Oil spill risk, preparedness, and response in the Arctic

A guideline and open-source toolbox for Pollution Preparedness and Response Risk Management

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DALHOUSIE UNIVERSITY

HELCOM

Guest Lecture at Aalto University, Maritime Risk and Safety Course, October 2023

OVERVIEW

Maritime activities in the Arctic

Accidents and oil spills in Arctic conditions

Oil spill response system

Challenges for oil spill response in the Arctic

Need for Pollution Preparedness and Response (PPR) risk management (RM) guidelines and tools

OpenRisk guidelines for PPR RM

OpenRisk tools for PPR RM

MARITIME ACTIVITIES IN THE ARCTIC

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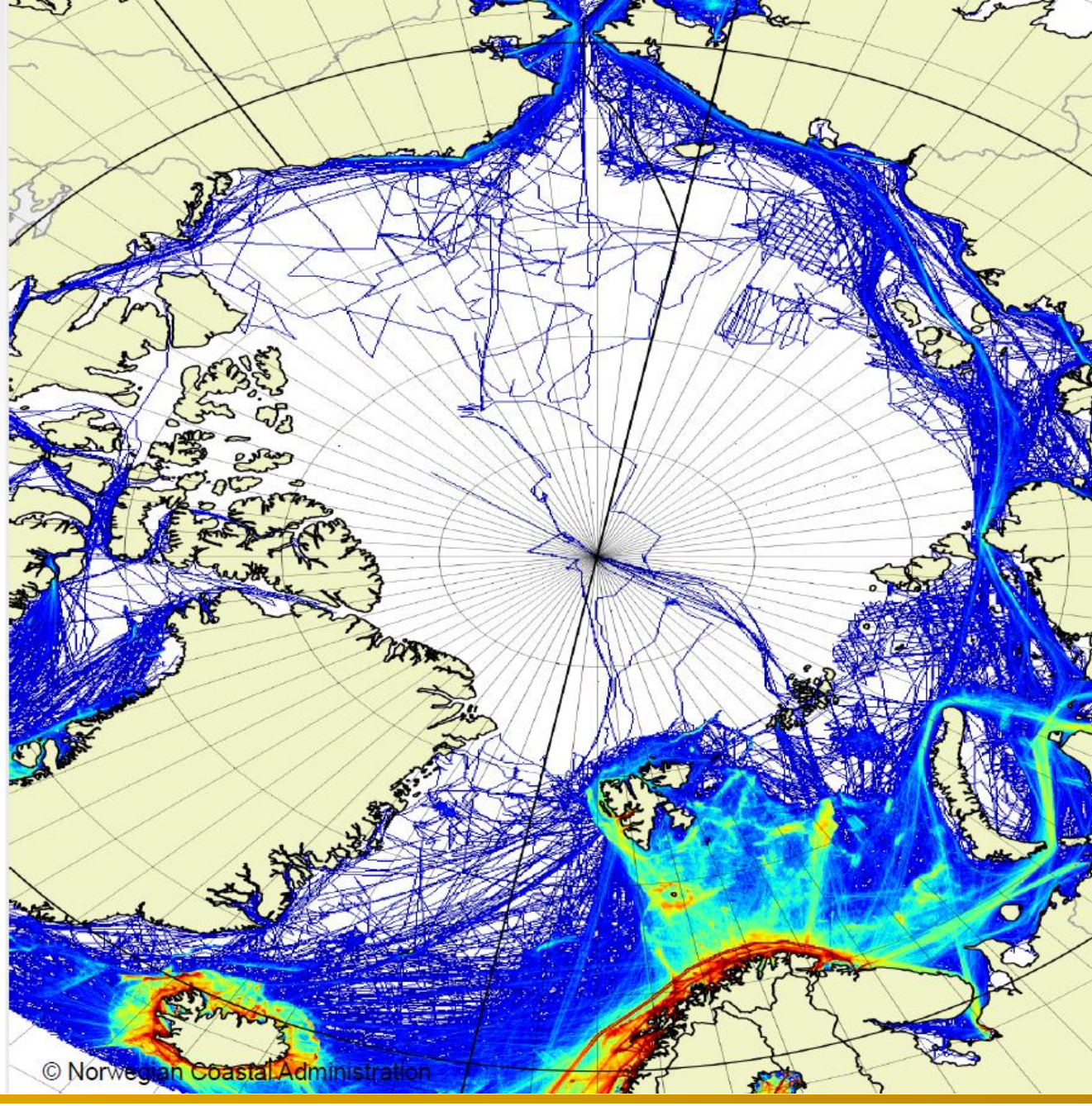
Source:
Paul Nicklen / National Geographic Stock / WWF-Canada

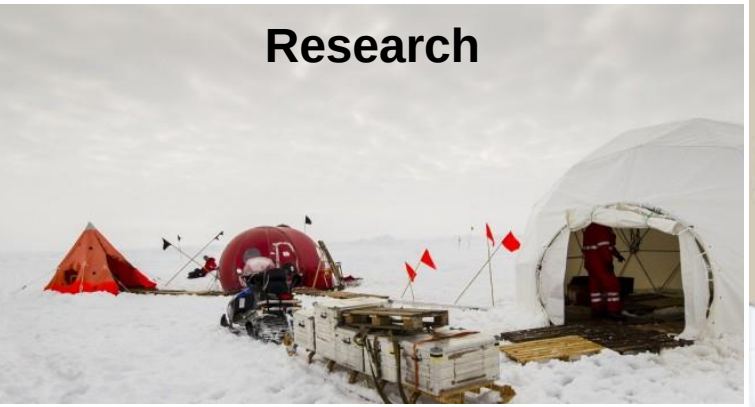
Maritime traffic in the Arctic is happening

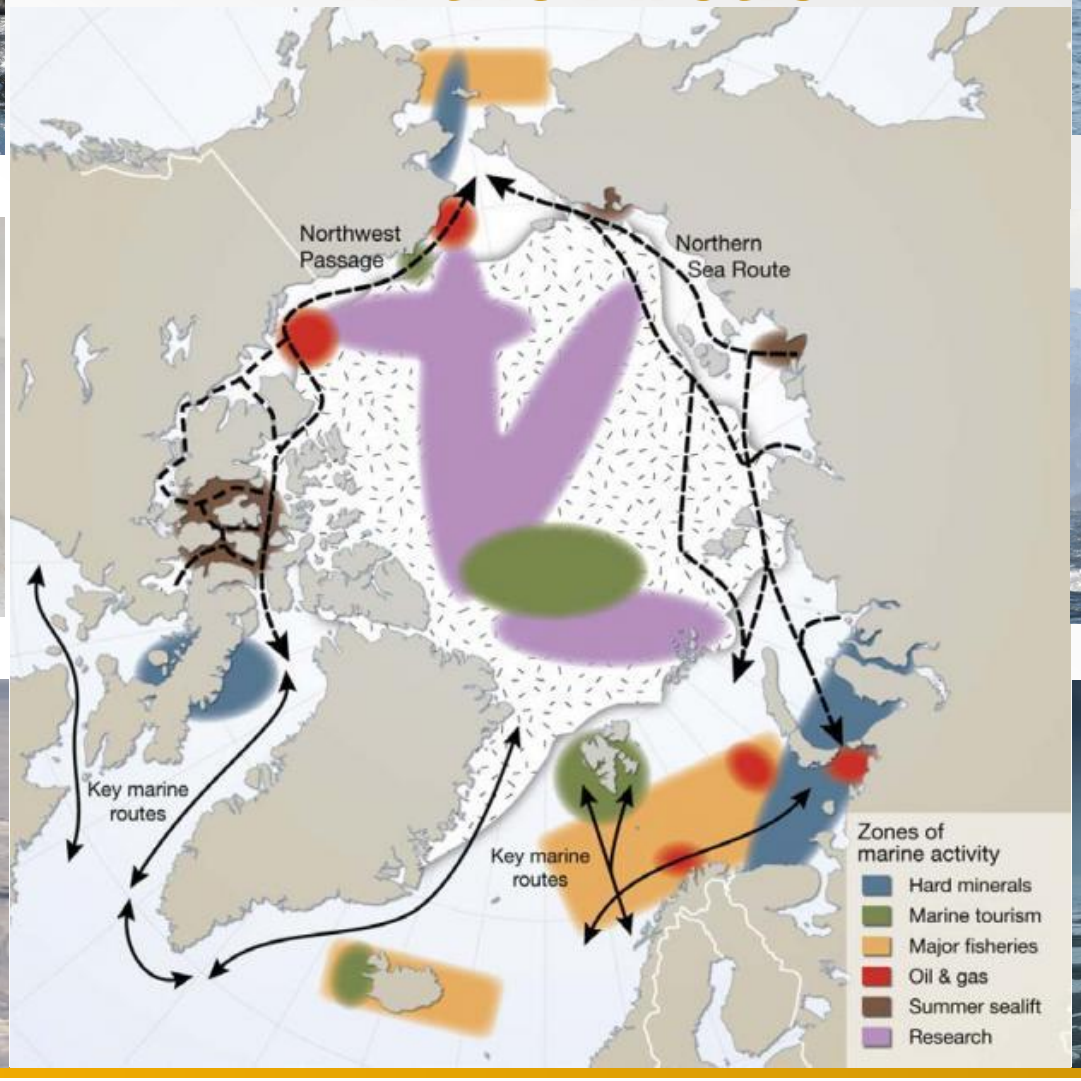
- Most commercial traffic is in Norwegian waters
- Intense traffic also in Russia and Canada
- Transit vs destinational traffic



Source:
Kvaal M. 2018. The importance of International Cooperation in the Challenging Environment of the Arctic. Arctic MOSPA, Oulu, Finland

Maritime-related activities in the Arctic





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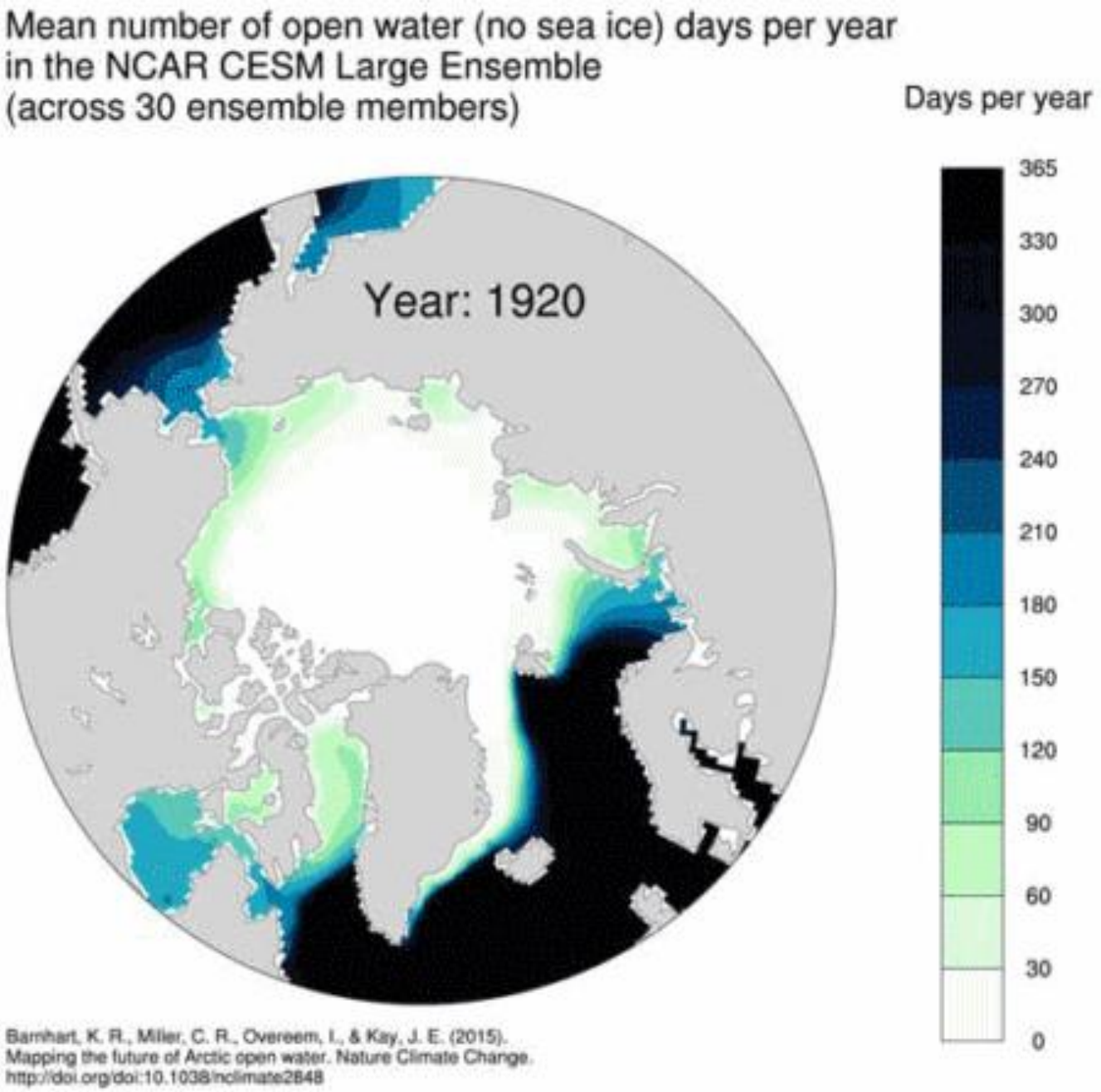
Source:
Maritime Herald 2018. WWF 2015. Times Magazine 2018. Arctic Energy Center 2018. Canadian Geographic 2018.

Projected decrease of sea ice in the Arctic

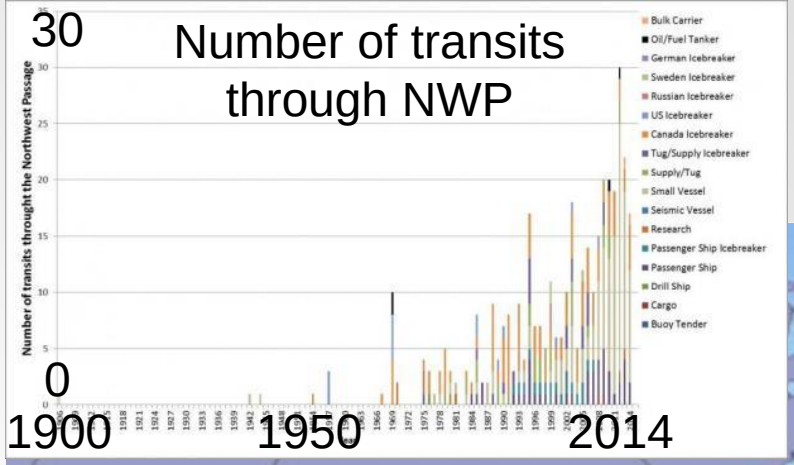
- Significantly more days with open water conditions in coming years / decades
- Potential for increased maritime activity in the Arctic



Source:
Barnhart K.R., Miller C.R., Overeem I., Kay J.E. 2016. Nature Climate Change 6, 280-285.

