. food, timber, medicine, storm protection, natural water filtrations) and the non-use values (the option to use ecosystem services in future, existence value) (Pearce and Moran, 1994). The value of biodiversity can be quantified in monetary terms by using direct market valuation techniques (Bertram and Rehdanz, 2013), but if the environmental goods do not have direct market prices, the value can be inferred using consumer preferences (Nijkamp *et al.*, 2008). The ecological value of biodiversity can be measured using the classical biodiversity indices, which describe the richness and distribution of species (Heip *et al.*, 1998) or using the biodiversity indicator approaches that define the ecosystem health by using specified criteria. In the Gulf of Finland, indices to assess the oil combating prioritization of nature values have been developed (Ihaksi *et al.* 2011, Altartouri *et al.* 2013, Venesjärvi *et al.* submitted). These indices take the biodiversity into account via threatened species and habitat classification (Rassi *et al.* 2010) and the recovery potential of those. In maritime risk analysis, it is important to notice the environmental values that maritime accidents pose a special threat to.

Multi-criteria assessment (Kiker *et al.* 2005) is an option, where several objectives or perspectives are taken into account at the same time, trying to find a solution that minimizes the total loss. By integrating all three above mentioned valuation perspectives into an ecosystem-based management (EBM) framework, we are able to recognise the complex and multi-dimensional nature of ecosystem along with the social and economic aspects (Gregory *et al.*, 2013). Although, suitable set of assessment criteria and the best method for conducting the risk and decision analyses are always case specific, thus the context and the exact research question should always be kept in mind when the choices are made (Laurila-Pant *et al.*, 2015).

7. Linking population models and experimental data: Bayesian techniques

Hierarchical Bayesian meta-analysis (HBMA) is one of the most powerful tools when it comes to rigorous knowledge transfer from well-studied systems and cases to those with less information (e.g. Punt *et al.* 2011). For example, the vulnerability of a species to oil contamination may be known for some species but not for species occurring at the area of interest. If species can be grouped based on their physiological characteristics, it may be concluded that within each group the vulnerability between species can be thought to vary according to a probability distribution for which the mean and variance are not known exactly. Having experimental or observational data from a subset of these species will then help to estimate the mean and variance of the group and consequently imply a predictive prior distribution for the species with no data (Figure 4). Such a hierarchal structure can be expanded further by considering the idea that means of species groups would also be random draws from a distribution that describes the variation across species groups. This enables the transfer of information even between groups of species, but with higher uncertainty. This learning between species is potentially useful when there is a need to get estimates for threatened species, which cannot be used in laboratory experiments.

HBMA has been utilized for about two decades in fisheries stock assessment (Pulkkinen *et al.* 2011). The latest developments include multivariate analyses of many population specific attributes that may be correlated due to evolutionary pressures (Pulkkinen *et al.* 2011, Kuparinen *et al.* 2012). For example, fish species that spawn very high numbers of eggs can be expected to have lower survival of eggs and young fish than species that carry lower numbers of eggs. Another recent innovation has been to acknowledge that typically the population specific parameters cannot be known precisely but are to be estimated using a population dynamics models. Thus, in order to fully utilize HBMA, the hierarchical modelling should be coupled to population dynamic models of different populations (Thorson *et al.* 2014).

In addition to the assessment of oil-induced consequences in the ecosystem, HBMA could also be utilized in the context of risk assessment of vessel traffic and in engineering decisions within ship design. Vessels of certain type could be seen analogous to species groups so that practical experience about e.g. crashworthiness of individual ships can be transferred to other ships of similar type, and with an addition of more uncertainty to ships of different type (Figure 5). Such learning from experience has been utilized in engineering design problems in other fields (e.g. Wijedasa and Kemblowski 1993, Rajabalinejad and Spitas 2013), but maritime applications do not exist yet.

