End-user and Stakeholder Views on Selected Risk Assessment Tools for Marine Oil Spill Preparedness and Response, Including Future Research and Development Needs

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ABSTRACT: Risks in the maritime domain have various sources, of which the transportation of oil and other noxious products is one of key concern to industry and public stakeholders. Operational or accidental releases of oil or other pollutants from ships or offshore facilities into the marine environment can have disastrous effects on the marine ecosystems, while also leading to very significant economical losses. Therefore, national states have implemented various mechanisms for preventing and responding to pollution in the maritime domain, with activities which are often embedded in regional cooperation frameworks clustered around certain sea areas. To support collaborative, harmonized, and risk-informed oil spill Pollution Preparedness and Response (PPR) planning for response authorities, the Baltic Marine Environment Protection Commission (HELCOM), together with its research partners, and with extensive end-user and stakeholder inputs, have developed the OpenRisk Toolbox. This toolbox includes several risk assessment tools and techniques, which can assist in providing answers to a range of PPR risk management questions in a range of organizational contexts. To better understand and ensure the applicability and usefulness of the OpenRisk Toolbox, a workshop was organized where some of these tools were tested. Selected end user and stakeholder views on the perceived usefulness of the tools were collected and analyzed. Another workshop focused on further development needs to implement the tools in organizational practices. This paper first presents the OpenRisk Toolbox, then describes the settings of the workshops. Finally, a summary of the end-user and stakeholder views on the tested tools, and on future development needs, is given.

1 INTRODUCTION

Maritime activities such as shipping are an essential component of the global economy, and represent a significant economic sector in many coastal countries (UNCTAD, 2018). While maritime transportation provides economic and social opportunities, it also carries inherent risks to human life, the environment, and economic interests (HELCOM, 2018). One of the significant risks concerns marine pollution, of which oil spills have been a significant concern for coastal communities already for a long time. Spills can have detrimental effects to marine ecosystems (Teal and Howarth, 1984), can disrupt marine-related economic activities such as fisheries and coastal tourism (Garza-Gil et al., 2006), and have important socio-economic implications for local coastal communities (Gill et al., 2011).

Globally, volumes of spilled oil have seen a steady decrease over the last decades (ITOPF, 2017). Nevertheless, accidental and operational spills do still occur, even large ones. Hence, the need for oil Pollution Preparedness and Response (PPR) activities, both at sea and on-shore, is undisputed, and many coastal countries dedicate significant resources to maintaining an oil response fleet (HELCOM, 2018). Given the possible trans-national nature of marine spills, several regional agreements have been agreed upon and implemented, to facilitate collaboration in pollution preparedness and response. These include, for instance, the Helsinki Convention in the Baltic Sea, the Bonn Agreement in the North Sea, and the Bucharest Convention in the Black Sea.

To facilitate the decision-making processes for PPR planning, risk assessment has been applied in several European sea areas, e.g. the Baltic Sea area (COWI, 2011), the North Sea (Bonn Agreement, 2014), and the Mediterranean (MEDESS-4MS, 2018). Also in other sea areas, risk analysis methods have been developed and/or applied to support pollution preparedness and response. See also e.g. Ösbaş (2013) for a review of maritime risk assessment methods.

Despite this progress, several European PPR authorities identified a gap in the tools available for risk management, and concerns were raised e.g. related to the lack of transparency of certain risk analysis methods, the use of proprietary methods, and the lack of comparability between results of different methods. Overall, a need was voiced to develop an open access toolbox for PPR risk analysis, with additional guidance on suitable processes to implement this into organizational processes (OpenRisk, 2018). Responding to this need, the Baltic Marine Environment Protection Commission (Helsinki Commission, HELCOM) initiated a project to develop a freely available toolbox for risk assessment of maritime activities, known as the OpenRisk Toolbox. While the tools included in this toolbox currently focus exclusively on accidental oil spill risks related to maritime transportation, the toolbox is envisaged to be open, so other methods can be included to address risks from other maritime or offshore activities.