Arctic Shipping Routes

- Traffic volumes on existing routes are expected to rise
- New shipping routes may emerge
- Uncertainties are large
  - market conditions
  - ice and weather conditions
  - vessel requirements
  - Infrastructure
  - political



Source:
The Arctic Institute. 2018
Government of the Northwest Territories, Environment and Natural Resources. 2015

ACCIDENTS AND OIL SPILLS IN ARCTIC CONDITIONS

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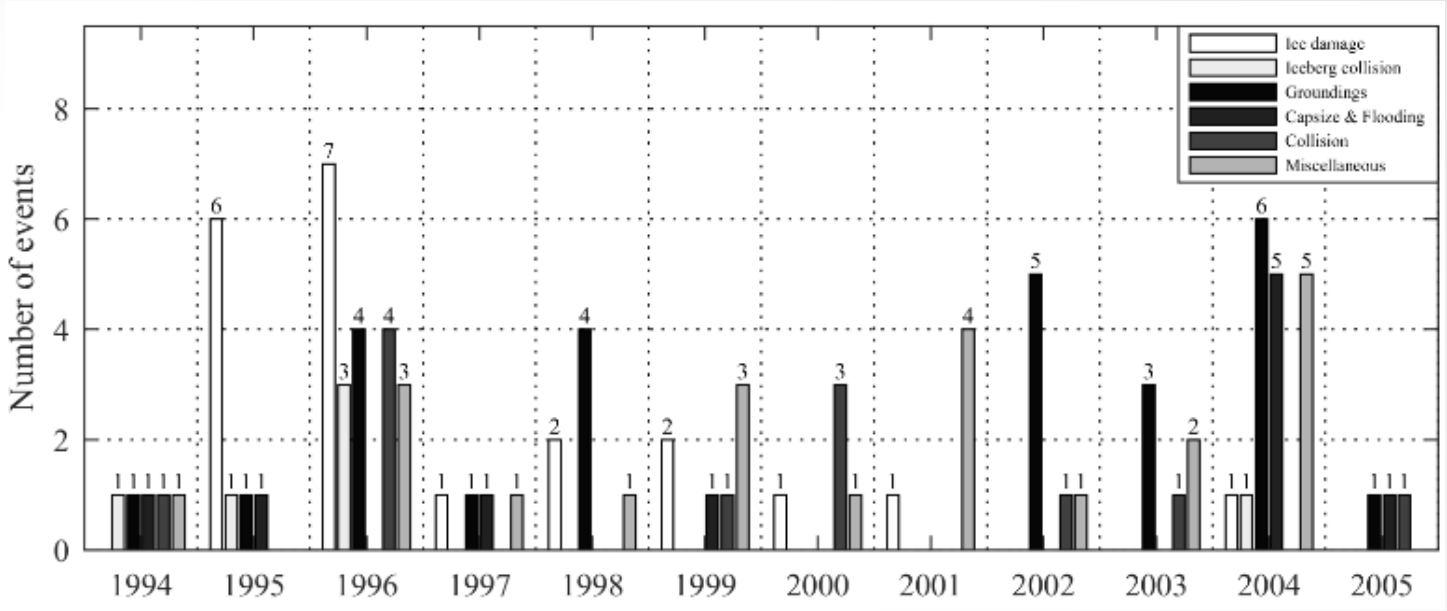
Source:
ArcticSave. 2018

Shipping accidents in Arctic Environment

Clipper Adventurer
Grounding, 2010

Accidents and incidents in the Arctic



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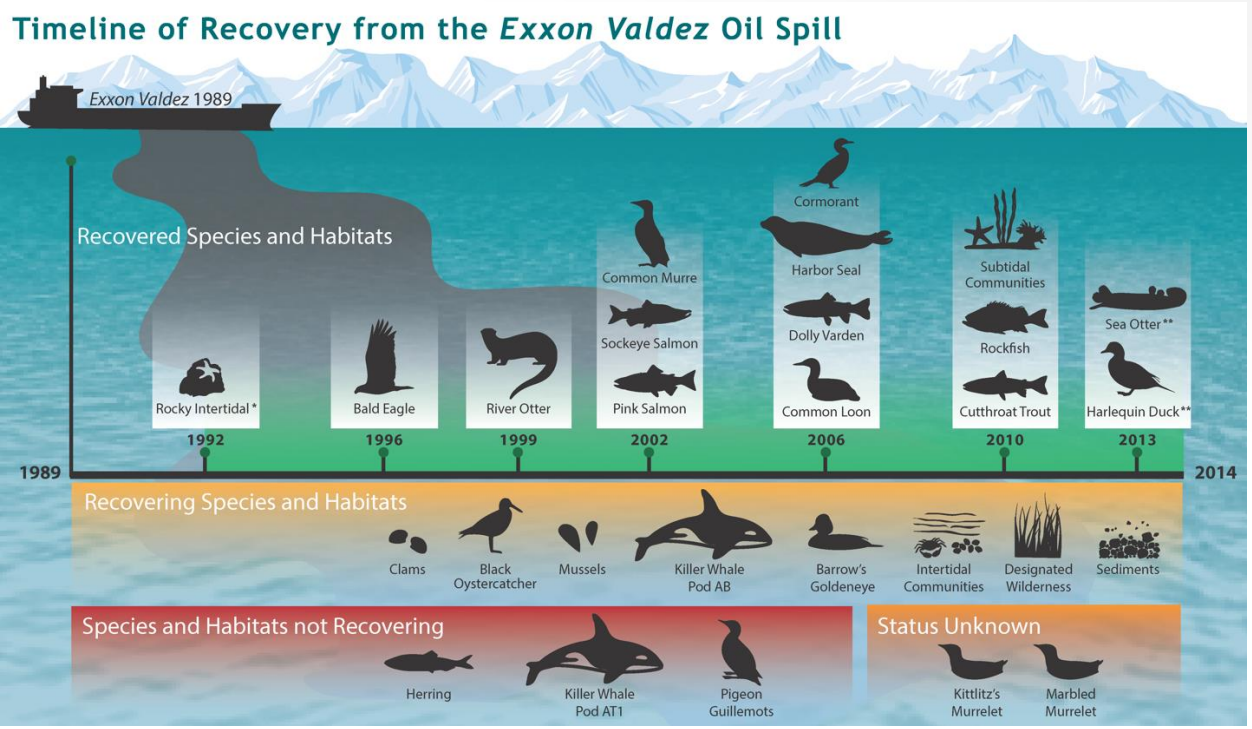
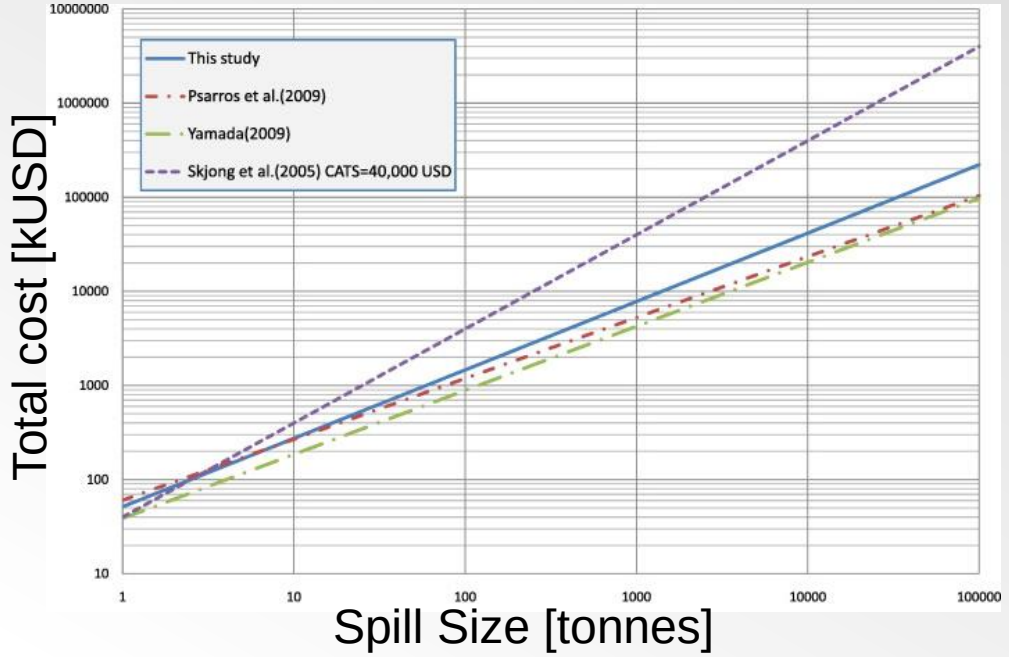
Source:
Stewart E.J., Dawson J. 2011. Arctic 64(2):263-267
Huuhtanen Y. 2018. Aalto University, MSc Thesis.

Impacts:
Ecosystem, economic, media, local communities



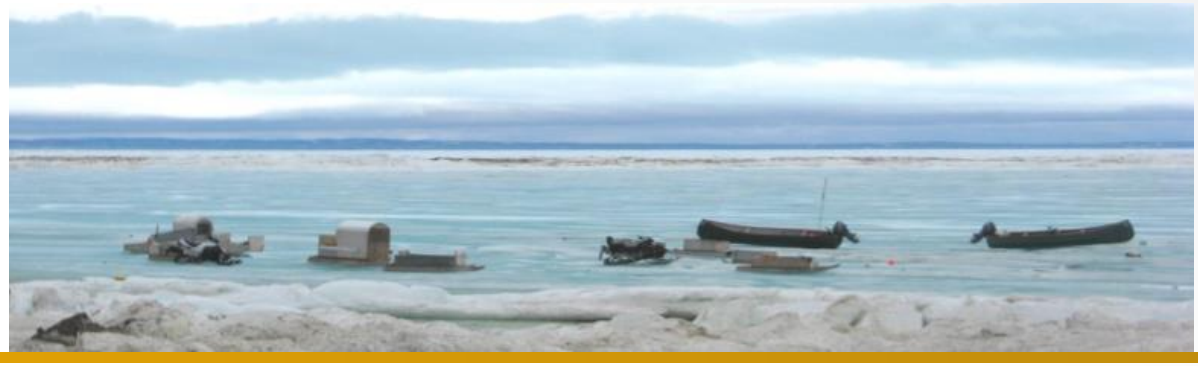


Coast Guard seeks damages for Arctic cruise ship accident

Clipper Adventurer hit uncharted sand bar in 2010

CBC News · Posted: Jun 19, 2012 11:23 AM CT | Last Updated: June 20, 2012

CBC



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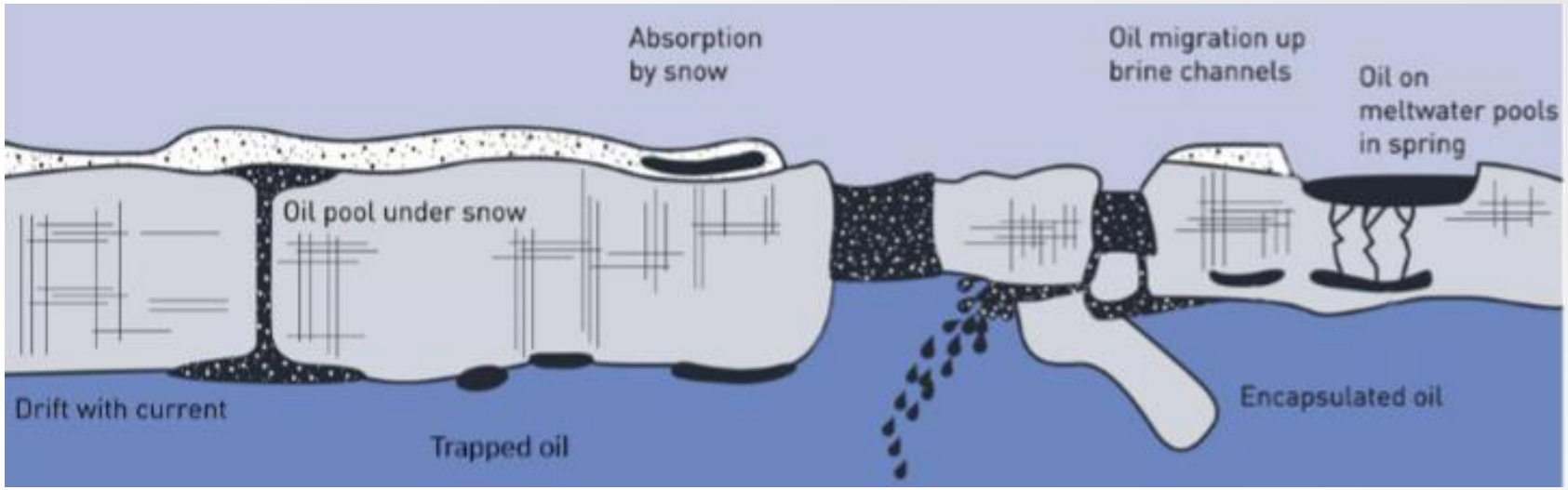
Source:

Shigeneka G. 2014. NOAA Office of Response and Restoration, 78p.

Kontovas CA., Psaraftis H.N., Ventikos N.P., Marine Pollution Bulletin 60:1455-1466.

Hurtubise J. 2016.
Marine Affairs Program Technical Report #14.

