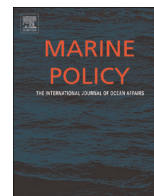




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A proactive approach for maritime safety policy making for the Gulf of Finland: Seeking best practices



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ABSTRACT

A rapid increase in maritime traffic together with challenging navigation conditions and a vulnerable ecosystem has evoked calls for improving maritime safety in the Gulf of Finland, the Baltic Sea. It is suggested that these improvements will be the result of adopting a regionally effective proactive approach to safety policy formulation and management. A proactive approach is grounded on a formal process of identifying, assessing and evaluating accident risks, and adjusting policies or management practices before accidents happen. Currently, maritime safety is globally regulated by internationally agreed prescriptive rules, which are usually revised in reaction to accidents. The proactive Formal Safety Assessment (FSA) is applied to risks common to a ship type or to a particular hazard, when deemed necessary, whereas regional FSA applications are rare. An extensive literature review was conducted in order to examine the opportunities for developing a framework for the GoF for handling regional risks at regional level. Best practices were sought from nuclear safety management and fisheries management, and from a particular case related to maritime risk management. A regional approach that sees maritime safety as a holistic system, and manages it by combining a scientific risk assessment with stakeholder input to identify risks and risk control options, and to evaluate risks is proposed. 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.

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1. Introduction

The global economy is based on an efficient transportation of goods among countries and continents, and today over 90% of the world's trade is transported by sea [1]. However, intense maritime traffic can have negative consequences, such as vessel accidents potentially leading to a loss of life and cargo, and detrimental impacts on the environment. Thus, there is an ever growing need for maritime safety measures to prevent and mitigate harmful consequences.

In the Gulf of Finland (GoF) in the Baltic Sea, rapidly increased maritime traffic has evoked calls for improving safety by adopting a regionally effective proactive approach to policy formulation [2–4]. In this context, safety refers to the absence of maritime accidents that can cause harm to the ship/cargo, humans/society

and/or the environment. The risks of accidents in the GoF are seen as high, because the environmental conditions and high traffic volumes make navigation challenging [5], and because the ecosystem of the area is very fragile [6]. A proactive approach to safety aims at preventing disasters by anticipating future events and adjusting policies or management practices before something happens. This, it is argued, will save economic resources, and prevent the loss of human life and environmental damage. As the future is uncertain, it is, however, difficult to know what kind of disasters might happen and what kind of preparations should be made. Thus, a proactive policy-making approach is grounded on a formal process of identifying, assessing and evaluating accident risks, and focusing adjustments on those risks that are evaluated as being at an intolerable or unacceptable level.

Maritime safety in the GoF is managed basically by the same prescriptive international regulations that are found in all the world's seas [7]. The international regulations mainly relate to ship conditions, construction and equipment, mariners and management, and navigational instruments. The global rules are set down

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by the International Maritime Organization (IMO) that brings together 168 states of the world as well as non-state actors, such as shipowners and environmental organizations, in order to achieve general acceptance [8]. At the level of the European Union (EU), the European Commission (EC) translates the regulations, determined at the IMO, into binding laws, with the support of the European Maritime Safety Agency (EMSA) [9]. Further, the rules are adapted to regional conditions by the Baltic Marine Environment Protection Commission (Helsinki Commission, HELCOM), an intergovernmental organization of nine Baltic coastal countries and the EU [7,10]. Finally, the regulations are implemented by individual nations. Only in their territorial areas (up to 12 nautical miles from the coast) do the coastal states have an extensive right to arrange and govern issues such as piloting, Vessel Traffic Services (VTS), the maintenance of waterways and safety devices, nautical charting, and weather, water level and ice services [11,7].

These international rules are widely regarded as the only possible way of managing safety at sea, because they ensure the principle of the freedom of navigation, guarantee uniform safety standards for all waters, and provide a coherent operational environment for shipping companies and seamen [11–13]. Still, the safety regime is criticized *inter alia* for being ineffective, diffuse and partial, too slow in its reactions, and incapable of addressing local shipping conditions and satisfying the needs of the most vulnerable sea areas [12–15]. The limitations are manifested in efforts by individual states or regions to implement additional safety measures in their adjacent waters [16–18,11]. Local measures are rarely supported by the IMO because they interfere with the integrity of global navigation [19,11,7].

The international regulations are of a reactive nature, which means that they are usually revised after major accidents have occurred somewhere in the world [20]. In 1997, the IMO took a step towards proactivity by inviting its member governments and non-governmental organizations to apply formal safety assessment (FSA) when deemed necessary, to support the IMO's decision making [21]. In 2002 the IMO approved guidelines for FSA [22]. FSA is defined as “a rational and systematic process for assessing the risks relating to maritime safety and the protection of the marine environment and for evaluating the costs and benefits of IMO's options for reducing these risks”. Since the initiative, a host of FSA studies have been submitted to the IMO [23–25]. As the FSA studies aim at enacting generic international regulations, they mainly focus on risks common to a particular type of ship or hazard, and rarely on risks of particular sea areas [26,27,20]. Thus,

the recommendation given by the IMO to conduct FSA provides a supportive, but not sufficient basis for a proactive approach for the GoF.