In the academic literature on risk analysis, there has been a recent focus on the validation of risk analysis methods, and the trust in the risk management activities (Goerlandt et al., 2017). One aspect of this concerns pragmatic validity, i.e. the extent to which the method succeeds in achieving what it intends to achieve. In case of risk analysis methods, pragmatic validity involves very practical issues like whether end-users find the method useful and whether they understand its underlying basis. Thus, testing risk analysis tools with end users and stakeholders, and obtaining feedback from them about their usefulness, is an important part of effective risk management. It is also important to consider what more is needed for risk establishing effective risk management.

Considering this, the aims of this paper are two-fold. First, a high-level overview of the OpenRisk Toolbox is given, focusing on which risk management questions the different tools address. Second, results are presented of end-user and stakeholder workshops aimed at evaluating selected methods of the OpenRisk Toolbox, and on future research and development needs.

The OpenRisk Toolbox is introduced in Section 2. The workshops and the and methods used to gather end-user feedback on the methods and future needs, are described in Section 3. Results of this work are shown in Section 4, and a discussion is given in Section 5. Section 6 concludes.

2 OPENRISK TOOLBOX: AN OVERVIEW

Table 1 provides an overview of the tools included in the OpenRisk Toolbox, with details about each methods given in (OpenRisk, 2018).

Table 1. OpenRisk Toolbox: tools included

Nr.	Tool name	Reference
1	AISyRisk	(Kystverket, 2018)
2	MarinRisk	(Koldenhof et al., 2010)
3	Delphi Method	(Zaloom and Subhedar, 2008)
4	RiskData Hub	(EC, 2016)
5	IALA Waterway Risk Assessment Programme (IWRAP Mk II)	(IALA, 2017)
6	Ports and Waterways Safety Assessment (PAWSA)	(USCG, 2018)
7	Maritime Event Risk Classification Method (ERC-M)	(ARMS-WG, 2010)
8	Accidental Damage and Spill Assessment Model for Collision and Grounding (ADSAM-C/G)	(Tabri et al., 2018)
9	SeaTrack Web	(Liungman and Mattson, 2011)
10	Next Generation SmartResponse Web	(Aps et al. 2016)
11	Response System Planning Calculators (ERSP, EBSP, EDSP)	(BSEE, 2018)
12	BowTie Method	(CGE RMS, 2017)
13	Functional Resonance Analysis (FRAM)	(Hollnagel, 2012)
14	Key Performance Indicators (KPIs)	(ARPEL, 2017)
15	Spatial Bayesian Oil Spill Risk Tool (SBOSRT)	(Helle et al., 2016)
16	Integrated Strategic Risk Analysis Method (ISRAM)	(COWI, 2011)
17	Strength of Evidence Assessment Schemes (SoE)	(Goerlandt and Reniers, 2016)
18	Risk Matrices and Probability-Consequence Diagrams (RM-PCDS)	(Goerlandt and Reniers, 2016)
19	As Low as Reasonable Practicable Principle (ALARP)	(Melchers, 2001)
20	Cost-Benefit Analysis (CBA)	(Boardman, 2006)

Some tools, such as AISyRisk and MARINRisk, are suited to detect trends in maritime risks, and hence should be used relatively frequently to identify a need for more in-depth risk analysis and risk treatment. Other tools, such as the Delphi method, are aimed to identify and assess the importance of new and emerging risks in the maritime transportation system, e.g. the use of new fuel types, or new technological systems such as unmanned vessels. Such tools are expected to be used less frequently, but are also aimed to identify a need for further risk analysis or risk treatment.

Other tools can be used together to support practical response planning and fleet organization. The Event Risk Classification Method (ERC-M) or the IALA Waterway Risk Assessment Programme (IWRAP Mk II) can be used to gain understanding of the likely accident scenarios in the maritime system. Using these scenarios, the Accidental Damage and Spill Assessment Models for Collision and Grounding (ADSAM-C/G) can provide insight in the likely spill amounts in collision and grounding accidents. Combining this information in the SeaTrack Web tool provides information about the fate and transport of the released oil, i.e. where the oil drifts to and how it would affect the shorelines. The Next-Generation Smart Response Web (NG-SRW) provides similar information, with additional information about ecosystem values and shoreline sensitivity. The Response System Planning Calculators (ERSP, EBSP, EDSP) aim to assess how much oil the response system can recover. Other tools, such as the BowTie method or the Functional Resonance Analysis Method (FRAM) can provide information about the causes, contributing factors, or critical system functions related to the spill occurrence or the response system performance.