Oil spill in ice: very complex



Frazil ice

Nilas

1st year ice

Melting ice

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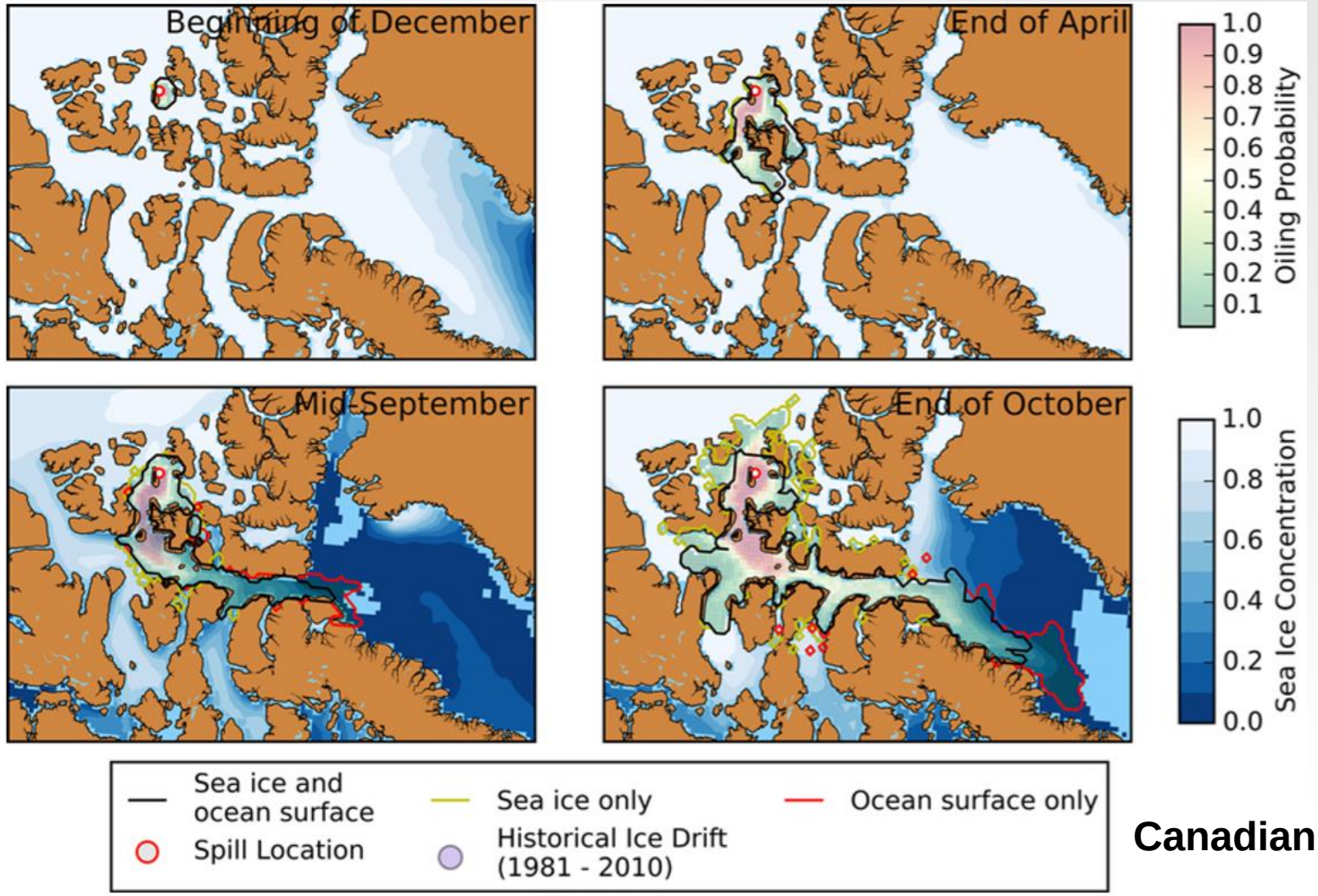
Source:
Bobra A.M., Fingas M.F. 1986. Water Science and Technology 18(2):13-23.
Goncharov V. 2018. Arctic MOSPA Conference, Oulu, Finland.

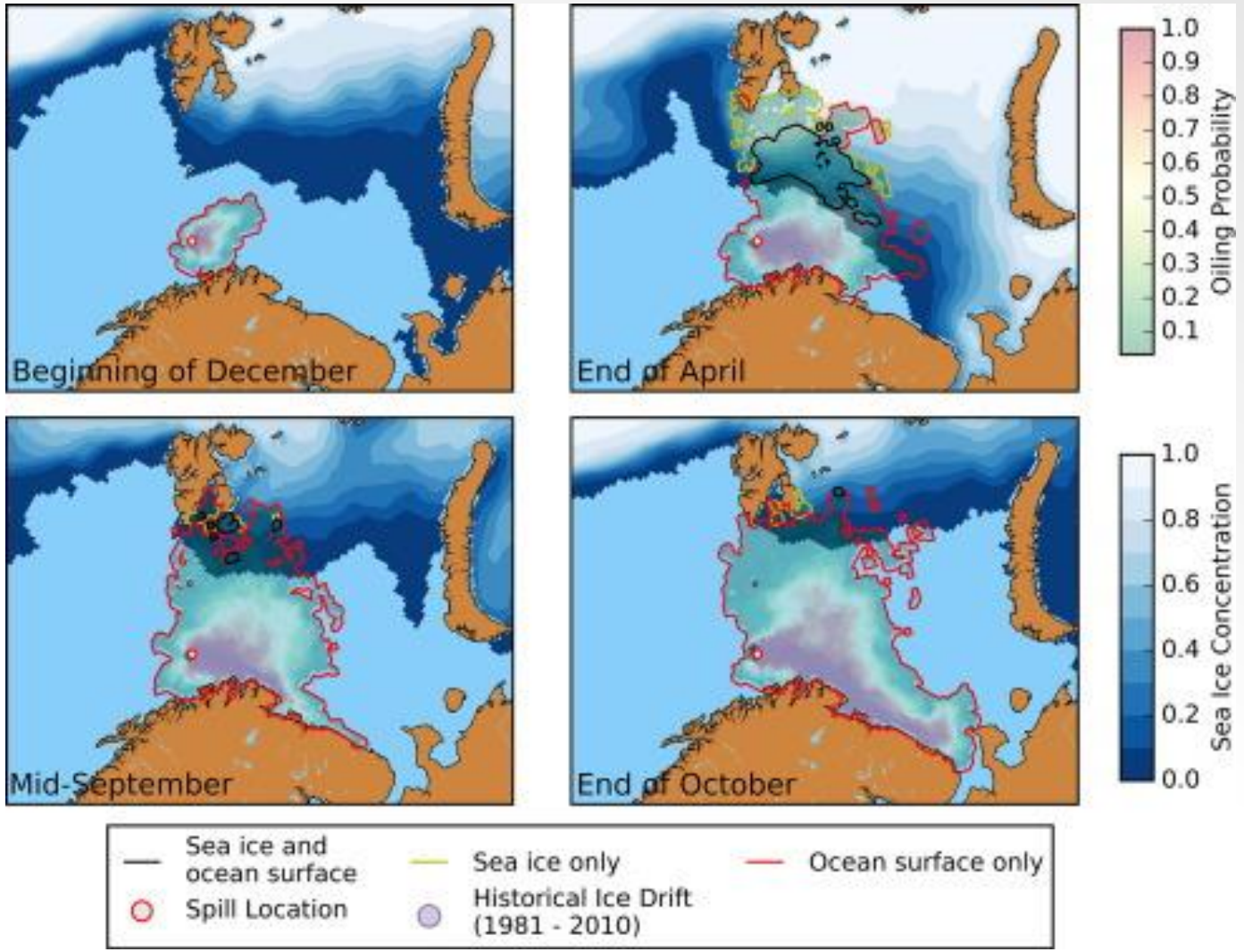
A worst-case spill would lead to vast polluted areas



Canadian Arctic Archipelago

Source:
Blanken H., tremblay L.B., Gaskin S., Slavin A. Marine Pollution Bulletin 116:315-331.

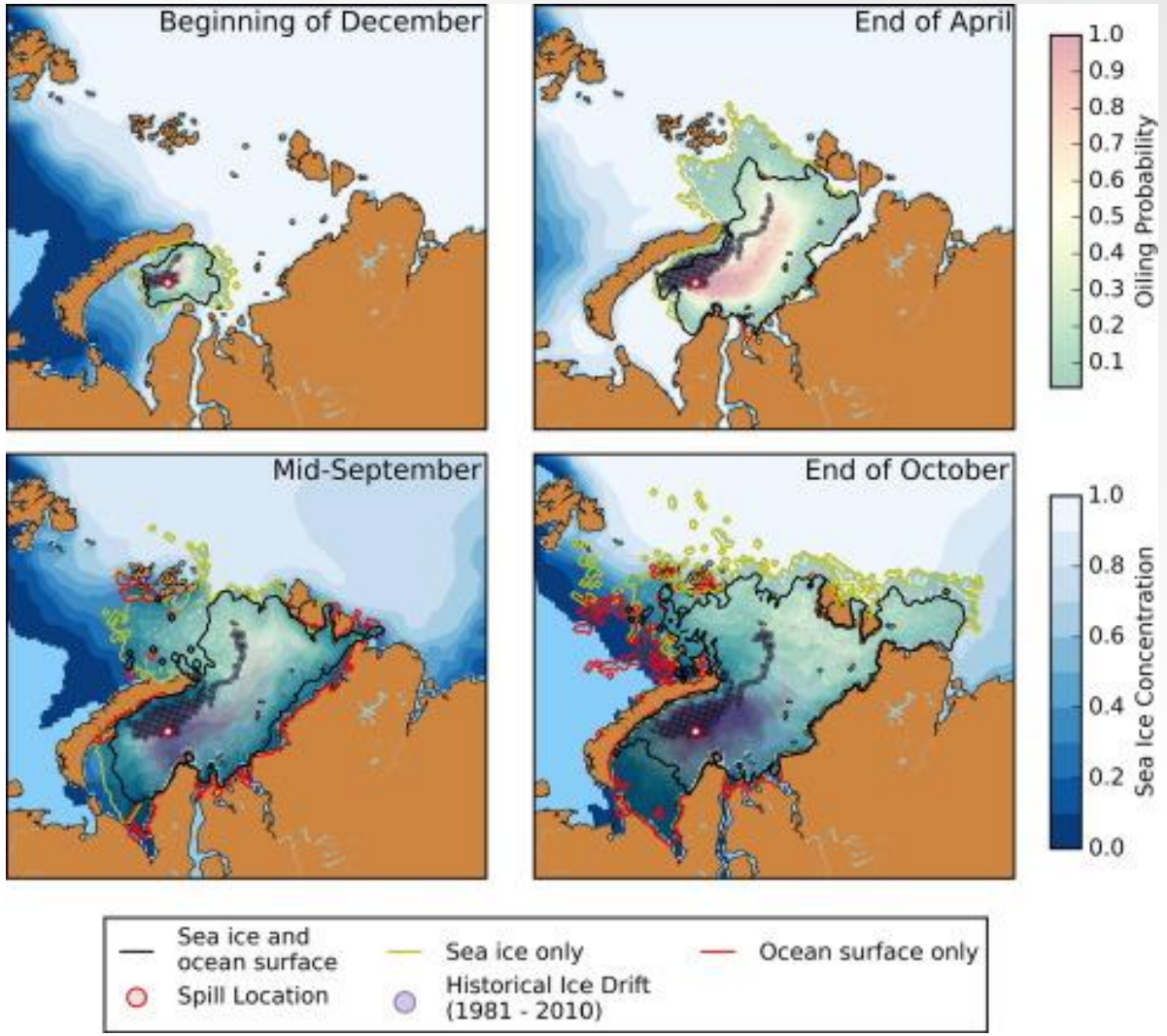
A worst-case spill would lead to vast polluted areas



Barents Sea

Source:
Blanken H., tremblay L.B., Gaskin S., Slavin A. Marine Pollution Bulletin 116:315-331.

A worst-case spill would lead to vast polluted areas



Kara Sea

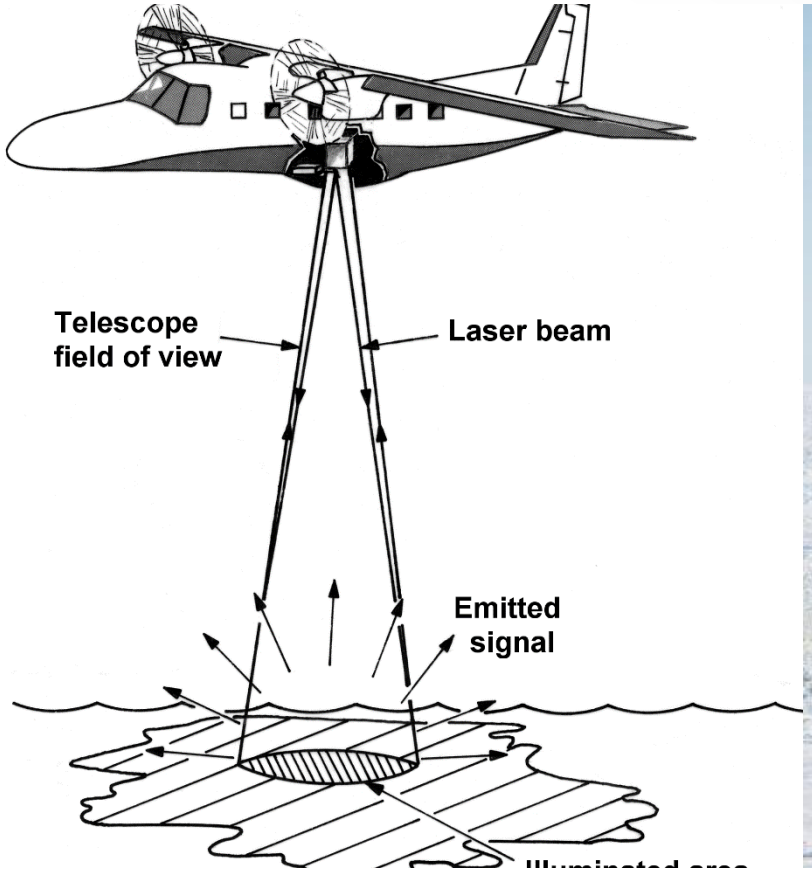
DALHOUSIE UNIVERSITY

Source:
Blanken H., tremblay L.B., Gaskin S., Slavin A. Marine Pollution Bulletin 116:315-331.

OIL SPILL RESPONSE SYSTEM

Oil spill response: complex socio-technical system

Detection

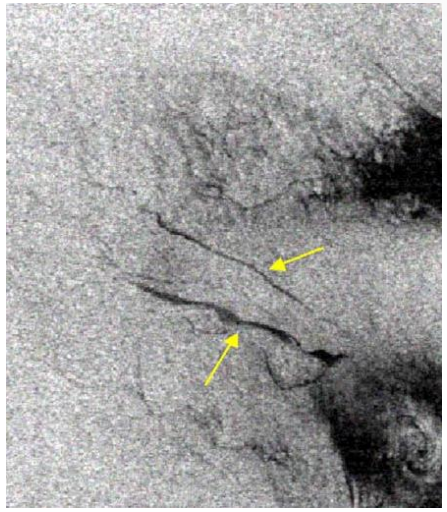


Response operation

Logistics

Source:
SEOS Project. 2018. SYKE 2015. ITOPF 2015.