There is a need for a framework in the GoF that enables a systematic process of handling regional risks at the regional level [28,13,29]. In this paper the possibility of developing such a formal approach is discussed, by seeking “best practices” from the maritime field and beyond it. Proactive management approaches are applied *inter alia* in the nuclear industry [30], aviation [31], climate science [32], and fisheries management [33]. The authors examine the procedures of probabilistic risk assessment (PRA) of the nuclear industry as an example of a highly advanced proactive safety management approach. Defining the total allowable catch (TAC) for fisheries in the EU provides an example of a governance framework involving scientists, policy makers, and stakeholders. Finally, the Prince William Sound (PWS) case from the maritime field demonstrates how stakeholder involvement in risk management has been actively utilized in improving maritime safety.

The paper is structured as follows. Section 2 introduces the GoF area. Section 3 provides theoretical considerations for proactive safety management, and Section 4 presents the selected examples. In Sections 5 and 6 the authors derive ideas from the examples, and discuss the prerequisites, challenges, and potential benefits of establishing a formal risk governance framework for the GoF. Section 7 is for conclusions. The paper is grounded on an extensive literature review.

2. The Gulf of Finland and its safety regime

The GoF, the easternmost basin of the Baltic Sea (Fig. 1), is one of the most trafficked sea areas in the world. For instance, in 2012, 41,005 ships crossed the pre-defined Automatic Identification System (AIS) passage lines in the GoF, including 7549 tankers. In the whole Baltic Sea, there were 407,425 AIS crossings, of which about 52% were by cargo vessels, 16% by tankers, 16% by other ships, and 9% by passenger ships [34].

According to the most recent estimations, about 160 million tons of oil and oil products is transported via the GoF per year [35]. The majority of them are exported from Russia, which exports one third of all its oil via the GoF [36]. As Russia's oil production and exports are growing, it has been estimated that oil volumes being transported via the GoF may even reach nearly 200 Mt in the near future [35].



Fig. 1. The GoF covers an area of 30,000 square kilometers, and is 400 km long and 48–135 km wide.

The increasing traffic together with difficult navigation conditions in the GoF has raised concerns about shipping accidents. Routes are narrow and cross each other in the middle of the Gulf, and the seafloor is rocky, and in places very shallow [5]. Ice conditions and limited hours of daylight in winter and autumn pose additional challenges, especially for ships with crews not used to navigating in ice [37].

Statistics reveal that the GoF is one of the most accident-prone areas in the Baltic Sea. Between 2004 and 2012, 14% (54) of all reported collisions and 13% (54) of all groundings in the Baltic Sea occurred in the GoF [34], although the area concerned is only 8.5% of the whole Baltic Sea. The yearly number of collisions and groundings in the GoF varied between 0 and 15, and 2 and 13, respectively.

The ecosystem of the GoF is vulnerable to the effects of oil spills [38,6,34]. Owing to low salinity, the aquatic biota involves both saline and freshwater species, yet biodiversity is fairly low and food-webs simple [38,6,39]. There are several threatened species and conservation areas in the GoF, which is also an important migratory route for arctic birds [40–42]. The dense Finnish archipelago, seasonality, and ice cover in winter can severely impede dealing with oil spills [43,44]. Further, as the water volume is small and the renewal time of water masses fairly long [45,46], any harmful substances can be expected to persist in the GoF ecosystem for a long time.

In the globally orientated maritime safety regime, the regional role of the HELCOM in the Baltic Sea is significant. As part of its aim to protect the marine environment of the Baltic Sea from all sources of pollution, the HELCOM aims to protect the sea from the impacts of shipping [47]. It collects data related to maritime traffic, accidents and oil transportation, gives recommendations related to maritime safety and pollution from ships, and coordinates multi-lateral response in case of major maritime incidents. The HELCOM's recommendations are not legally binding, but are usually implemented by states [7]. The HELCOM has five interrelated advisory working groups [48]. Two of them focus on maritime issues: the Maritime Working Group (WG Maritime) and the Response Group (WG Response). WG Maritime aims at ensuring that the IMO's and other adopted regulations are observed and enforced effectively and uniformly, and identifying and promoting actions to limit pollution from ships and to enhance safe navigation. For this, it organizes meetings once a year in which representatives of inter-governmental organizations, non-governmental organizations (NGOs), maritime transportation authorities, and pollution incident response organizations participate. WG Maritime's subgroup, the HELCOM Group of Experts on the Safety of Navigation (Safe Nav) seeks to enhance navigational safety through regional cooperation in exchanging information, discussing and proposing measures, and providing feedback and expertise [49]. The other subgroup, HELCOM AIS administers a centralized HELCOM AIS database that records shipping traffic in the Baltic Sea. WG Response meets three times every two years, to ensure a swift national and international response to maritime pollution incidents, and to coordinate surveillance regarding sea-based pollution.

In 2007, the HELCOM launched the Baltic Sea Action Plan (BSAP) to restore the good ecological status of the Baltic marine environment, and to provide a real basis for the HELCOM's work. In addition to aims related to reducing eutrophication and hazardous substances, and improving the status of biodiversity in the Baltic Sea, the program aims at enhancing the environmental friendliness of maritime activities in the Baltic Sea [50,2,51]. The BSAP is supported by the EU Strategy for the Baltic Sea Region (EUSBSR) [52], which promotes cooperation between stakeholders and sectors, in order to improve the environmental condition of the sea. The objectives of the EUSBSR include making the Baltic

Sea a leading region for maritime safety and security, and clean shipping.