Finally, some tools can be used to support long-term strategic investment decisions, for instance related to the number of response vessels required in different sea areas, or the need for new equipment. The integrated risk analysis methods (ISRAM) and Spatial Bayesian Oil Spill Risk Tool (SBOSRT) can be used for that.

In all decision contexts, the Strength of Evidence assessment tools can be used to provide information about how good the evidence underlying the risk analysis is. Risk analysis results can be visualized in Risk Matrices (RMs) or Probability-Consequence Diagrams (PCDs), e.g. for comparing risks in different sea areas. The As Low As Reasonably Practicable (ALARP) and Cost-Benefit Analysis (CBA) can guide risk evaluation and provide decision support for the risk treatment phase.

The tools are aimed to cover a set of typical risk management questions in a pollution preparedness and response context, over different time scales and in different decision-making contexts. Table 2 lists the risk management questions which the different tools included in the OpenRisk Toolbox aim to help answering.

Table 2. OpenRisk Toolbox: risk management questions

Nr.	Risk management questions
1	- Where are the historic accident risks in the sea area? - How do the risks develop over time?
2	- Where are the historic accident risks in the sea area? - How do the risks develop over time?
3	- What kinds of future hazards should be considered? - What are the associated risk levels?
4	- Where are the historic accident risks in the sea area? - How do the risks develop over time?
5	- What is the accident likelihood in different sea areas? - What accident scenarios are likely? - What effect do risk control options have on risk level?
6	- How important are various waterway factors on the risk? - What effect do risk control options have on risk level?
7	- What kinds of hazards occur in the sea area? - What is the risk level in different sea areas? - What accident scenarios are likely? - Which are contributing factors to the event occurrence?
8	- What size of oil spills can occur in collisions? - What size of oil spills can occur in groundings?
9	- Where does the oil drift to in the sea area?
10	- What size of oil spills can occur in collisions? - What size of oil spills can occur in groundings? - Where does the oil drift to in the sea area? - What are consequences to the ecosystem? - What are consequences for human use of marine space?
11	- How much oil can the response system recover? - How much oil can the response system burn? - How much oil can the response system disperse?
12	- Which factors contribute to the event occurrence? - Which factors contribute to the event consequence? - What is the effectiveness of different risk controls?
13	- Which system functions are responsible for the variation in the system performance?
14	- How important are different system indicators in regards event occurrence and/or consequences? - What is the performance of different system elements compared to target levels?
15	- What are the oil spill risks in the sea area? - What is the extent of ecological damage in different oil spill risk scenarios?
16	- What are the oil spill risks in the sea area? - What size of spills can occur? - Where does the oil drift to in the sea area? - What are the ecosystem and human use consequences? - What effect do different risk control options have on the risk level?
17	- How much can the risk analysis results be relied on?
18	- How do the risks compare to one another?
19	- Are the risks acceptable? - Should further risks control options be implemented?
20	- How cost-effective are different risk control options?

The tools in the OpenRisk Toolbox cover the whole scope of risk assessment, including risk identification, risk analysis, and risk evaluation. This is shown in Table 3.

Table 3. OpenRisk Toolbox: risk assessment stages

Nr.	Risk Identification	Risk Analysis	Risk Evaluation
1	A	SA	NA
2	A	SA	NA
3	SA	A	A
4	A	SA	NA
5	NA	A	A
6	A	SA	A
7	SA	SA	NA
8	NA	SA	NA
9	NA	SA	NA
10	NA	SA	NA
11	NA	SA	NA
12	SA	A	A
13	SA	A	NA
14	NA	SA	SA
15	NA	SA	A
16	NA	SA	A
17	NA	SA	A
18	NA	A	SA
19	NA	NA	SA
20	NA	NA	SA

A = applicable | NA = not applicable | SA = strongly applicable

3 OPENRISK WORKSHOPS: WORKSHOP DETAILS AND TOOL EVALUATION APPROACH

To understand end-user needs for risk assessment, and make end-users and stakeholders familiar with risk management and the OpenRisk Toolbox, several workshops were held.