Technologies for oil detection



Sattelite remote sensing

Underwater surveillance

Ground-penetrating radar

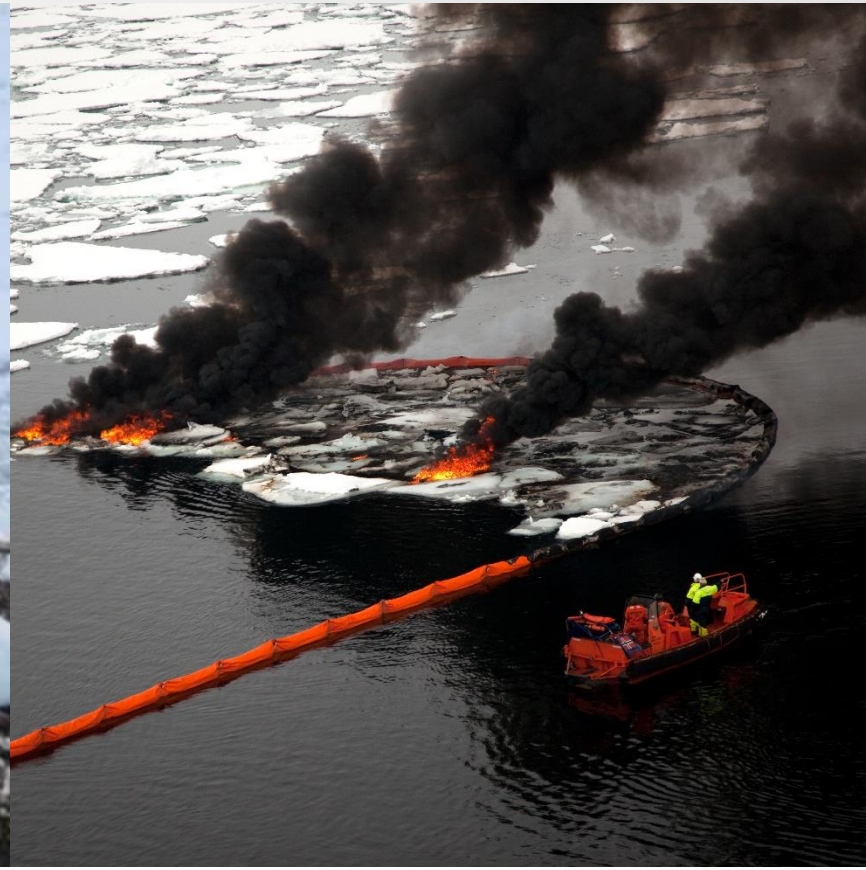
Unmanned Aerial vehicle

Source:
ITOPF 2015. Oil Spill Response Ltd 2017. Marine Technology News 2018.

Technologies for oil response

Mechanical recovery

Dispersant application



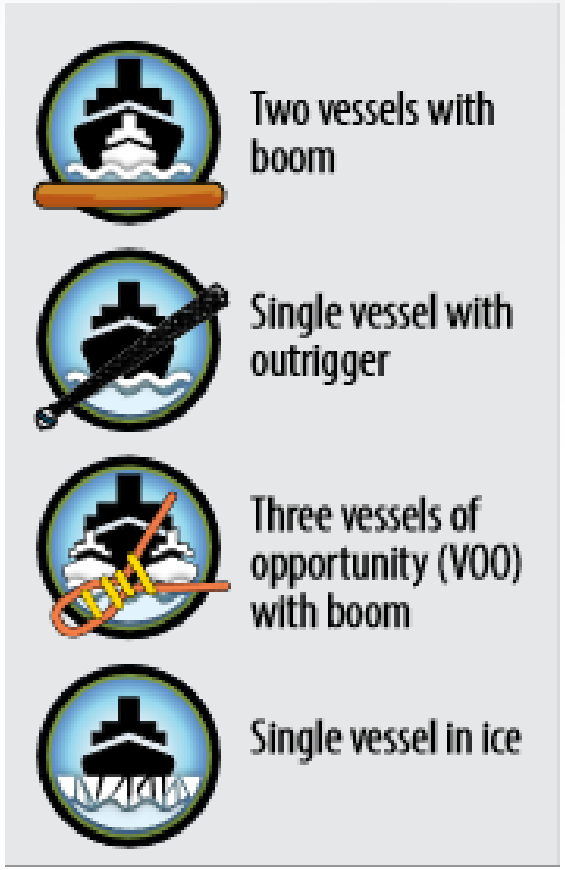
In-situ burning

DALHOUSIE UNIVERSITY

Source:
SYKE 2015. Sintef 2015.

Technologies for oil response

Mechanical recovery

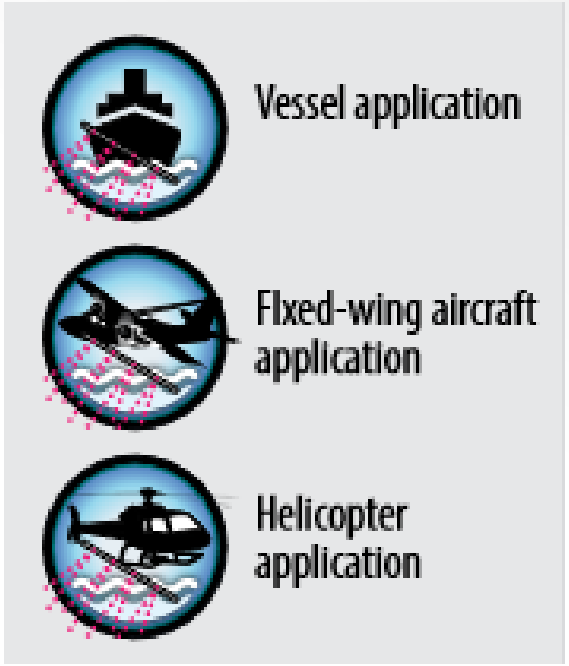


- Specialized response equipment
- Containment
- Waste storage, treatment, and deposition

Source:
SYKE 2015. EPPR 2017. Circumpolar Oil Spill Response Viability Analysis: Technical Report. 134pp.

Technologies for oil response

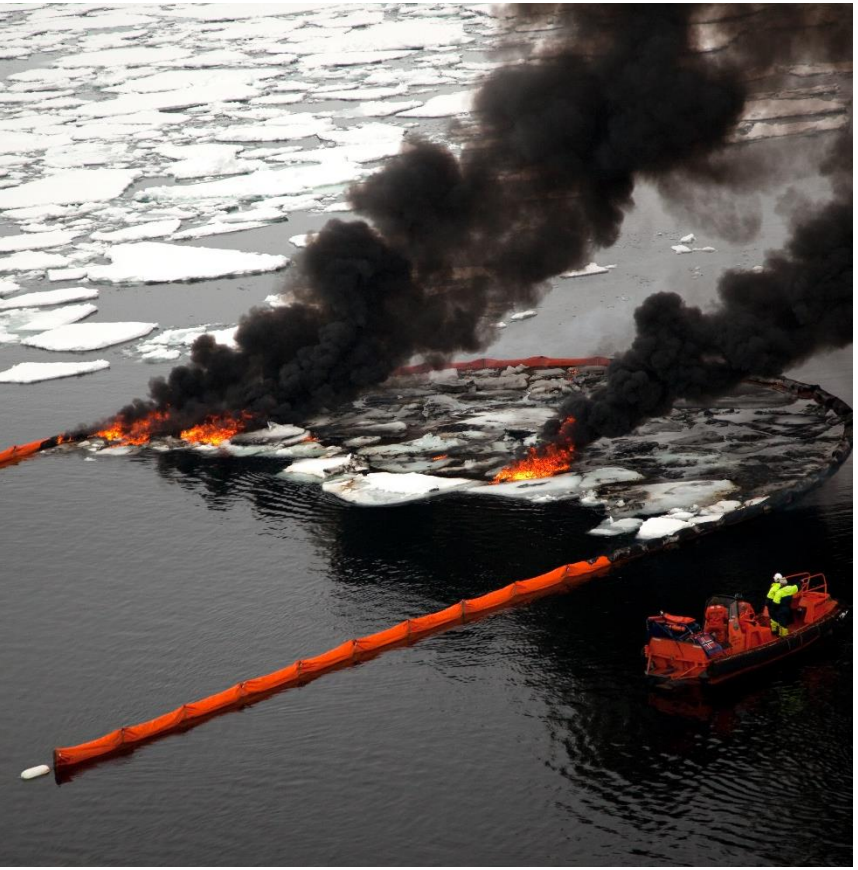
Dispersants application



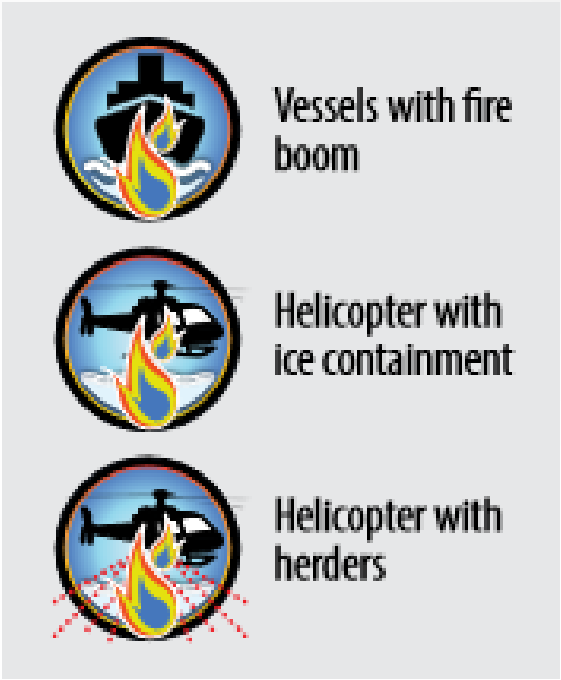
- Specialized response equipment
- Window of opportunity
- Oil type dependent
- Regulatory approval
- Mixing energy

Source:
Sintef 2015. EPPR 2017. Circumpolar Oil Spill Response Viability Analysis: Technical Report. 134pp.

Technologies for oil response



In-situ burning



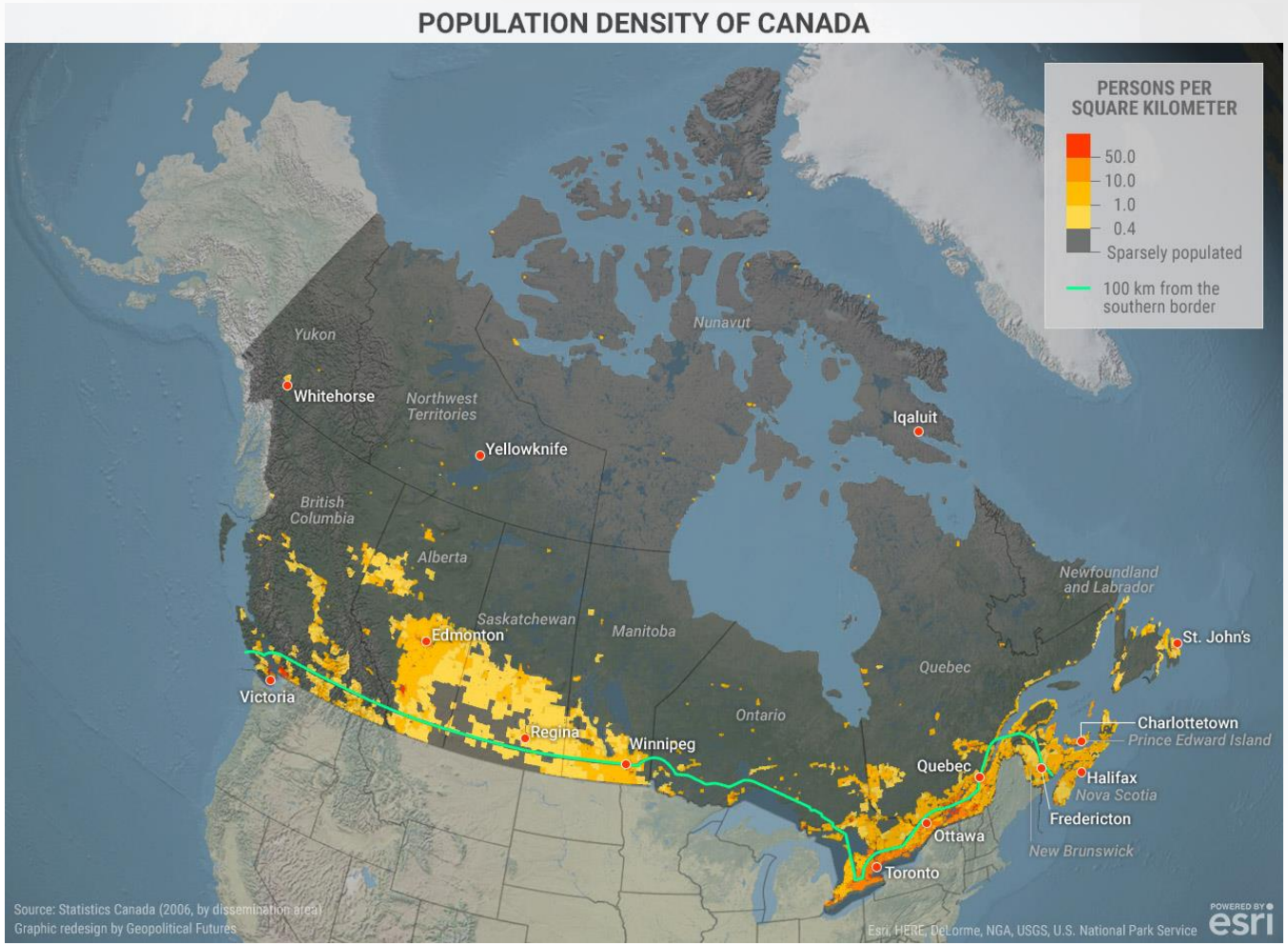
- Containment, slick thickness
- Window of opportunity
- Regulatory approval
- Oil type dependent
- Residues
- Smoke plume

Source:
Sintef 2015. EPPR 2017. Circumpolar Oil Spill Response Viability Analysis: Technical Report. 134pp.