The Baltic Sea (except for its Russian waters) is one of 13 areas worldwide that the IMO has designated as a Particularly Sensitive Sea Area (PSSA) that needs special protection from the hazards of shipping [19,53]. Other PSSA areas are inter alia the Great Barrier Reef (Australia), the Wadden Sea (Denmark, Germany, and The Netherlands) and the Galapagos Archipelago (Ecuador) [54]. The PSSA status justifies specific measures that are approved and adopted by the IMO, to be used to control maritime activities in the area. The measures can relate for example to routing, ship reporting, or discharge and equipment requirements for ships [54]. Since the designation in 2005, directly PSSA-associated protective measures have not been implemented in the GoF, but in the Southern Baltic Sea the status has brought traffic separation schemes, a deep-water route, and areas to be avoided [53]. The need for the PSSA system has been seen as an additional sign of the failure of international regulation in addressing regional/local shipping conditions [19,13].

The International Convention for the Safety of Life at Sea (SOLAS) of the IMO recommends Vessel Traffic Services (VTS) for areas in which the volume of traffic or the risk of accident is high [55]. In the GoF, automated VTS centers have operated in Helsinki, St. Petersburg, and Tallinn since the 1990s [56,7]. Their purpose is to interact with vessel traffic and respond to traffic situations in their operational area, in order to improve the safety and efficiency of traffic and to protect the environment. A mandatory ship reporting system (GOFREP) for monitoring ship movements in the international waters of the GoF was established under the framework of the IMO in 2004 [53]. Recently, a regional project led by a private foundation has developed an Enhanced Navigation Support Information (ENSI) service for the GoF [57,58]. The ENSI service aims at enhancing information exchange regarding, for example, routes and weather conditions between ships and the VTS center, and it is currently in test use. Piloting, which is regulated nationally, is compulsory in the GoF within defined pilotage areas for all tankers that carry dangerous cargo. Pilotage services, as with ice-breaking assistance services, are organized by the coastal states [7].

Elevated concern about shipping accidents in the GoF has also seen a response in the form of investments in the ability to respond to pollution and in salvage operations. Finland, for instance, has altogether 19 oil-combating vessels capable of recovering oil independently at sea, and additional assistance can be requested from neighboring countries and the European Maritime Safety Agency (EMSA) [59]. The Contracting Parties of the HELCOM also have regular joint oil response exercises. In addition, three incident and near-miss reporting systems have been established in the Baltic Sea area during the 2000s, to provide insights about conditions in which errors take place: one in Denmark (Nearmiss.dk), one in Sweden (Insjö), and one in Finland (ForeSea). Their significance in terms of safety management has, however, been minor as seafarers' motivation to report problems is low due, for example, to the blame culture that still exists within the maritime industry [60,61].

Research related to shipping safety and related risks in the GoF has been active during the 2000s. These studies have (1) assessed the causes and likelihood of shipping accidents [62,5,63], (2) analyzed the consequences of accidents for ships and/or passengers [64–66], or the ecosystem [67,6], and (3) evaluated risk control options and provided recommendations for policy [28,68–73]. Several studies have focussed on oil combating [43,44,74], incident reporting [60,61], and safety policy instruments [13,75].

Of the above mentioned, the studies by Hänninen et al. [69] and Jalonen and Tirkkonen [70] were commissioned by government authorities responsible for maritime safety, and explicitly followed the FSA's steps; the first mentioned was also submitted

to the IMO. Most of the other studies are research-driven and not bound into actual policy processes. The studies are highly relevant for maritime safety in the GoF, but their direct impact on policy making has not been analyzed.

3. Safety and risk

Safety means that people understand risks and the ways in which their system's defenses can break, and are prepared to face such risks [76–78]. Several definitions for risk exist, most of which refer to the uncertainty or likelihood, and consequences of an (undesirable) event that potentially threatens the achievement of the objectives of a system [79,80]. Specifically, safety thus implies that actors understand the nature, likelihood and consequences of events that may threaten their system, and are prepared for them. 'Understanding' implies (formally or informally) identifying, assessing and evaluating risks, whereas 'preparing to face them' refers to deciding how to control them. A proactive approach to maritime safety therefore means a shift of focus from prescriptive rules towards exploring risks. A system is considered safe if the likelihood of the occurrence of an undesirable event is judged to be low and/or its consequences considered to be tolerable. If risks are seen to be intolerable, measures must be taken to decrease them.

A formal risk assessment or management process involves four basic phases: (1) Identifying risks, and outlining perspectives, methodologies and objectives to assess and manage them; (2) analyzing causal factors behind risks and assessing the likelihood of the occurrence and potential consequences of such risks; (3) characterizing risks based on knowledge, evaluating the intolerability/tolerability/acceptability of risks based on values, and considering the need to ban or reduce risks to a desirable or to an 'as low as is reasonably practical' (ALARP) level using pre-defined criteria, and evaluating risk control options; (4) deciding and implementing measures to reduce risks [79–81]. Risk communication refers to the transfer, exchange, or sharing of data, information and knowledge about risks and their assessment and management by all concerned [79–81]. The FSA's guidelines include the basic steps of risk management but, as a scientific practice disconnected from maritime reality and only targeted at the IMO's decision makers, they do not pay attention to risk communication [22,82].

Conventionally, managing large-scale public policy problems has been the responsibility of professionals and authorities. In fields dealing with uncertain, complex and ambiguous problems, a change is taking place away from top-down approaches towards involving stakeholders in policy processes [83,84]. The aim is to improve the understanding of the problems, strengthen the acceptance of decisions, and enhance trust [85,86]. The importance of dialog with interested parties is highlighted in the principles of the European Governance [87], and also included in the BSAP and EUSBSR programs [50,52]. In policy making related to maritime safety, participatory approaches are still rare.