A first workshop was organized in Helsinki in June 2017, focusing on previous experiences with maritime risk assessment, and end-user expectations from the new toolbox. The second workshop, held in Lisbon in October 2017, provided an initial scoping of available tools, and initial suggestions for how those can be integrated. A third workshop, which focused on practical testing and evaluation of selected risk analysis tools, was organized in Valetta in April 2018. In October 2018, a final workshop was held in Malmö, which gave an overview of the guideline for risk management for pollution preparedness and response, the OpenRisk Toolbox, and a case study for the Baltic Sea. It also included a round-table discussion on future research and development needs. In both cases workshop participation was free and open to all interested end users and stakeholders. Invitations were sent by project staff at HELCOM to pollution response authorities, maritime safety authorities, consultants, academia, and regional response organizations.

As evident from the above descriptions, the third and fourth workshops are relevant for the second aim of this paper, i.e. to provide end-user feedback on selected methods, and on further development needs. These workshops are described in some more details in Section 3.1 and 3.2. The methods used to elicit the end user feedback on the tools and further development needs are also described below.

3.1 *Third OpenRisk workshop*

The workshop was organized at the offices of the Regional Marine Pollution Emergency Response Center of the Mediterranean Sea (REMPEC) in Valetta, Malta, on 24-25 April 2018. Participants were familiarized with the OpenRisk guidelines for regional risk management to improve European pollution preparedness and response at sea (OpenRisk, 2018), and specifically with the OpenRisk Toolbox. Project staff provided presentations on the tools to be tested and evaluated. These included the AISyRisk, MarinRisk, IWRAP Mk II, ERC-M, ADSAM-G, NG-SRW, and FRAM tools, see Table 1, 2, and 3, respectively, for their full name and reference, details about the risk management questions they support, and their use within the risk assessment process.

In different sessions, the workshop participants were given a case study to execute using the above tools. Subsequently, they were asked to answer a survey, which includes statements listed in Table 4. Responses consisted of a rating on a 7-point Likert scale ranging from ‘strongly agree’ to ‘strongly disagree’, where appropriate combined with space for open comments.

In addition, a roundtable discussion was held, where participants could voice their views on the OpenRisk Toolbox, and their findings concerning the risk assessment tools tested during the sessions. A project note taker wrote down and subsequently summarized the issues raised in this discussion. Through communication after the workshop, participants were given the opportunity to comment on this workshop report, and request modifications or additions to the discussion points.

The workshop was attended by representatives from several pollution response organizations, maritime safety authorities, regional emergency response centers, marine risk consultancy companies, and universities. In total, 25 persons participated in the workshop, including 6 project staff and 19 external participants.

Table 4. Statements for tool evaluation, third workshop

Nr.	Question
1	The tool could be useful to my organization.
2	My organization has the required information to apply the tool.
3	The method and tool is easy to understand.
4	The tool is easy to use.
5	My organization would benefit from having training courses to learn how to use the tool.

3.2 *Fourth OpenRisk workshop*

The workshop was organized at the campus of the World Maritime University in Malmö, Sweden, on 30 October 2018. Participants were familiarized with the OpenRisk guidelines for regional risk management to improve European pollution preparedness and response at sea (OpenRisk, 2018), and specifically with the OpenRisk Toolbox. Project staff provided a high-level presentation on the contents of the risk management guideline and the toolbox. Subsequently, an oil spill risk assessment case study for selected areas of the Baltic Sea, was introduced. This includes results of application of AISyRisk, MarinRisk, FRAM, ERC-M, ADSAM-C/G, and SpillMod, a tool used by the Finnish Environment Institute to assess probabilistic oil drift in Finnish waters and to plan response activities. Also the principles of the SoE, RM-PCDS, and ALARP tools were outlined. The reader is referred to Table 1 to 3 for information about these tools.