CHALLENGES FOR OIL SPILL RESPONSE IN ARCTIC AREAS

Arctic features

Cold



Unpredictable

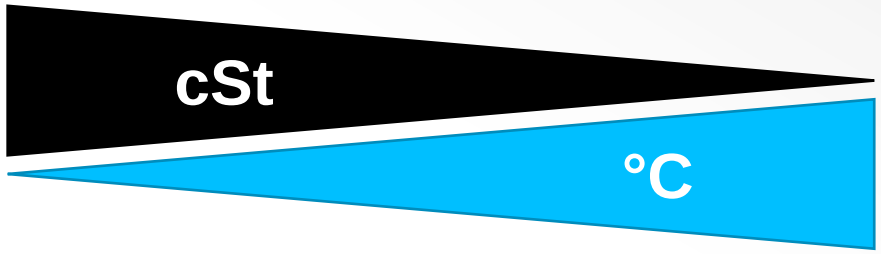
Complex, dynamic ice

Remote, few people, lack of infrastructure

Light conditions

Source:
Statistics Canada 2006. ITOPF 2015. National Snow and Ice Data Centre 2016.

Effects on and challenges to response:cold temperature



Wider operational window

- Slower spreading
- Less evaporation

Restricted operational possibilities

- Impeded mechanical recovery
- Reduced effectiveness of dispersants
- Winterization

Safety, efficiency, costs

- Personal Protective Equipment
- Restricted working hours
- Heated accommodation

Source: ITOPF 2015.

Effects on and challenges to response: sea ice

Improved response effectiveness

- Natural containment
- Reduced spreading
- Dampened waves

Logistical and safety challenge

- Unpredictable (dynamic, complex)
- Often unsafe to work on ice
- Specialized skills for response and support operations
- Transport challenge

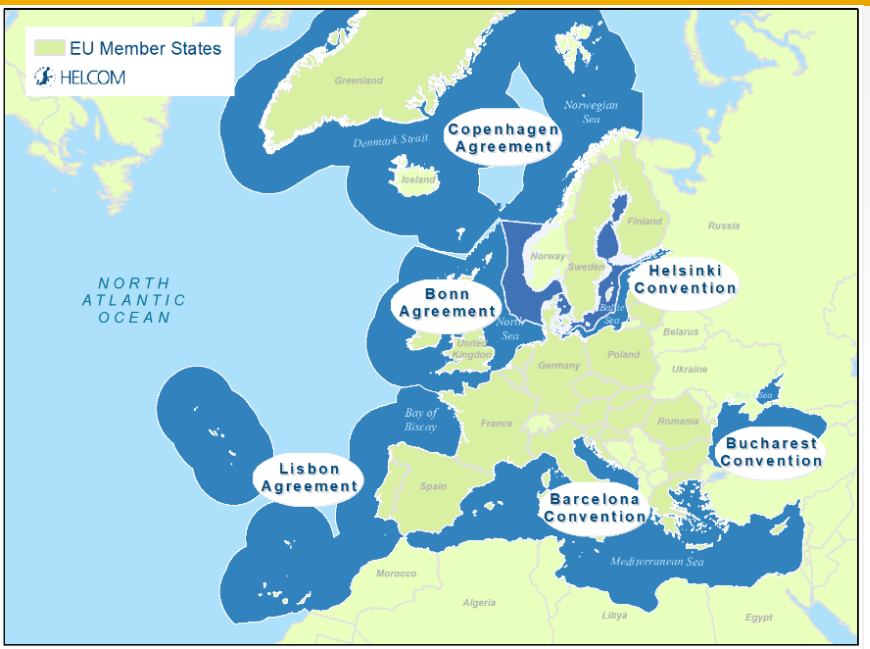
Source:
ITOPF 2015. NOAA 2005. RCI 2015.

Effects on and challenges to response: remoteness

Challenges to practical operations

- Logistics, getting equipment on site
- Waste storage, treatment, disposal
- Communications
- Manpower
- Personnel Health and Safety
- Accomodation

Source: ITOPF 2015.

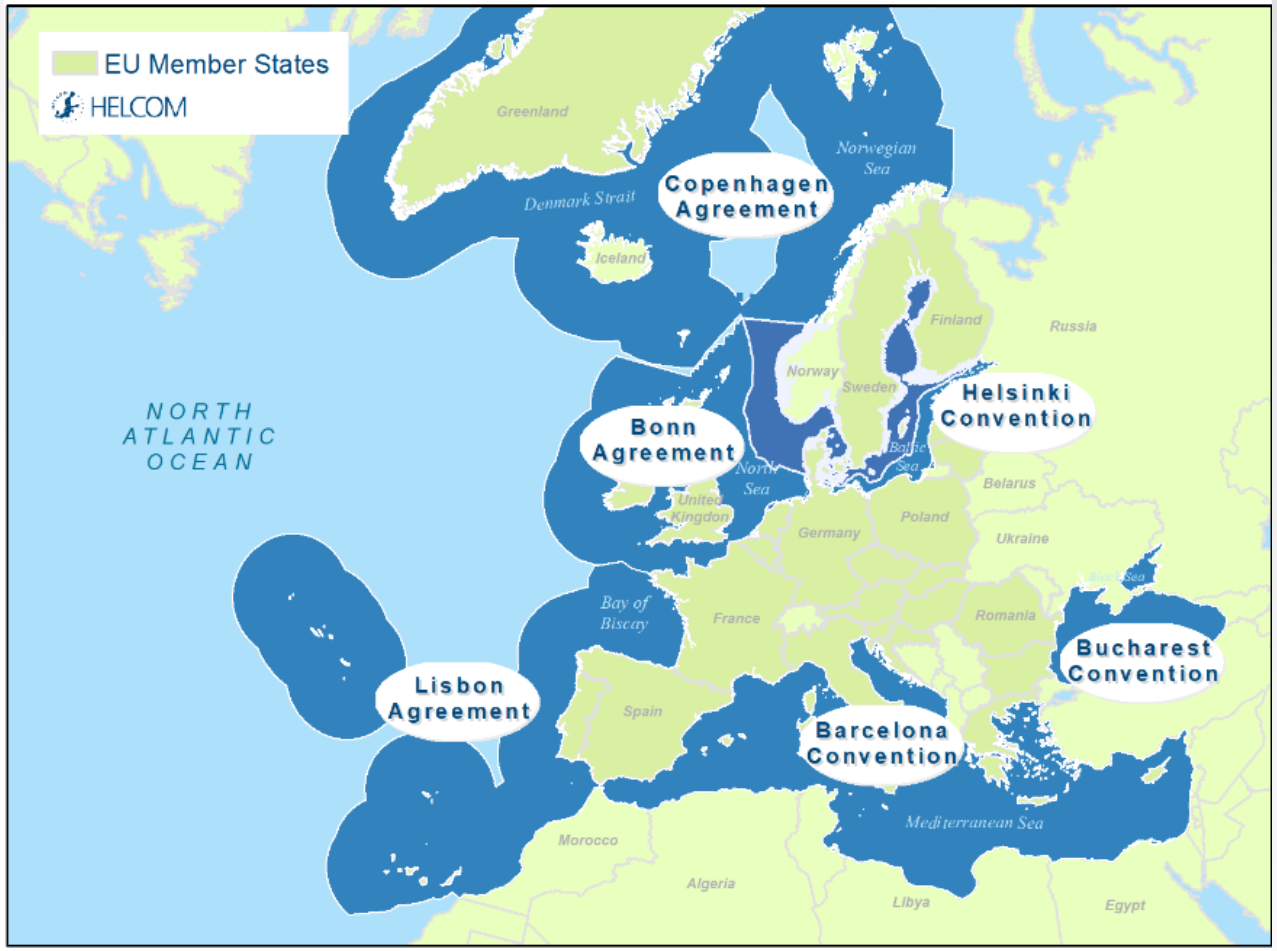


EP PR
EMERGENCY PREVENTION, PREPAREDNESS AND RESPONSE

NEED FOR POLLUTION PREPAREDNESS AND RESPONSE RISK MANAGEMENT GUIDELINES AND TOOLS

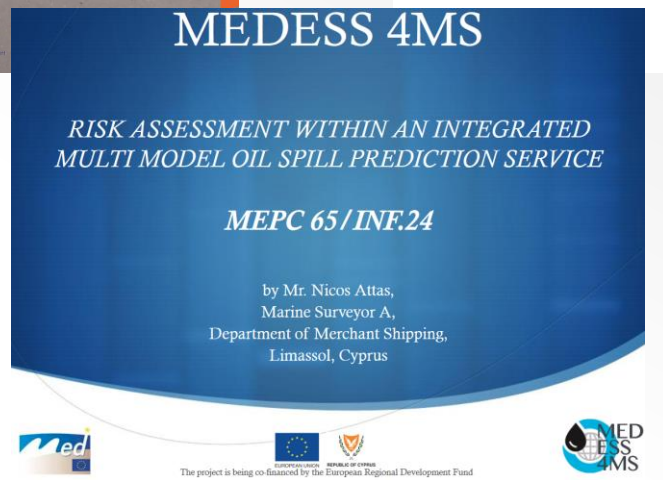
Regional Response Agreements in Europe

- Contents of agreements varies
- Generally the same aims:
  - Prevent and eliminate pollution to the marine environment
  - Land-based sources, ships, incineration, dumping, seabed exploration
- Specific provions related to collaboration in enhancing maritime safety and collaboration in oil spill response



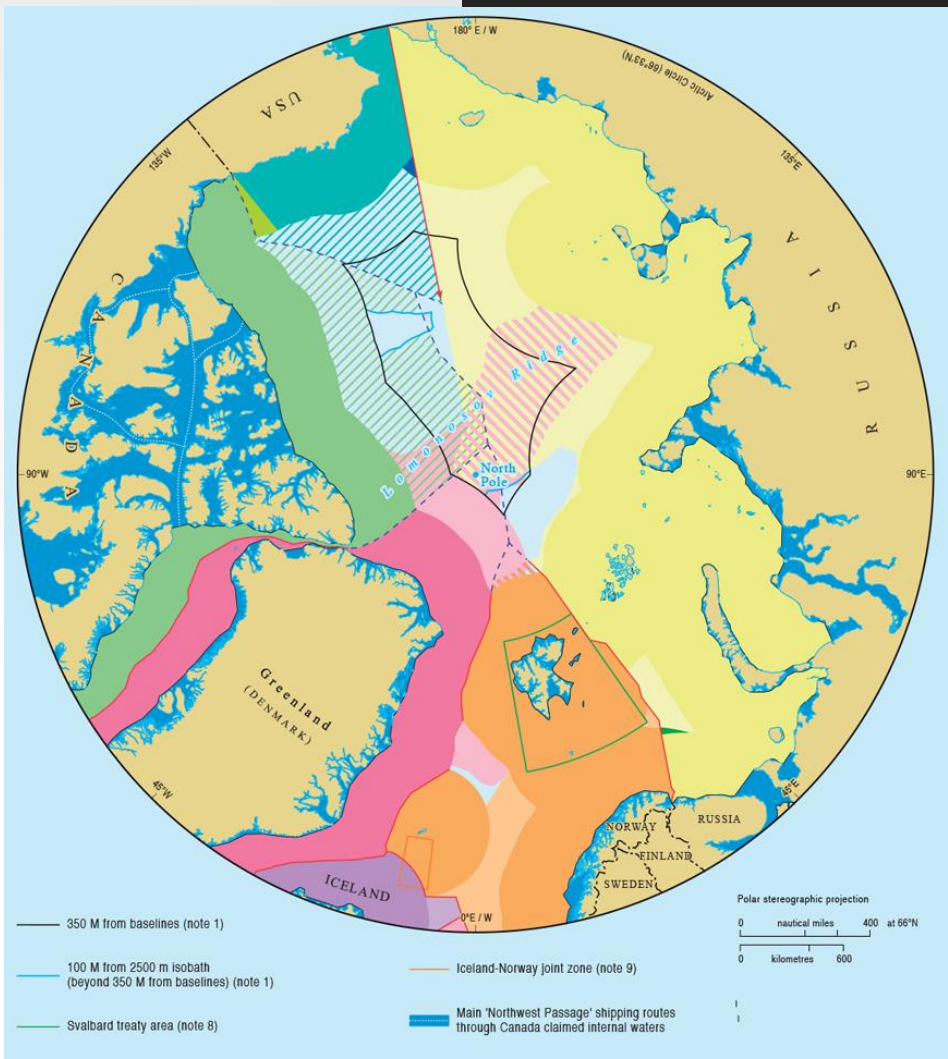
Previous experiences with risk assessments

- Regional risk assessments for pollution prevention and have been performed in the past
- Challenges:
  - High costs of earlier projects
  - Lack of transparency
  - Methodologies not streamlined, making cross-border comparisons difficult
  - Need for strengthening the link between risk assessment and management
- ! Need for integration, harmonization, and guidance



Agreement on Cooperation on Marine Oil Pollution Preparedness and Response in the Arctic

- Agreement between 8 Arctic States
- Ratified 2016.03
- Articles:
  - Art. 4. Systems for oil pollution preparedness and response
  - Art. 6 Notification
  - Art. 7 Monitoring
  - Art. 8 Request for Assistance, Coordination and Cooperation in Response Operations
  - Art. 12 Cooperation and Exchange of Information
  - Art. 13 Joint Exercises and Training