Renn [88–90], Renn and Walker [91] and Aven and Renn [79] (etc.) present an analytical framework, currently promoted by the International Risk Governance Council (IRGC) [92], for dealing with public systemic risks, that is, risks that cross boundaries between the environment, society and human health, and between nations and sectors, and that have both factual and socio-cultural dimensions. The framework stresses that judgments of risk depend on perspective and context, and that therefore different types of knowledge and values must be addressed when assessing and evaluating risks. For combining scientific evidence with socio-cultural and economic considerations, the framework engages all relevant stakeholders in the governing of risks. In current literature, the concept of governance is widely used to

describe collective decision making as distinct from or as opposed to government- or authority-centered ruling, that is, governing [79] and [86]. The risk governance framework redefines risk as "uncertainty about and severity of the consequences (or outcomes) of an activity with respect to something that humans value", and stresses the importance of risk communication in acknowledging the stakeholders' role in dealing with risks, and in bridging different views of risks. Slovic [93] and Burgman [94] also stress the importance of value judgments in risk management.

4. What can be learned from other risk-prone industries?

4.1. Proactive safety management in the nuclear industry

In the nuclear industry, safety is managed, and regulated, in a *risk-informed* way by combining up-to-date probabilistic risk assessment (PRA), also called probabilistic safety assessment (PSA), with successive defense-in-depth safety measures [30,95–99]. In a risk-based system, safety decisions would be solely based on PRA. The PRA provides a thorough understanding of the nuclear power plant as an integrated socio-technical system, its failure modes and uncertainties. It allows the locating of weaknesses in the safety system and the allocation of resources to correct the problems.

PRA means building accident scenarios to assess risks related to an individual power plant, using event or fault trees or other logic diagrams. All the evidence available and expert judgment is used to determine potential events that might lead to nuclear fuel damage and to estimate their probabilities (Level 1); to assess the magnitude, probability and timing of a release of radioactive substances (Level 2); and to assesses the consequent risk to people and the environment (Level 3) [100,101,98]. The risks are evaluated against pre-defined risk acceptance criteria [81]. For instance, in Finland, the power companies must show that their safety measures accomplish the requirements for level 1 and level 2, whereas a PRA for level 3 is not required [98]. If the defined limit for accepted risk is violated, expert judgment, brain storming, or written guidelines are used for proposing strategies to reduce the risk to an acceptable level. The most appropriate measure to avert, control or minimize the risk is selected through subjective judgments, supplemented by formal techniques (e.g. cost-benefit/risk effectiveness/multi-objective decision analysis) [81]. 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 (Living PRA), which makes risk management a continuous cyclical process [81,102,97]. In addition to the PRA, the nuclear field utilizes qualitative risk matrices, that is, a verbal description of probabilities and of any consequences, in safety management [81].

As nuclear power is based on scientific research and high-level engineering, nuclear safety management is expert-driven work conducted by analysts, managers, reviewers, and government authorities. Conducting the PRA is the responsibility of the organization operating the nuclear power plant. A peer review of the PRA by independent experts and/or national radiation and nuclear safety authorities is an essential part of the process [96–98]. The importance of public participation, stakeholder consultation and deliberation procedures is, however, acknowledged as a way to enhance the transparency and accountability of the processes and the robustness and legitimacy of decisions, in particular in policy processes related to the siting of nuclear power plants or nuclear waste [103,104].

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 [1:02,105]. Maintaining far-reaching information systems by the industry, including communication both within the nuclear facility and between its employees and outside stakeholders is therefore important [1:06,102,81]. The PRA as such is an important tool of communication between the nuclear power companies and the government authorities responsible for nuclear safety. Efficient risk communication can enhance the trust of both the general public and the employees in an individual nuclear power plant and in the whole nuclear sector [103]. Within the nuclear community, efficient communication is associated with a positive safety culture [1:02,107]. The term ‘safety culture’ was introduced by the nuclear sector after the Chernobyl disaster in 1986, and it refers to an organizational atmosphere in which safety is understood and accepted as the number one priority. The Fukushima nuclear accident in 2011 is an example of a communication failure between nuclear reactor experts and earthquake scientists, which led to tsunami predictions being ignored, although the tsunami risk was known [1:08,109].

4.2. Structured information flows in fisheries management

In fisheries policy making, the importance of involving stakeholders in policy processes has been increasingly understood during the 2000s [110]. Participation is seen as a way both to create a socially robust knowledge base for management and to enhance trust towards decision-making processes [111–113]. In 2004, the European Council decided to establish six regional advisory councils (RAC) in which 2/3 of the seats were occupied by the fishing industry and 1/3 by other stakeholder groups, to help meet management goals through enhanced communication between stakeholders [114]. The advisory role of the RACs basically mandate stakeholders to take part in knowledge generation and in the evaluation of management options, but their contribution has been limited to commenting on pre-defined management proposals informed by scientific advice [113]. Still, fisheries management in the EU provides an example of a governance framework with structured information flows between scientific, policy making, and stakeholder organizations, and in particular a formal way of including stakeholders in policy making.

Fisheries management deals with the risk of overfishing and the collapse of commercially important fish stocks. The main EU-level management measure to control this risk is the total allowable catch (TAC), which is the largest yearly catch that a fish stock is assumed to be able to sustain. The TAC is defined in an annual (or bi-annual) policy process that includes assessing the biological status of the stock and its implications for fishing, and considering how the risks related to the stock can be reduced.