In this workshop, no practical tests were made using the tools. Instead, a roundtable discussion was held, focusing on the future research and development needs to support analysts and decision makers in pollution preparedness and response planning.

A project note taker wrote down and subsequently summarized the issues raised in this discussion. Through communication after the workshop, participants were given the opportunity to comment on this workshop report, and request modifications or additions to the discussion points.

The workshop was attended by representatives from several pollution response organizations, maritime safety authorities, regional emergency response centers, marine risk consultancy companies, and universities. In total, 25 persons participated in the workshop, including 7 project staff and 18 external participants.

4 RESULTS

Section 4.1 presents the results of the end-user and stakeholder feedback on the selected OpenRisk tools tested in the third workshop. This includes a simple statistical analysis of the survey responses for the statements of Table 4, and a narrative summary of some issues raised in the roundtable discussion. Section 4.2 presents the results of the stakeholder views on the future research and development needs.

The results shown here are based on survey results and notes from moderated roundtable discussions. Participation to the survey was voluntary, and the response rate was around 53% for most questions, with a minimum of 32%, and a maximum of 63%).

4.1 *Stakeholder and end-user feedback on selected OpenRisk tools*

The survey results of statement 1 of Table 4 are shown in Figure 1. The figure shows a descriptive statistical analysis of the responses in box-and-whisker format, with minima, maxima, median, and lower and upper quartiles. The results for the different tools are shown with different colors next to one another.

The results clearly show the variety of support for using the tools in practical in the organizations. The AISyRisk, IWRAP Mk II, and MarinRisk receive very positive ratings, indicating a high perceived usefulness in pollution preparedness and response. Tools like ERC-M, ADSAM-G, and NG-SRW received mixed support, with some participants finding the tools useful while others do not.

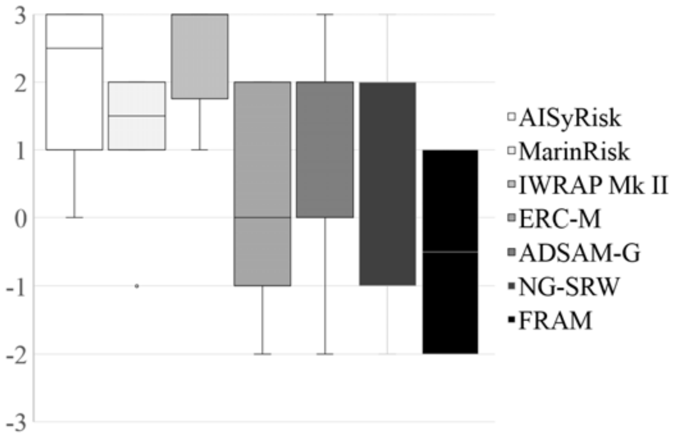

Figure 1. Workshop 3 survey results for statement 1 of Table 4: “The tool could be useful for my organization.”
OpenRisk tool abbreviations: see Table 1
-3=strongly disagree, 0=agree nor disagree, 3=strongly agree

Interestingly, there was a relatively strong consensus among the participants that FRAM would not be useful for their organization.

The survey results for statement 2 of Table 4 are shown in Figure 2, with similar information as in Figure 1. For all tools, there appears to be a wide variety in the data availability. Mostly, there is some information available for applying the tools, e.g. for MarinRisk, IWRAP Mk II, ADSAM, and NG-SRW. For AISyRisk and ERC-M, the variation is large. For FRAM, respondents found that the information to utilize the tool is mostly not available in their organization.