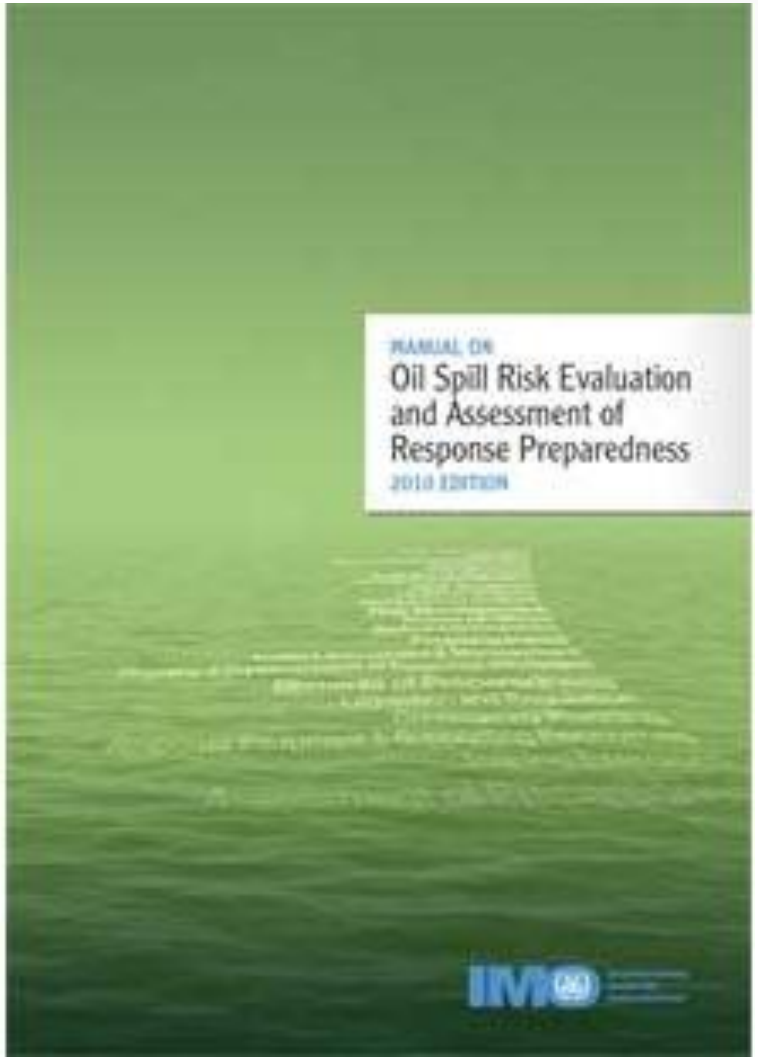
EPPR Scoping Workshop on Risk Assessment Methods and Metadata, 11.2017

- Agreement to develop a guideline and a toolbox (data and tools) for best practice on Arctic marine risk assessments
- Long-term aim to perform comprehensive circumpolar risk assessment

OpenRisk

OPENRISK GUIDELINES FOR PPR RM

There are existing guidelines for maritime risk



YEAR OF THE SEAFARER 2010

IMO INTERNATIONAL MARITIME ORGANIZATION

E

4 ALBERT EMBANKMENT
LONDON SE1 7SR
Telephone: +44 (0)20 7735 7611 Fax: +44 (0)20 7587 3210

Ref. T2-OSS/2.7.1

SN.1/Circ.296
7 December 2010

DEGREE OF RISK EVALUATION

INTERNATIONAL MARITIME ORGANIZATION
4 ALBERT EMBANKMENT
LONDON SE1 7SR

Telephone: 020 7587 3152
Fax: 020 7587 3210

IMO

E

Ref. T1/3.02
T5/1.01

MSC/Circ.1180
MEPC/Circ.474
25 August 2005

AMENDMENTS TO THE GUIDELINES FOR FORMAL SAFETY ASSESSMENT (FSA) FOR USE IN THE IMO RULE-MAKING PROCESS (MSC/Circ.1023 - MEPC/Circ.392)

Why implement ISO31000 in PPR?

- HELCOM and its member states [*] has identified a **need for a wider and integrated set of tools** for managing maritime risk, for pollution prevention and response.
- All major risk management standards stress the need for **linking the application of tools to organizational commitment and processes** for effective risk management.
- **Current maritime PPR risk guidelines** do not cover links to organizational issues, and lack a coherent set of tools for executing risk analysis for different decision making contexts.

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OPEN-SOURCE TOOLS FOR REGIONAL RISK ASSESSMENTS TO IMPROVE EUROPEAN PREPAREDNESS AND RESPONSE AT SEA

Co-financed by the EU – Civil Protection Financial Instrument

[*] With support from BONN Agreement, the Copenhagen Agreement, REMPEC and the Norwegian Coastal Administration

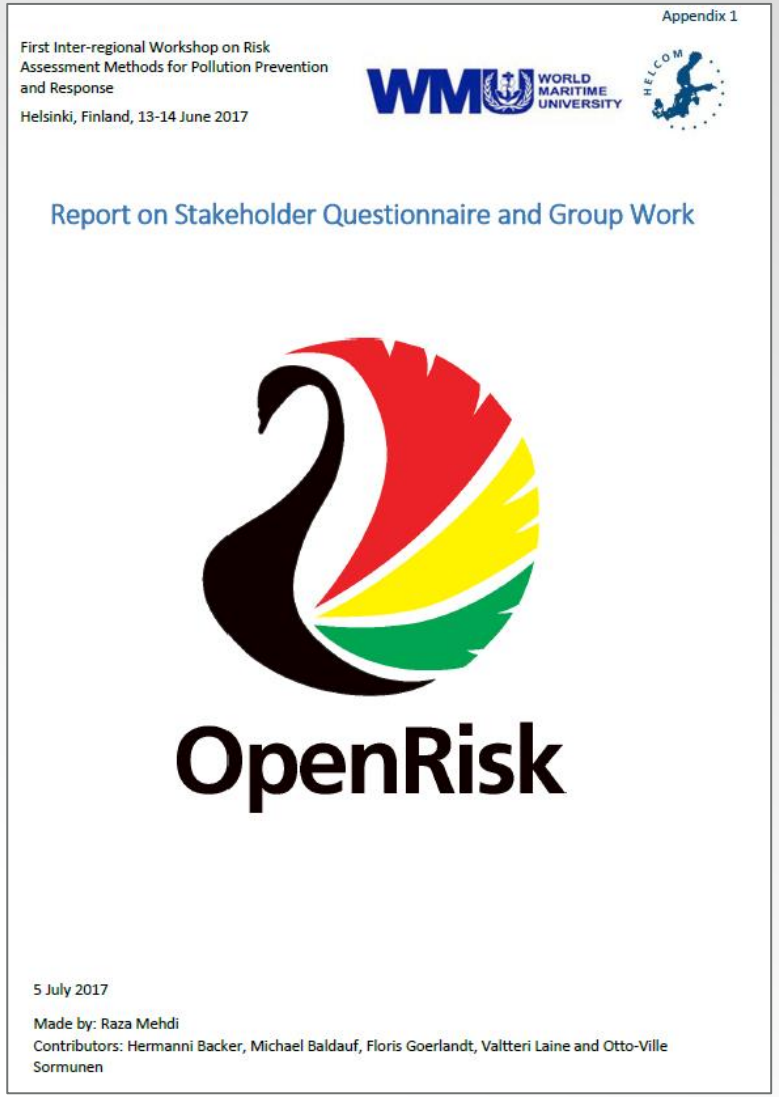
Why implement ISO31000 in PPR?

- Needs of the users at the strategic end and those at the operational end are different, but complementary.
- It is important to consider risk-based tools and methods which can fulfil user needs at either end of the spectrum
- While also focusing on **how to consider risk assessment in different decision contexts and time scales.**

WS1 & WS2 EMSA WS ↓

HELCOM RESPONSE 12.04.2018

ISO31000:2009 ⟶ **ISO31000:2018**



Appendix 1

First Inter-regional Workshop on Risk Assessment Methods for Pollution Prevention and Response

Helsinki, Finland, 13-14 June 2017

WMU WORLD MARITIME UNIVERSITY

HELCOM

Report on Stakeholder Questionnaire and Group Work

OpenRisk

5 July 2017

Made by: Raza Mehdi

Contributors: Hermanni Backer, Michael Baldauf, Floris Goerlandt, Valtteri Laine and Otto-Ville Sormunen

WHAT IS ISO31000:2018?

ISO: International Organization for Standardization

- International Organization for Standardization (ISO) is the world's largest developer and publisher of International Standards

- ISO is a specialized international organization founded in Geneva in 1947 and concerned with standardization in all technical and non-technical fields except electrical and electronic engineering.

- Upon request, the ISO establishes international technical committees to investigate and resolve specific issues of standardization.

ISO31000:2009 Development Process

- ISO31000:2009 was published in November 2009 and it is the result of **four years** of consultation between risk and standards **experts** in **30 countries**.
- It pulls together and replaces a number of similar international standards. AS/NZS 4360:2004, which was due for revision in 2009, formed the basis of ISO31000.
- This new standard was prepared by the **ISO Technical Management Board Working Group on risk management**.

- Updated guidelines **ISO31000:2018** adopted in 02.2018.

ISO31000:2018 Status and Characteristics

- ISO 31000 is **not** intended for **certification**.
- It does **not** contain **compulsory requirements**.
- It is a collection of **suggested best practices**.

Guide to develop area-specific processes.

Flexibile application.

ISO31000:2018 Key definitions

Risk

Effect of uncertainty on objectives.

An effect is a deviation from the expected – positive and/or negative.

Risk Management

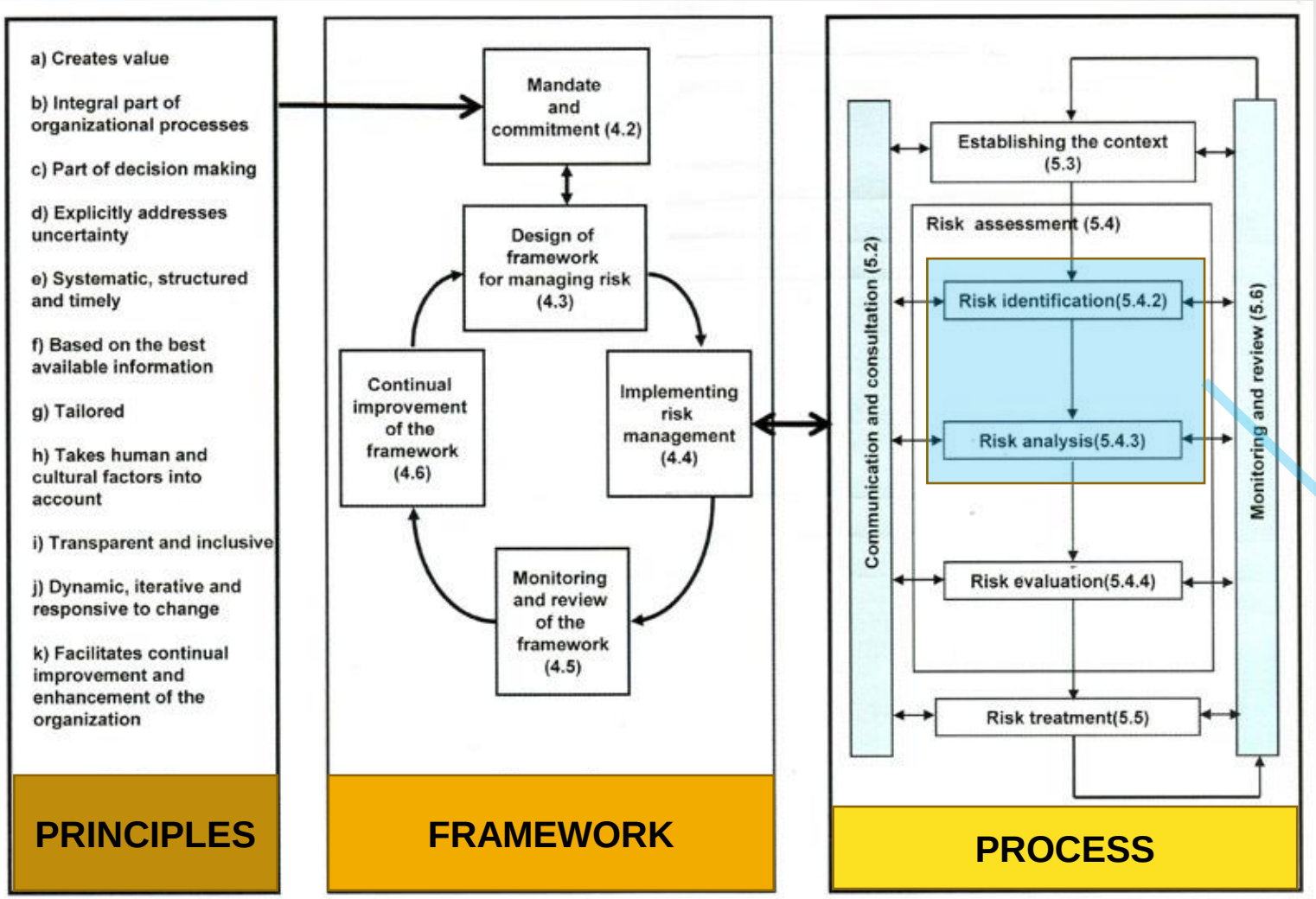
Coordinated activities to direct and control an organization with regard to risk.

- Risk definition is in line with recent trends in academic and professional organizations
- Risk management refers to the architecture for managing risk effectively, i.e. to principles, framework and process

ISO31000:2018 Key definitions

PRINCIPLES
Underlying values and considerations

FRAMEWORK
Embedding risk assessment in organization



PROCESS
Steps to assess risk and take action

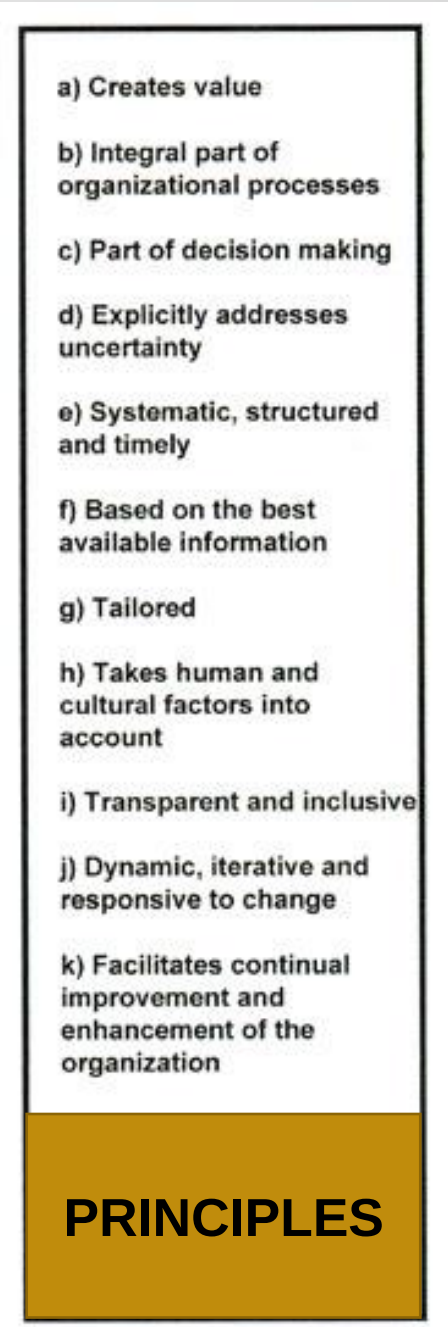
OpenRisk Toolbox

ISO31000:2018 Principles

ISO 31000 contains 11 Principles for risk management:

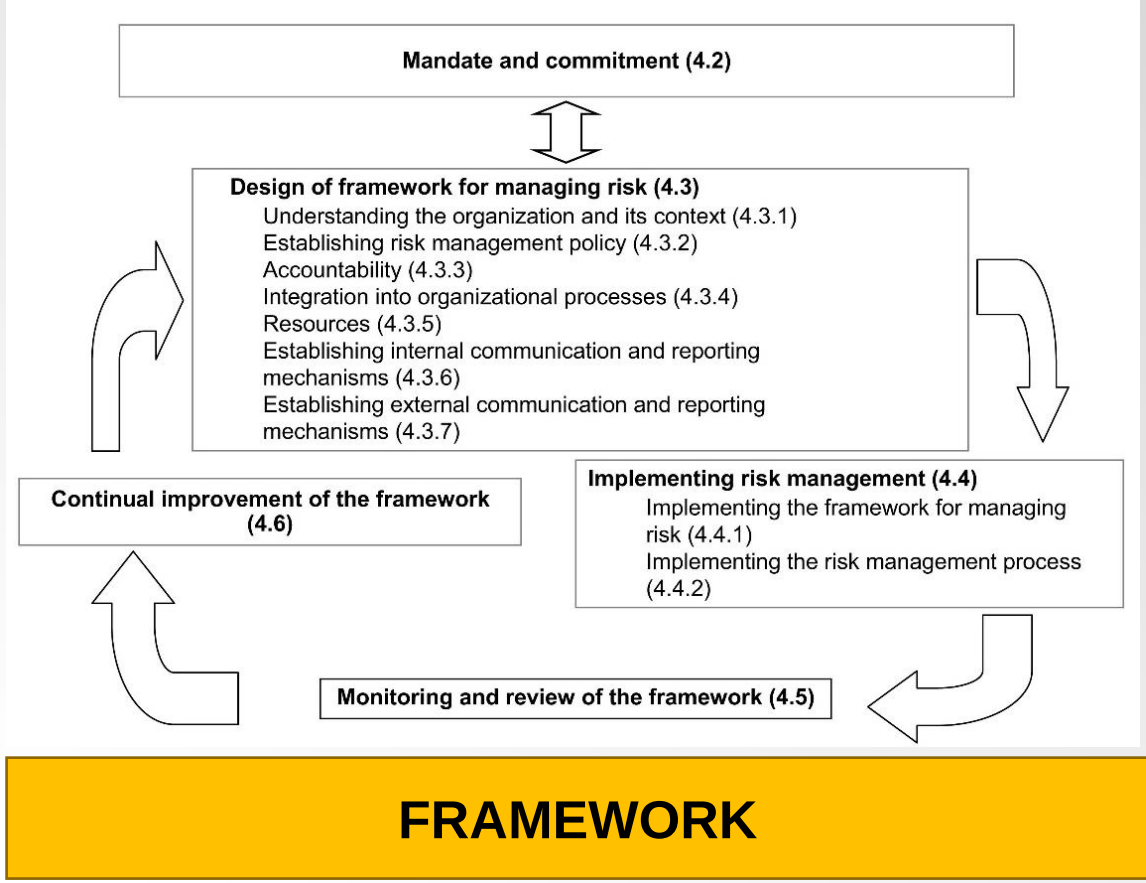
a) Creates and protects value
b) Integral part of all organizational processes
c) Part of decision making
d) Explicitly addresses uncertainty
e) Systematic, structured and timely
f) Based on the best available information
g) Tailored
h) Takes human and cultural factors into account
i) Transparent and inclusive
j) Dynamic, iterative and responsive to change
k) Facilitates continual improvement of the organization

Flexibile application when implementing for PPR



ISO31000:2018 Framework

- Risk management process needs to be **integrated** into the overall **organizational** system and processes and needs to be supported by strong **management commitment**.
- The framework needs to be **tailored to the organization(s) involved** and take into account the organization's internal and external context.
- There need to be **accountability**, sufficient resources and internal and external reporting mechanisms.
- Framework needs to be **monitored** and reviewed to ensure that the feedback process results in continuous improvement (Quality Management).



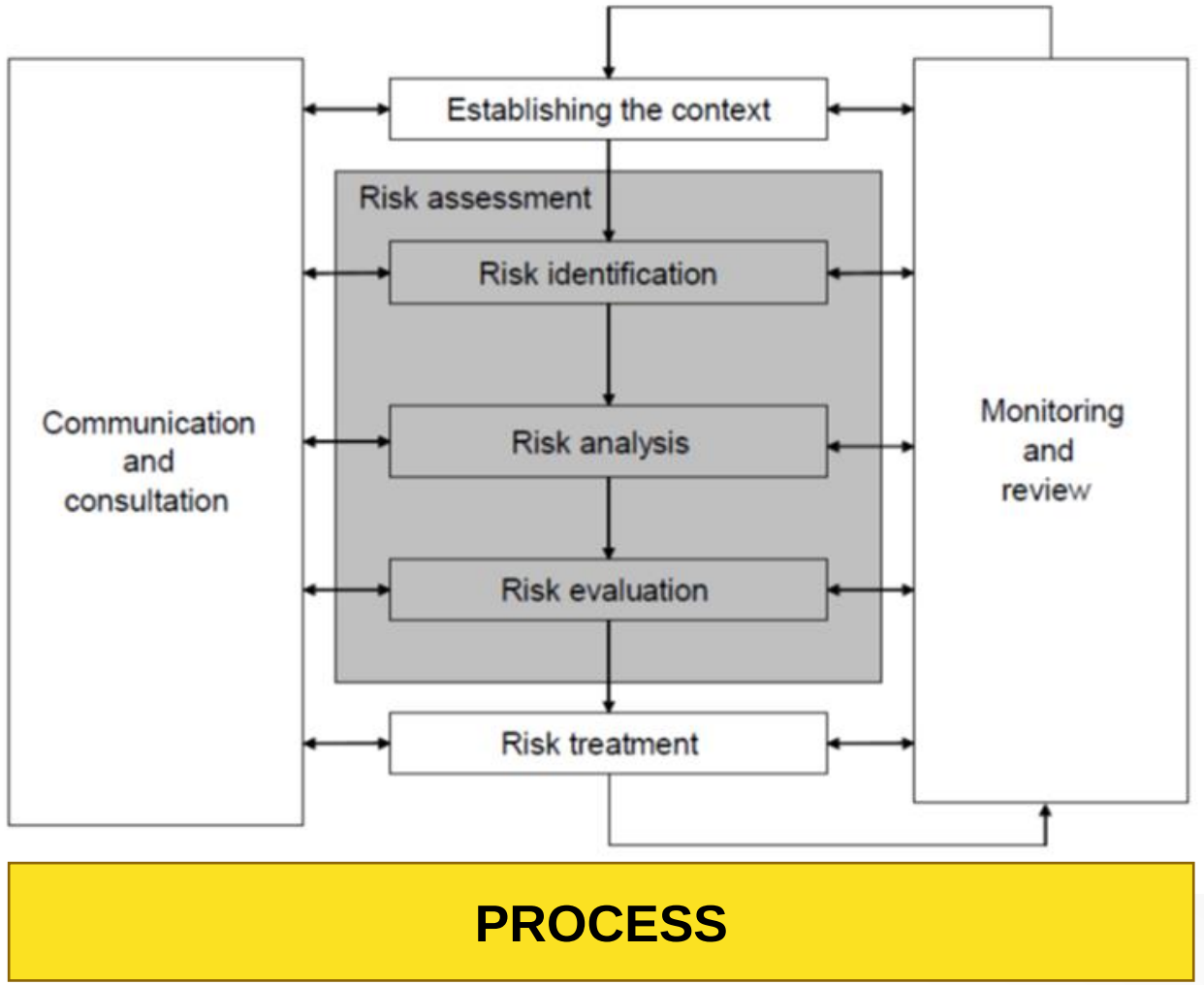
FRAMEWORK

Flexibile application when implementing for PPR

ISO31000:2018 Process

Risk management is effected by applying the classic process of:

- **Risk Identification**
  Identify sources of risk, areas of impact and consequences.
- **Risk Analysis**
  Understanding the risk and whether it needs to be fully evaluated.
- **Risk Evaluation**
  Compare the level of risk established
  in the previous stage with the risk tolerance criteria established.
- **Risk Treatment**
  Modification of risk and decision on treatment option.

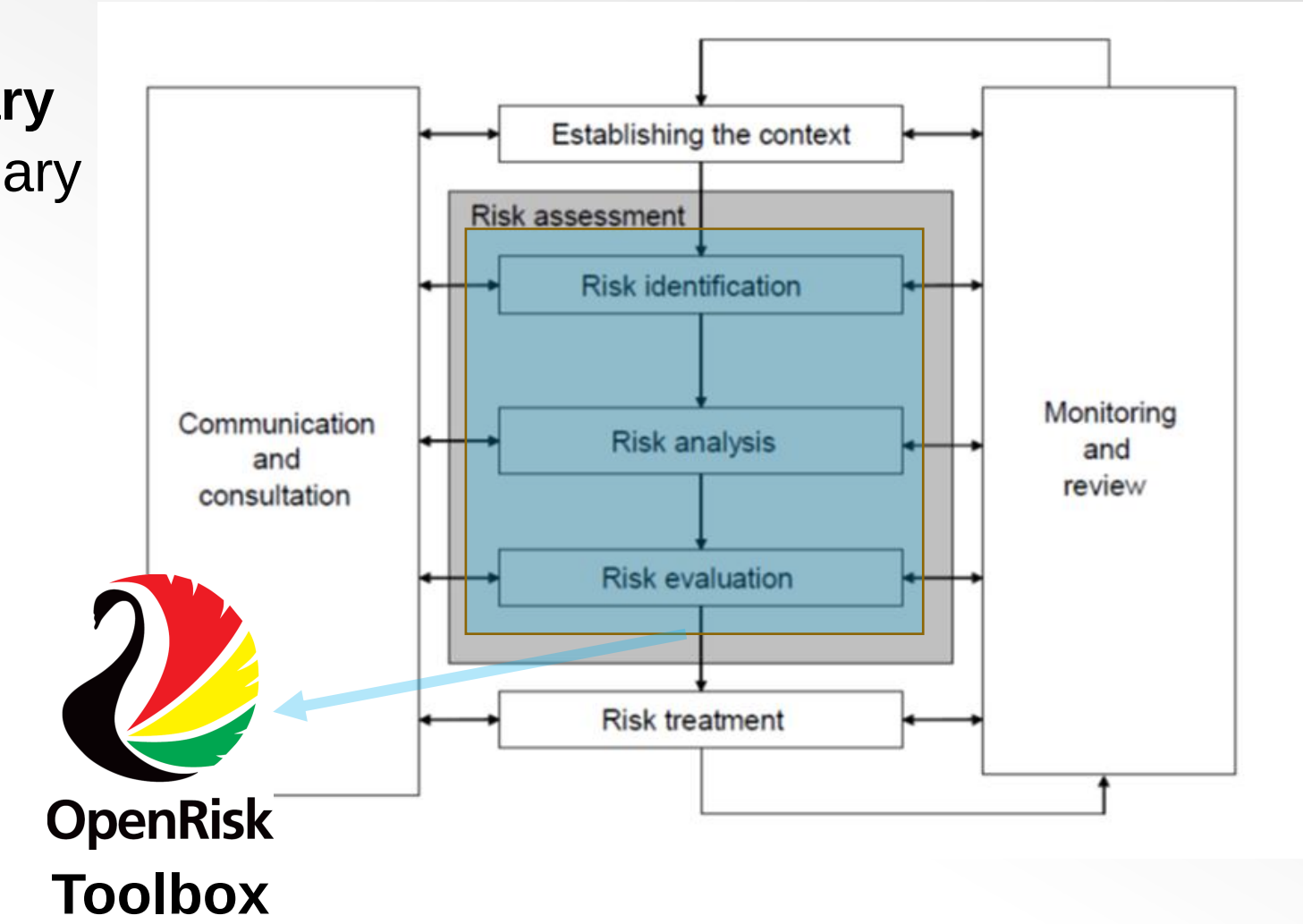


ISO31000:2018 Complementing Documents

ISO Guide 73:2009
Risk Management Vocabulary
Establishes a revised vocabulary to accompany ISO 31000.

ISO/IEC 31010
Risk Management – Risk Assessment Techniques
Contains a collection of tools used for risk assessment.