The process starts with a request by the European Commission’s (EC) Directorate General for Maritime Affairs and Fisheries (DGMARE) for scientific management advice for a fish stock, from the International Council for the Exploration of the Sea (ICES). In the ICES, specific expert groups assess the fish stocks using different methods, and the assessments are reviewed by scientific peers. Most of the methods do not represent risk assessment in the strict sense, but the current requirements of the ecosystem-based management and the precautionary principle imply a need to develop methods capable of addressing uncertainty and the associated risk, that is, methods that enable managers to take uncertainty into account in decision making [33,115]. For this purpose, stock assessment applications utilizing for example the potential of Bayesian statistics have been developed [116–118]. Expert groups together with the Advisory Committee (ACOM) of the ICES evaluate the status of the stock against the agreed harvest control rule (maximum sustainable yield, MSY, stock specific reference points), and provide management advice to the DGMARE.

Within the EU, the combined stock assessment and biological management advice is reviewed by the Scientific and Technical Committee for Fisheries (STECF) that potentially adds economic information to its review report. The relevant RAC expresses the stakeholders’ view(s) on the advice and its impact on the fish stock, fishing, and the fishing industry’s livelihood. Formal methods for including stakeholder views both in framing a fishery management problem, and in stock assessment have been recently developed [1:19,118], but they have not yet been applied in the policy processes. 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. The process ends with the Ministerial Council defining the TAC for the stock for the next year. The decision must be consistent with the Common Fisheries Policy and possible species-specific agreements [120].

Communication between the EC, ICES, and the RACs follows a formalized line, which is defined each year in a Memorandum of Understanding [121] and in the Terms of References (ToR) [122]. They include guidelines inter alia for the form and content of the scientific advice and of the working group report that the ICES delivers to the DGMARE. In addition to the catch status and advice, the ICES is required to inform the EU about the origins and causes of uncertainty in the scientific advice, and about the methods of the assessment and advisory procedure [1:21,122]. In order to improve and enhance communication with stakeholders and the general public, the ICES currently prepares an easy-to-read digest of the official ICES advice [123].

4.3. Stakeholder committee managing maritime risks in Prince William Sound

In 1989, the oil tanker the *Exxon Valdez* grounded in Prince William Sound in Alaska, and spilled an estimated 11 million gallons of crude oil into the sea [16]. This caused public and government concern about the safety of oil transportation in the area, and led to the implementation of several measures, such as weather-based closures, passage restrictions, and the usage of escort tugs, to reduce the risk of an oil spill.

In 1995, a Steering Committee involving a broad range of stakeholders (shipping companies, government, the oil industry, local industries, local citizens, representatives of environmental conservation, the coast guard, etc.) was formed for developing a risk management plan for the PWS region and for evaluating the effectiveness of the implemented and new risk intervention measures [124,16,125]. It was deemed important that both a substantive knowledge of and the different interests and values related to oil transportation and the ecosystem were covered. The Steering Committee defined the aims, main concepts (such as “undesirable event”) and temporal and areal focus of the risk assessment, and outlined methodologies. It also provided expertise in identifying the risks and risk control options to be evaluated. The risk assessment was expected to estimate the frequency of accidents involving an oil tanker per year in defined locations [124,16,125]. Consultant analysts were hired to conduct the risk assessment. The analysts built accident scenarios using PRA (fault trees, event trees) that sought to capturing the dynamic nature of risk in oil transportation. The frequency of occurrence of each casualty was estimated using a system simulation model, and the effect of organizational and situational factors on the triggering of incidents and accidents was elicited from experts. The consequences of accidents were estimated using an oil outflow model [124,16,125]. The acceptability and tolerability of oil accident risks in PWS was determined by the Steering Committee based on the risk assessment, and on information related to the costs, feasibility, and social aspects of the risks and risk reduction measures. Finally,

risk intervention measures, including those already implemented, were evaluated by using an integrated system risk-simulation model [124,16,125].

The Steering Committee members were educated in the language and modeling of risk, to facilitate discussion [125]. The analysts reported the results of the risk assessment to the Steering Committee monthly in the form of accident scenarios, and a final report that included technical documentation of the methodology, results, and recommendations. The Steering Committee wrote joint press briefings and implemented the recommendations [125]. It was reported, that the stakeholder involvement facilitated the building of a common understanding of oil transportation risks, enhanced trust, and supported the implementation of the decisions, but that it also challenged the objectivity of the analysis and independence of the analysts, and led to compromises [126,16,125]. The study has also been criticized for not addressing uncertainty in its results [127].

Still, the process was successful in reducing risks. The risk model indicated that the actions that the stakeholders had taken

prior to the study had reduced the risk of an oil spill by 75%. New measures identified during the process were assessed to reduce accident frequency by an additional 68%. This included using an enhanced-capability tug to escort oil tankers, a change to a tanker route, managing interactions between fishing vessels and tankers by the VTS, increasing the number of bridge crew on board escort tugs, and the production of long-term quality assurance and safety management plans by shipping companies. The project fostered a cooperative risk management atmosphere involving all stakeholders, and resulted in the acceptance of the results of the study by all stakeholders and the acceptance of high levels of investment to reduce the risk of further oil spills [16,125]. Today, the environmentally safe operation of the Valdez Marine Terminal and associated tankers is promoted by a stakeholder council, although risk assessments are not a systematic part of the council's work [128]. Grabowski [129] provided recommendations for the council regarding a new or updated risk assessment in PSW.