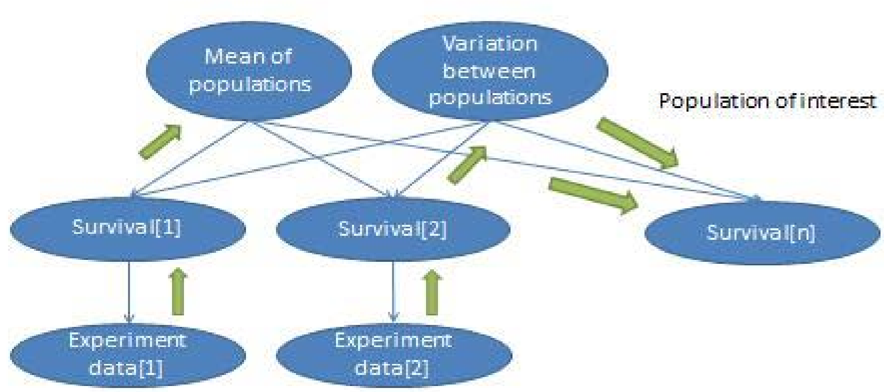

Figure 4. A probabilistic Bayesian estimation model to estimate survival from two independent databases.

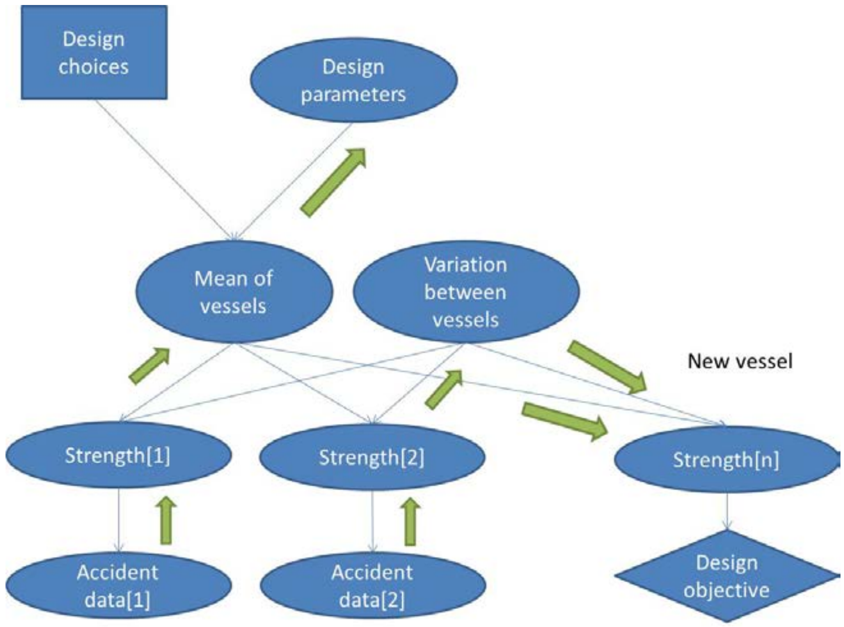

Figure 5. A probabilistic Bayesian network model describing the strength of a vessel with different vessel structures, including a decision on design choices.

8. Current databases of maritime activities in Finland and in HELCOM

Maritime transport data is used as background information for maritime risk assessment in Finnish Transport Safety Agency. Our national databases cover information such as ships port of calls, AIS transmissions and harbour figures. This data can be sorted out e.g. per type and size of the vessel and routes that they are navigating. This helps to evaluate the potential locations of future accidents and their consequences. Main sources of maritime transport data are European Marine Safety Agency (EMSA) and Finnish Transport Agency. Similar data is also available from Russia and Estonia.

Flag state and Port State Control data is valuable when evaluating, how well the shipping companies and vessels that are navigating in the Finnish territorial waters and in the Gulf of Finland, comply with international rules and regulations. Even that compliance is not a guarantee of safety; it is a basic requirement for safe maritime operations. It has been studied that the probabilities of detecting zero deficiencies of all deficiency types are higher if the inspected ship has not been involved in accidents than if she has (Hänninen & Kujala, 2014). Sources of these databases are EMSA, ParisMoU and Finnish Transport Safety Agency. From Lloyd´s List Intelligence data service, shipping companies and vessels hull risk profiles are also available. This is an interesting extra source for evaluating compliance issues.