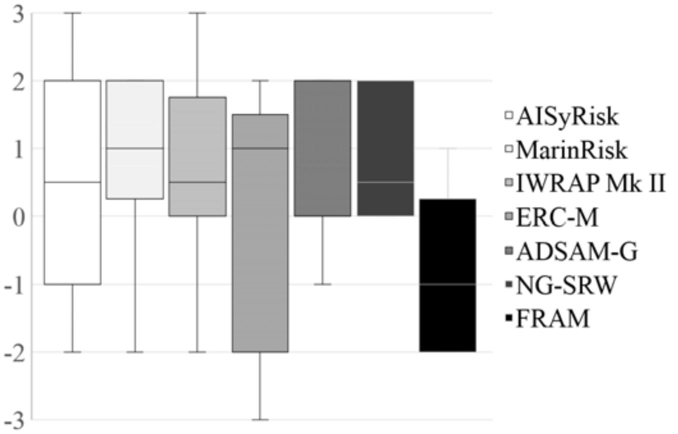

Figure 2. Workshop 3 survey results for statement 2 of Table 4: "My organization has required information to apply the tool."
OpenRisk tool abbreviations: see Table 1
-3=strongly disagree, 0=agree nor disagree, 3=strongly agree

The survey results for statement 3 of Table 4 are shown in Figure 3, with similar information as in Figure 1. It is seen that most tools are considered relatively easy to understand, with especially AISyRisk and MarinRisk scoring high averages. IWRAP Mk II, ADSAM-G, and NG-SRW score similarly, with mostly rather positive responses. ERC-M was on average rather easy to understand, but some respondents found it more difficult. FRAM was considered comparatively more difficult.

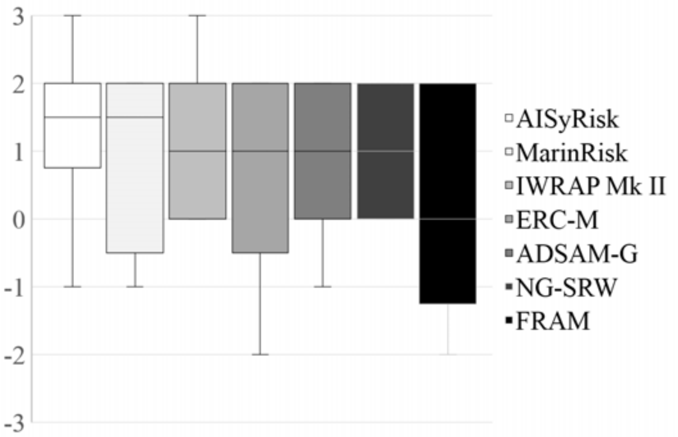

Figure 3. Workshop 3 survey results for statement 3 of Table 4:
"The method and tool is easy to understand."
OpenRisk tool abbreviations: see Table 1
-3=strongly disagree, 0=agree nor disagree, 3=strongly agree

The survey results for statement 4 of Table 4 are shown in Figure 4, with similar information as in Figure 1. It is seen that most tools are considered relatively easy to use. MarinRisk, IWRAP Mk II, ERC-M, ADSAM-G and NG-SRW received moderately positive responses, but some respondents found the MarinRisk and ERC-M tools not so easy to use. The AISyRisk tool received mixed feedback, with some finding the tool really easy to use, while rather many participants found it not so easy. FRAM received moderately positive responses, although a bit less favorably compared to other tools.

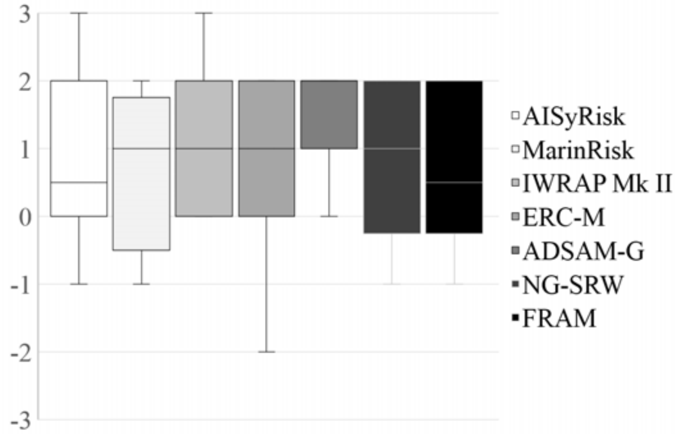

Figure 4. Workshop 3 survey results for statement 4 of Table 4: "The tool is easy to use."
OpenRisk tool abbreviations: see Table 1
-3=strongly disagree, 0=agree nor disagree, 3=strongly agree