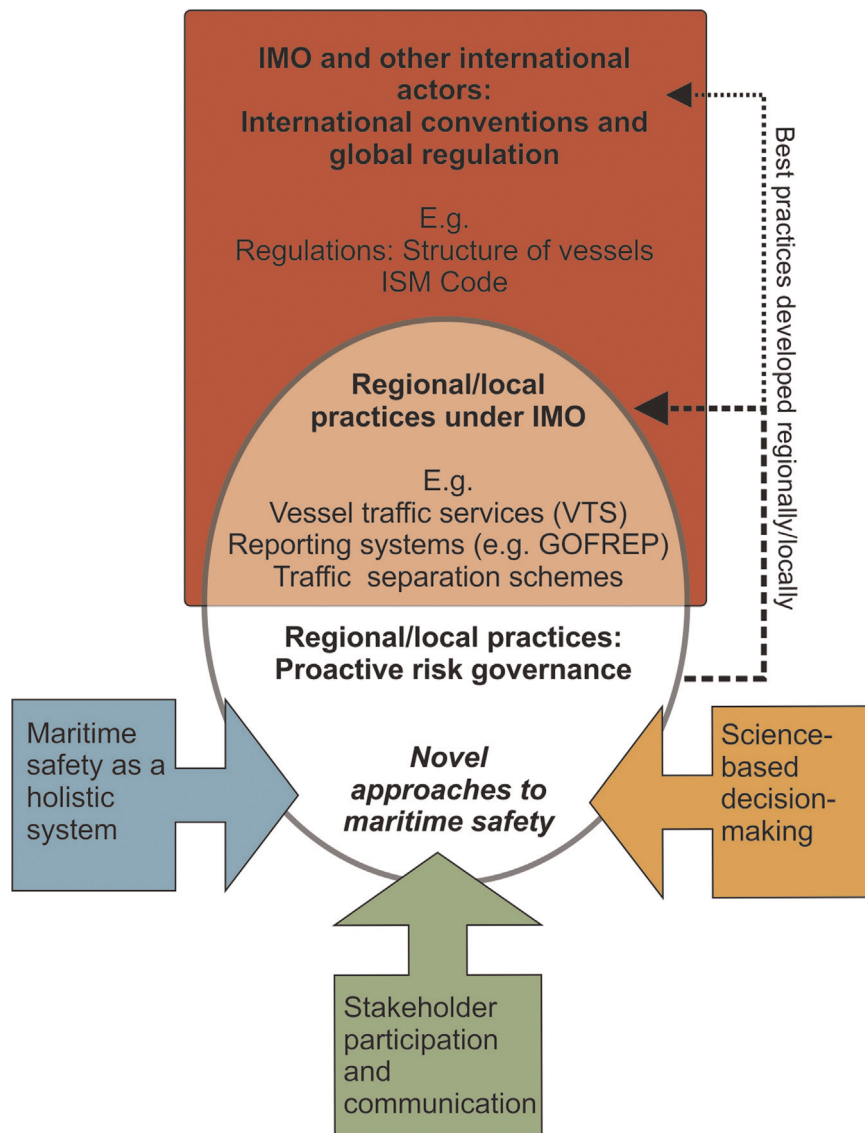


Fig. 2. The proposed framework. In addition to IMO-regulated global (red) and regional (pink) regulative measures there is a need for maritime safety measures that can be adopted locally/regionally (white). The best practices for developing a proactive risk governance framework include regarding maritime safety as a holistic system (adopted from nuclear risk management), decision-making based on scientific advice (EU fisheries management), and the active role of different stakeholders in governing risks (the PWS case). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

5. Picking up best practices: a proactive safety governance framework for the GoF

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 [130,5]. The 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, straits, 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, like in the GoF. In such areas, the systemic nature of risks is pronounced: they do not only concern the ships, ship owners, and the humans and cargo onboard, but the regional environment, inhabitants, societies and nations around the sea area. The international policy regime is not adequate for managing systemic regional risks, and thus a regional framework involving a strong stakeholder contribution is needed.

Here, “best practices” for a maritime risk governance framework for the GoF are discussed and proposed, based on the examples described above (Fig. 2). The nuclear risk management sees a power plant as a holistic system consisting of human and technical parts influenced by internal and external factors, and has developed advanced techniques for anticipating system weaknesses that potentially threaten safety. The TAC decision process in the EU provides an example of a formal way of making decisions based on both scientific advice and stakeholders' views. Finally, the PWS case proves that stakeholder participation in governing risks can be both feasible and beneficial for maritime safety.

First, establishing a permanent stakeholder committee is proposed, for contributing to or even taking responsibility for risk governance, as in the PWS case (Fig. 3). For instance, the HELCOM working groups could be developed into a direction of permanent stakeholder involvement. A broad range of stakeholders (ship companies, crews, maritime safety authorities, pilots, the oil industry, port employees, environmental authorities and non-governmental organizations, local citizens and scientists) allows the different types of knowledge required for a comprehensive identification of risks and risk control options, and the relevant values for both the evaluation of risks and the discussion about the need for actions to reduce them to be brought in. The involvement and support of the IMO and EU/EMSA would be required for considering the regional risks and their management in the international context.

Second, a scientific body is required for conducting risk assessment. Potential organizations for this are, for example, the HELCOM, which already has a role in dealing with maritime safety in the Baltic Sea, or the ICES, which is experienced in risk assessment related to the marine environment and its living resources. On the initiative of the authors of this paper, the ICES recently took the first step towards this, by establishing the “Working Group on the Risks of Maritime Activities in the Baltic Sea” (WGMABS), which started operating in the spring of 2015. As for individual states, in Finland, for example, the Finnish Transport Safety Agency (TRAFI) has recently developed its analysis activities.