Traditional safety science (Safety I) defines safety as a condition where the number of adverse outcomes is as low as possible (Hollnagel 2014). In Finland this type information consists of accident investigations, which are done by the Safety Investigation Authority and data provided by the Finnish Transport Safety Agency. From HELCOM and Lloyd´s List Intelligence data sources it is possible to have accident data of the whole Baltic Sea area. By investigating and analysing maritime accidents, agencies try to promote general safety and prevent any new accidents from occurring. Recently Finnish Transport Safety

Agency has made a lot of effort to get more information about near miss and hazardous events. This kind of information is widely used in air traffic risk assessments that are more sophisticated than maritime risk assessments. Great challenge is to make mariners tell about their own mistakes as e.g. the blame culture in maritime sector is still strong.

There may be a need to make the databases of insurances companies' public, to be able to identify practices that do not follow best available techniques. Such information may be valuable for the discussions of NGOs and those actors that create main risks for marine environment, like suggested in section 8 of this appendix.

New safety science (Safety II) defines safety as a condition where as many things as possible go right. (Hollnagel 2014). This new way of thinking aims to reinforce the traditional "find and fix" and "drift into failure" approach. Finnish Transport Safety Agency has an ongoing project, where some of the Safety II elements are included. The data used in this project consists of Finnpilot Pilotage Ltd and VTS near miss reports and mariners interviews. The potential with this new approach can be considered high since in the Gulf of Finland there are approximately 0.7 accidents per 1000 ships port of calls, which means that rest of them goes right.

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The actors in marine companies (e.g. mariners, pilots, etc.) may provide valuable information for risk analysis with expert knowledge, if actors are motivated well by the companies. They should be made to have an interest to avoid risks, and the insurances and the vetting practices of e.g. oil companies are often more strict than those of officials. This shows, that the legislation is not actually used as main driving force to decrease risks. It is rather the interest of private companies to do their best. Current knowledge suggests, that e.g. big oil companies are stricter than any insurance companies. This may indicate that the oil companies take into account their brand value, as the insurances and international oil foundation cover the damages to 830 million euros if Finnish partner is guilty and 225 million if Russian partner is guilty. This is due to the fact that these two countries belong to different foundations. Increasing this limit and making the business to be public are likely effective ways to take care of the risks. This may need careful planning of international maritime legislation by the existing experts. Such expertise is needed to WGMABS next meeting.

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9. Possible new governance model for the Baltic Sea: new role of science?

This text is a summary of the Haapasaari *et al.* (2015) and Haapasaari *et al.* (2014).

A proactive approach is proposed for improving maritime safety (Haapasaari *et al.* 2015). This means that adjustments are made before accidents occur rather than after, and it requires anticipating events or conditions that could lead to accidents. As the future is uncertain it is, however, difficult to know what kind of disasters could happen and what kind of preparations should be made. Thus, a proactive policy making approach is based on a formal process of identifying, assessing, and evaluating risks, and focusing adjustments on those risks that are evaluated unacceptable. Proactive approaches to decision making are predominant *inter alia* in the nuclear sector (Keller and Modarres 2005) and in fisheries management (Francis and Shotton 1997). A proactive approach enables creating a holistic picture of a socio-ecological or a socio-technological system, its failure modes and uncertainties, and taking decisions based on that.

The nuclear industry uses probabilistic risk assessment (PRA) to locate the weaknesses in safety system of an individual power plant, and to allocate resources to correct the problems. PRA builds accident scenarios to assess and evaluate risks that could lead to nuclear fuel damage, using event or fault trees or other logical diagrams, and all available evidence as well as expert judgment (Garrick and Christie 2002; Kafka 2008; Modarres 2006). Then, measures to avert, control or minimize the risk are evaluated through subjective judgments and/or formal techniques (e.g. cost-benefit/risk effectiveness/multi-objective decision analysis); (Modarres 2006). The impact of the implemented strategy is monitored and measured over time, and adjustments and revisions are made, if necessary. The PRA is continuously updated, which makes risk management a continuous cyclic process (Modarres 2006; IAEA 2001). Conducting the PRA is the responsibility of the organization operating the nuclear power plant, and a peer review of the PRA by independent experts and/or national radiation and nuclear safety authorities is an essential part of the process (Apostolakis 2004). Preparing and conducting a PRA requires using both internal (plant operations) and external (e.g. environmental conditions) information as well as state-of-the-art methods, scientific knowledge and other relevant information (IAEA 2001; Kafka 2001).