The survey results for statement 5 of Table 4 are shown in Figure 5, with similar information as in Figure 1. It is seen that there is strong support for training for especially AISyRisk. IWRAP Mk II, ADSAM-G, NG-SRW, and to a lesser extent also MarinRisk, were also considered valuable tools to receive training for. Responses were mixed and showing significant variation for ERC-M. FRAM was not considered necessary to provide training for in a PPR risk management context.

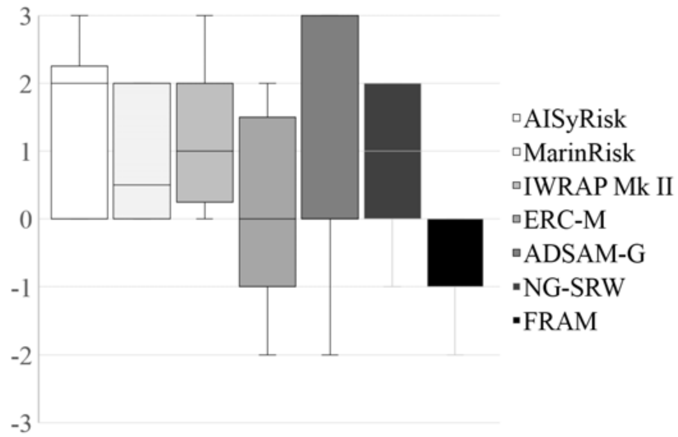

Figure 5. Workshop 3 survey results for statement 5 of Table 4: "My organization would benefit from having training courses to learn how to use the tool."
OpenRisk tool abbreviations: see Table 1
-3=strongly disagree, 0=agree nor disagree, 3=strongly agree

4.2 *Stakeholder views on future research and development needs*

In a roundtable discussion in the fourth workshop, several avenues for future research and development needs, were identified. Some modeling aspects of the tools were found to require further work, such as the causation factors in IWRAP Mk II, the scope of vessel types and environmental influences (waves, waves) in the ADSAM-G/C models, and the geographical coverage of and ecosystem values and human uses of the marine space in the NG-SRW.

It was also found that it would be beneficial to develop integrated software, e.g. taking AISyRisk as a basis, to which other tools could be integrated. This was believed to be a cost-effective way to implement risk analysis tools in practice, because the development and operation of the tools is expensive. However, participants also agreed that different tools were needed for different problems, and than integrating all tools in one software package may not be the best way to proceed.

Existing tools for response system planning were also raised as requiring additional research, focusing on the practical response effectiveness rather than on theoretical recovery values. The actual ability of the response system to recover oil, burn, or disperse it, also depends on logistical and environmental aspects, which are not included in the current approaches.

The issue of availability, accessibility, and quality of accident and incident data and information was raised as well. While some risk analysis tools received quite strong support for implementation (e.g. AISyRisk), as evident from the results of the third workshop, the necessary data for this is not available in all organizations. Hence, data quality and availability also requires further improvement.

In a wider risk assessment context, another identified need for future work was the development and testing of risk identification and analysis methods and tools for new and emerging risks in maritime transportation. Such risks relate for instance to the effects of autonomous vessels on PPR activities, or the introduction of new fuel types. There were also concerns raised about the lack of research and practical guidance for decision makers on risk acceptability in PPR context. While the ALARP principle is generally supported, the lack of indicative values of what are acceptable accident rates, and what is an acceptable response level, was raised as issues for future work.

Finally, a critical issue for risk management concerns the development of frameworks, policies, and procedures for implementing risk management processes in organizational processes (ISO, 2018). There is relatively little practical guidance about how to do this in a PPR context, and very little research has been dedicated to this topic. There is also a need for further development of inter-organizational processes for risk governance, e.g. in regional sea basins, or on a European level. Developing this however requires strong political support from member states and response authorities, and clear roles and responsibilities.