Third, risk assessments require up-to-date information of regional risks. Currently, the most obvious source for identifying risks is the incident and near miss reporting systems. Focusing risk identification on hazards that have materialized in the past, however, leads to a bias towards historical data instead of being proactive [82]. A proactive approach thus requires establishing a novel risk database for reporting any kinds of potentially unsafe acts or conditions by a wide variety of users (shipping companies, seafarers, pilots, the Vessel Traffic Service (VTS) and the Automatic Identification System (AIS) operators, Flag State and Port State control inspectors, classification societies, authorities, fishing industry, boaters and other leisure users, local citizens). A ‘risk database’ would imply a shift from lagging indicators to leading indicators.

It can also be considered if information regarding unusual situations and conditions is sufficient for a risk assessment, or if data regarding normal situations is also needed, like in the nuclear sector. Developing monitoring practices and associated indicators for measuring safety performance and the effect of implemented decisions might help identify risk factors that remain hidden in reports focusing on assumed risks. Establishing systems with valid indicators for monitoring safety would also support a cyclical risk assessment process.

Fourth, a proactive approach requires developing a method that enables assessing both current and future risks under uncertainty, and using it in cyclical processes as in the nuclear sector, to keep the understanding of risks updated. In the maritime field, a risk assessment typically concerns events or conditions potentially leading to an accident and the most accident-prone spots in the area, the probabilities of the events/conditions, and the consequences of an accident to the ship, to people and the environment. The nuclear industry uses event trees and fault trees in building accident scenarios, and they were also applied in the PWS case. In the Baltic Sea area, the use of Bayesian belief networks (BBNs) is well advanced in risk assessments related to shipping

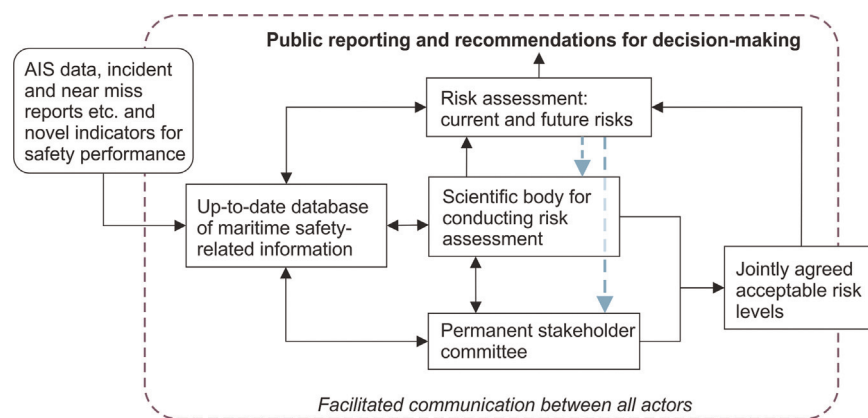


Fig. 3. A novel approach to enhance maritime safety in the GoF. A permanent stakeholder committee communicates actively with and offers input to a scientific body that conducts regional risk assessments. Assessments exploit a comprehensive risk database, which include data from several other databases, reporting systems, etc., and can also include knowledge from different stakeholders. Risk assessments are based on jointly agreed risk levels. Scientists and other stakeholders can learn from the results of risk assessments and update their own understanding of risks. Enhanced communication is essential for successful risk management.

[131,132,73] and fisheries [1,16,118]. The probabilistic BBNs enable the integration of quantitative and qualitative knowledge in assessing uncertain future events in a holistic way, and the updating of prior knowledge when new information is available, to get an improved (posterior) understanding of the problem. The method can also be used as a decision support tool. Hänninen [133] discusses the benefits and challenges of using Bayesian networks for maritime traffic accident prevention. Inter alia the IMO [22,82] and Aven and Renn [79] propose a number of other risk assessment methods. Rosqvist and Tuominen [134] discuss the role of a peer review in qualifying a FSA study.

Fifth, risk assessment criteria, and an acceptable and tolerable level of risks must be agreed. The criteria are used for evaluating loss, and defining limits for acceptable risk to individuals (fatalities, injuries, ill health), society (risk to society as a whole or local communities or ports), and the environment (e.g. accidental releases of oil and oil products). Criteria, and their mutual weighting, are also needed for ranking alternative risk-controlling measures in relation to one another. In addition, criteria are required for defining the cost-effectiveness of risk management, or acceptable costs in relation to expected benefits, [82,135–140]. Laurila-Pant et al. [141] discuss approaches to placing a value on the ecosystem in case of, for example, an oil accident or other serious accidents in the sea. An important topic to be discussed by the stakeholders and/or the society is how to share the costs involved in decreasing the risks between the public and the private sector.

Sixth, both the theoretical part of our paper and the practical examples that we have presented highlight the significance of communication in risk governance. A formal process of risk identification, assessment, evaluation, and management ensures information flows between stakeholders, and between the stakeholder organization, the scientific body conducting the risk assessment, the EU, and the IMO, as takes place in the TAC formulation process of the EU. In addition, informal risk communication between all those involved is required for identifying, discussing and sharing information about risks and for observing, monitoring, reporting and discussing the effects of the implemented policy instruments in a continuous process. A risk assessment report would disseminate relevant findings and justified recommendations for all stakeholders, in particular seafarers, shipping companies, decision makers, the EU, and the IMO. It would also give feedback to those that reported risks, to show that their concerns have been responded to. This is expected to support reporting and further the development of scientific practices to support decision making.