Fisheries management utilizes scientific stock assessments in controlling the risk of overfishing (Wilson 2009). In the EU, the main risk control measure is the total allowable catch (TAC), which is the largest yearly catch that a fish stock is assumed to sustain, and it is defined annually or bi-annually for each commercially relevant fish stock. Decisions on the next year's TAC are taken in the previous year. Defining a TAC includes assessing the biological status of the stock and its implications to fishing, evaluating the status of the assessed stock against the agreed harvest control rule, and considering how the risks related to the stock can be avoided.

The stock assessments are conducted by the International Council for the Exploration of the Sea (ICES), which then summarizes the peer-reviewed results in a scientific advice, as requested by the European Commission's Directorate General for Maritime Affairs and Fisheries (DGMARE); (Wilson 2009). The combined stock assessment and biological management advice is reviewed by the Scientific, Technical and Economic Committee for Fisheries (STECF) that potentially adds economic information to its review report, even though STECF usually has no time or resources to carry out an economic analysis for the required advice.

A relevant Regional Advisory Council (RAC), expresses stakeholders' view(s) on the advice and its impact on the fish stock, fishing, and the fishing livelihood (Linke *et al.* 2011). Based on the scientific advice, and the statements of the STECF and the RAC, the DGMARE finally considers the tolerability of the risk, and makes a decision proposal for the Ministerial Council, which then takes the decision. The decision must be consistent with the Common Fisheries Policy and possible species-specific agreements (Wilson 2009). The agreed risk levels vary between agreed harvest management plans, but an indicator of risk is usually obtained from simulation models and their estimated probability distributions.

In the maritime field, proactive risk governance should take place at the regional level, to complement the current national and international level prescriptive policy making. This is because maritime risks are to a great extent of a local or regional nature. Environmental conditions (waterways, marine weather, visibility, traffic density/volume etc.), in addition to human and technical factors, are major causes of maritime accidents (Hetherington *et al.* 2006, Kujala *et al.* 2009). Local/regional environment is also a major victim of accidents, the consequences of which must be withstood and taken care of by the local society. The local or regional dimension of risks is particularly evident in gulfs, bays, fjords, and other rather enclosed sea areas, where the accident risk is considerable and an accident occurring anywhere concerns the whole area and its people. In such areas, the international policy regime is not adequate for managing risks.

Governing regional maritime risks at the regional level might lead to better results in maritime safety. A regional governance framework would enable viewing maritime safety as a holistic system, and assessing risks using scientific methods. Risk assessment would require a committed scientific body for conducting the work. In addition, state-of-the-art methods, and available up-to-date information of the regional risks would be needed.

In this report, the Bayesian approach to maritime risks is presented by using several examples from the Baltic Sea. Three types of databases would provide for the information required in the risk assessments: 1) Incident and near miss reporting systems, 2) Risk databases for reporting any kinds of potentially unsafe acts or conditions by a wide variety of users, and 3) Data regarding normal situations, based on monitoring and measuring safety performance and the effect of the implemented decisions. Risk assessment also requires agreeing risk assessment criteria, and the acceptable and tolerable risk levels before any recommendations can be given (informative utility function in risk, i.e. probability, model). Such limits should be defined for evaluating loss, and for defining limits for acceptable risk to individuals, the society, and the environment. Criteria and their mutual weighting are also needed for ranking alternative risk controlling measures. For bringing in both relevant knowledge and values for identifying and evaluating risks, strong stakeholder contribution and an effective communication between stakeholders is needed.

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Annex 3: Recommendations

Recommendation 1): WGMABS proposes a theme session to ICES ASC 2017 by name: "Interdiscplinary risk and knowledge analysis of oil disasters: how to maximize preventive interests" to be chaired by Dr Sakari Kuikka (Finland), Dr Ari Jolma (Finland Biwatec ltd, Dr Ken Lee (Australia).

Recommendation 2): the interests of IMO to become active member must be requested, as well as those of international oil and maritime insurance companies. Especially expert of marine legislation should be found.