5 DISCUSSION

The workshop results provide new information about the perceived usefulness of several oil spill risk analysis tools, as well as insights in new research and development needs.

In interpreting the results, it is important to consider the relatively small number of survey respondents. This means that the results should be taken as indicative, and that it would be prudent to seek further confirmation of the results by additional research before engaging in specific research and development actions in support of PPR risk management. In addition, caution should be taken in the sense that the workshop participants may not be constitute a representative sample of the end users and stakeholders. Participation to the workshops was voluntary, and it can be assumed that mainly organizations with an interest in performing risk assessment and in advancing activity, would dedicate time and resources to participate. Such sampling biases are however in practice difficult to avoid. The practical challenges in having people from different organizations to participate in workshops such as the ones presented, are important obstacles to having more representative samples of stakeholders and end-users to provide views on the tools and future needs. Nevertheless, the results provide unprecedented insights in some practical aspects of selected PPR risk analysis tools, and in future development directions.

Another interesting issue, which would need further consideration, is the actual validity of the tools. As mentioned in the introduction, pragmatic validity of risk analysis concerns whether the analysis achieves what it aims to achieve. Practical usefulness as perceived by end users and stakeholders is an important aspect of this, but the adequacy of the methods underlying the tool development clearly is important as well. This latter aspect of pragmatic validity has not been addressed in the current work.

The importance of assessing the adequacy of maritime risk analysis tools has however been highlighted in earlier work. For instance, an analysis by Goerlandt and Kujala (2014a) suggests that application of different risk analysis methods can lead to significantly different results, see also Goerlandt et a. (2014b). In this context, it is also noteworthy that more advanced methods such as FRAM, which have been shown to outperform other risk identification and analysis methods, see e.g. Praetorius et al. (2017), are not supported by end users for practical implementation, based on the results shown in Section 4.1. The issue of perceived usefulness, practicality, and ease of use of risk analysis tools, versus the firmness of the scientific basis of these, hence is a topic which would also benefit from further research.

6 CONCLUSIONS

In this article, an overview has first been given of the OpenRisk Toolbox, which is a collection of methods and tools for performing risk assessment for oil spill Pollution Preparedness and Response activities at sea. The description included a high-level overview of the purpose of the tools, the risk management questions they aim to support, and the location in the risk assessment process (identification, analysis, or evaluation).

Second, the results of two end user and stakeholder workshops have been shown. The first workshop focused on the evaluation of selected tools, the second on knowledge gaps and future research and development needs.

The results indicate that some tools, especially those of which the execution can be largely automated in software, have rather high support among end-users and stakeholders. This includes e.g. AISyRisk, MarinRisk, and IWRAP Mk II. These tools were also considered to be relatively easy to understand and use, and training courses for these were generally welcomed. However, the availability of data to use these tools varies significantly between organizations.

Other tools, such as ADSAM-G, NG-SRW, and ERC-M, were received with more mixed support. While the tools are considered relatively easy to understand and use, there was more variation in the perceived usefulness of the tools in different organizations. The availability of the required data was an issue of concern especially for ERC-M. Nevertheless, for ADSAM-G and NG-SRW, it was rather generally agreed that having training courses, would be welcomed.

Finally, FRAM received little support for use in PPR contexts, across the board. The tool was found understandable and easy enough, but it was found that the information needed for it was not available in organizations, and the results the tool could provide were not considered very useful. Training courses for FRAM in a PPR context received little support.

Various knowledge gaps were identified as well. Apart from the improvement (in terms of accuracy and scope) and integration of existing tools for oil spill risk analysis, the data and information quality and availability needs to be improved so that analyses can be executed in practice. A need was also identified to develop risk identification and analysis methods for new and emerging risks in maritime transportation. In addition, more guidance should be developed for risk acceptability (in terms of accident occurrence and response capabilities). Finally, future work should also focus on how to link the risk management processes to organizational processes, and to inter-organizational governance bodies.

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