6. Benefits and challenges

The proposal presented above brings the FSA approach advocated by the IMO from the international to the regional level, and develops it from a task solely conducted by scientific experts towards a participatory procedure involving stakeholders. Governing risks at the regional level can be advantageous because local actors have an interest in protecting their own sea areas and in investing in managing the associated risks, as shown both in the PWS and in the GoF area. In addition, the proposal enhances the FSA from an occasional “when deemed necessary” practice to a regular procedure to be used systematically as the basis of decision making. A FSA that focuses on regional risks may be more manageable than a generic one both in terms of scope and time used for the risk assessment and management processes.

A regional-level risk governance framework enables one to focus on real, regionally relevant safety threats and to find the most appropriate measures to manage them before disasters occur. Thus it can produce tailor-made safety measures that may be

more effective and cost-effective than the “one size fits all” type of IMO regulations that mostly concentrate on ship safety, and less on issues external to a ship [28,7]. Regional policy making can develop PSSA-type regulatory safety measures related, for example, to routing or pilotage, special requirements for ports or for ships entering the area, traffic control, inspection, emergency preparedness, or navigation support tools like the ENSI system, but the measures can also be recommendations to shipping companies, crews, ports, or other actors, regarding information sharing, education, safety performance, communication, auditing or something else that has been found to be significant in the risk assessment. In addition, a regional governance approach can enhance cooperation between regional authorities and thereby harmonize and decrease overlapping procedures in, for instance, inspections. Regional-level risk governance can also feed information and recommendations to the IMO, to be used in generic policy making. Risk governance at a smaller scale enables a constant learning process about risks, and has the potential to improve the preparedness of both the administration and the seafarers to react more quickly and more efficiently to them.

It is, however, evident that a regional maritime risk governance approach cannot operate separately from international rules and that international prescriptive regulations cannot be overridden. Thus a regional proactive approach to maritime safety is necessarily *risk-informed* by nature. This means that regional risk management could complement international prescriptive rules, not replace them. Critical issues to be considered include, for example, (a) Which body, and at what level, should implement the recommended management measures? (b) What are the legal rights underpinning, and the economic, technical, and other resources to implement the actions? (c) Can regional measures be decided and adopted regionally or is the review and approval of the IMO required? In the current situation, the principle of the freedom of navigation and the harmonizing role of the IMO in the maritime safety regime may not easily give way to regional safety measures. Thus, implementing regional regulations may require long negotiation processes between policy levels, concerning, for example, whether the intended policy instruments conform to international regulations and whether the IMO is willing to approve them [11].

The proposed framework develops policy making from pure prescriptive ruling towards a more transparent bottom-up approach based on efficient communication. It has the potential to build an understanding of maritime safety as a holistic system consisting of technical, human, and environmental components, improve the commitment of seafarers to the agreed policies, generate trust, and support social learning [142–145]. Further, it can enhance a positive safety culture within the shipping industry, and thereby support risk reporting, decrease human failures, and break the blame culture [78,146,60,147,61]. A direct influence on the safety culture, and corporate social responsibility of shipping companies can even decrease the need for regulatory policy instruments [1,48,149]. However, it must be remembered that stakeholder participation as such is neither necessarily a guarantee of success, nor a panacea for solving problems related to maritime safety, and that, overall, evidence of the impact of stakeholder involvement on decision making is often lacking, outdated or inappropriate. Therefore, in order to satisfy the requirements of the process and the parties, the form of involving stakeholders must be commonly defined, and their actual performance evaluated. Learning lessons from failures such as the examples provided in this paper can greatly benefit planning.

7. Conclusions

The Baltic Sea area provides a fertile ground for the establishment of novel regional forms for maritime governance. The

regional programs EUSBSR and BSAP incorporate the objective of restoring the good ecological status of the Baltic Sea, and, as part of this, making it a leading region in maritime safety. They also incorporate the principle of involving stakeholders in policy making upheld by the EU. In the Baltic Sea area, public environmental awareness is relatively high, and most stakeholders are willing to promote maritime safety. Political decisions, and mandates from the IMO and the EU are all that is required, as well as commitments from both the public and the private sector regarding finance. We expect that a well documented and open risk governance framework would be supported by *inter alia* oil companies, as it is in no-one's interest to get involved in a large-scale oil accident.

A regional maritime risk governance framework would not only provide a forum for addressing the safety risks of shipping. It also provides the potential for enlarging stakeholder collaboration to other environmental issues related to shipping, such as sewage pollution, illegal discharges, the introduction of alien species, air pollution, and security issues, and even to other sectors affecting the sea, such as aquaculture, fishing, wind energy, leisure boating, and agriculture. Multi-sector stakeholder collaboration would reinforce the coordination of interrelated problems and facilitate the formation of an integrated approach to maritime spatial planning, which is seen as a key to governing the fragile Baltic Sea [150].

A shift of focus in maritime safety policy formulation from the prescriptive and reactive approach towards proactive approaches will probably take place. This paper proposed an approach based on identifying, assessing and managing risks. Another future path may be related to the Safety II approach [151,152]. It is grounded on performance adjustments and resilience engineering, that is, learning from events that go right and managing performance variability, rather than focusing on preventing accidents. The approach is being introduced in fields such as aviation and healthcare as a response to the ever more complex and automated reality that the cause-effect models may no longer be capable of capturing [151,152].

In this paper, fisheries, nuclear power, and the maritime field were referred to as examples of established risk governance practices. Other examples, such as safety management in aviation [31] and the railways [153] might be the next parallels worth reviewing. Although this paper proposed a governance framework for the GoF, the approach could be extended to cover the whole Baltic Sea, or applied to any small scale vulnerable sea area.

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