OpenRisk develops and selects tailored tools for PPR activities



OpenRisk

OPEN-SOURCE TOOLS FOR REGIONAL RISK ASSESSMENTS TO IMPROVE EUROPEAN PREPAREDNESS AND RESPONSE AT SEA

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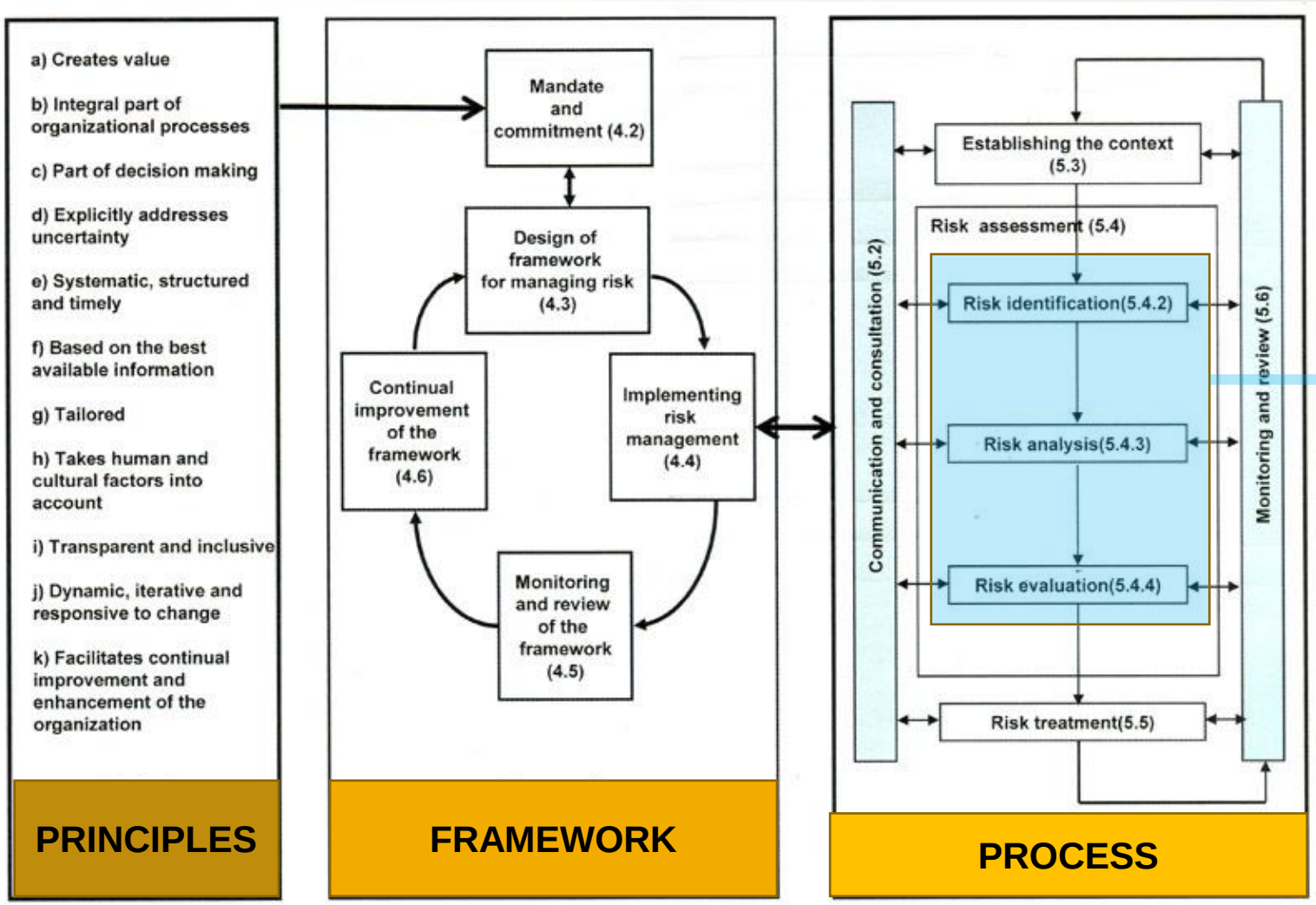
OPENRISK OBJECTIVES IN CONTEXT OF ISO31000

Scope and focus of OpenRisk: Primary Objective

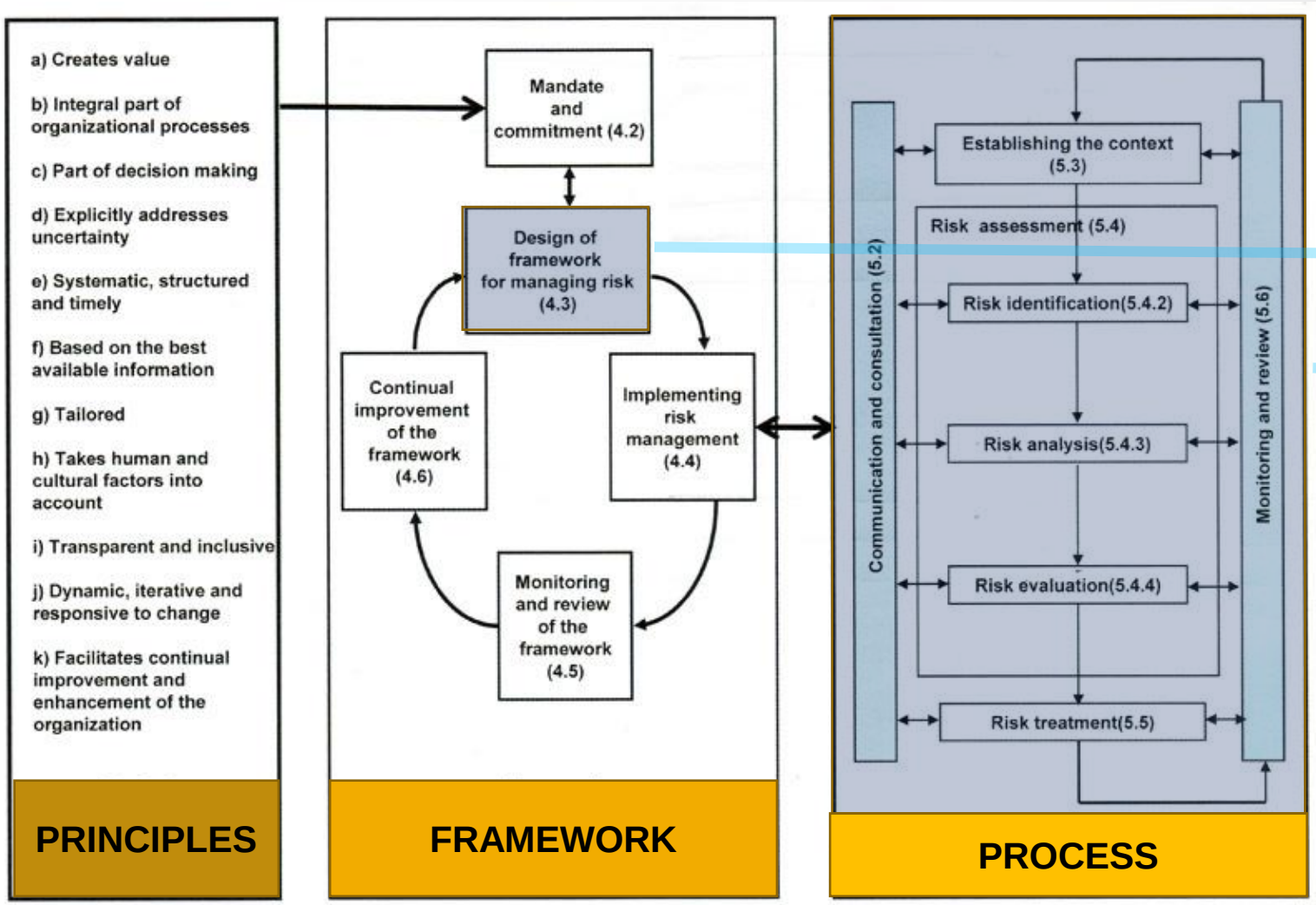


Primary objective

Develop a toolbox for PPR risk management

OpenRisk Toolbox

Scope and focus of OpenRisk: Secondary Objective



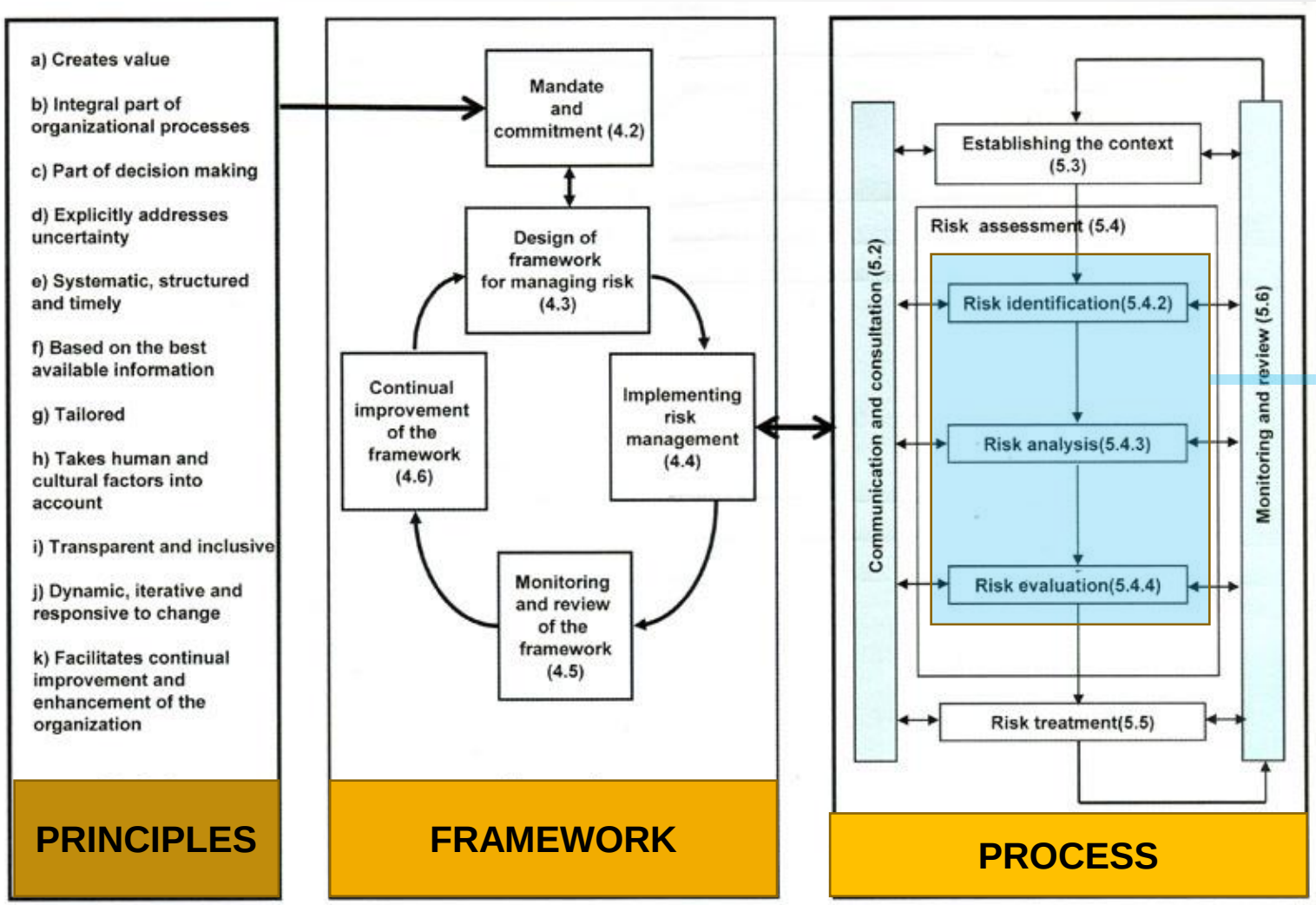
Secondary objective

Develop an intital framework and processes for managing risk in PPR activities

OpenRisk WS1 and WS2, and EMSA Risk Assessment Workshop

Need for risk management on different time scales and for different decision contexts (similar to DG ECHO approach)

Scope and focus of OpenRisk: Secondary Objective



Tertiary objective

Test the toolbox for PPR risk management in workshops and through a Baltic Sea case study

OpenRisk Toolbox

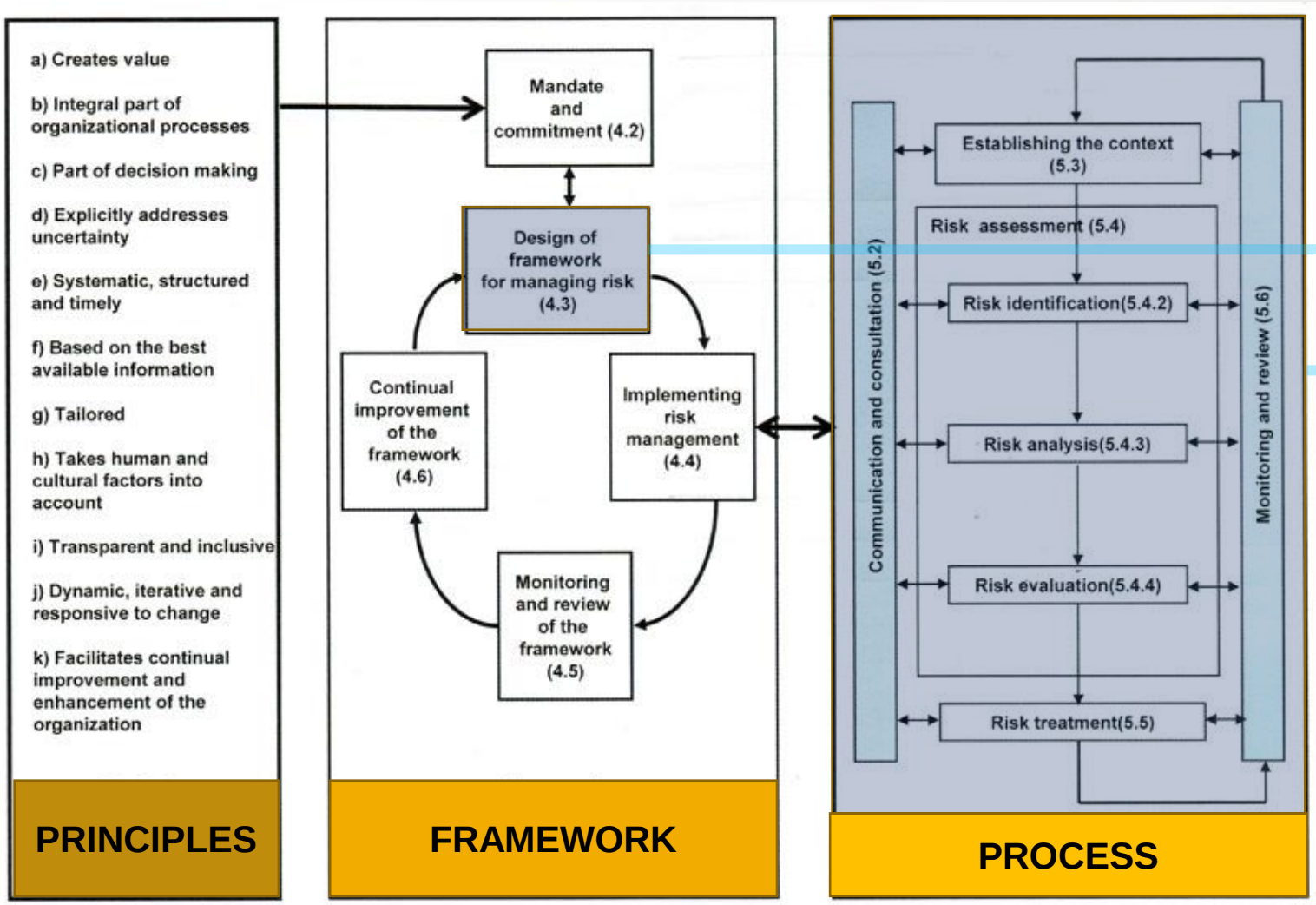
OpenRisk

OPEN-SOURCE TOOLS FOR REGIONAL RISK ASSESSMENTS TO IMPROVE EUROPEAN PREPAREDNESS AND RESPONSE AT SEA

Co-financed by the EU – Civil Protection Financial Instrument

IMPLEMENTING ISO31000 IN PPR: FRAMEWORK

Scope and focus of OpenRisk: Secondary Objective



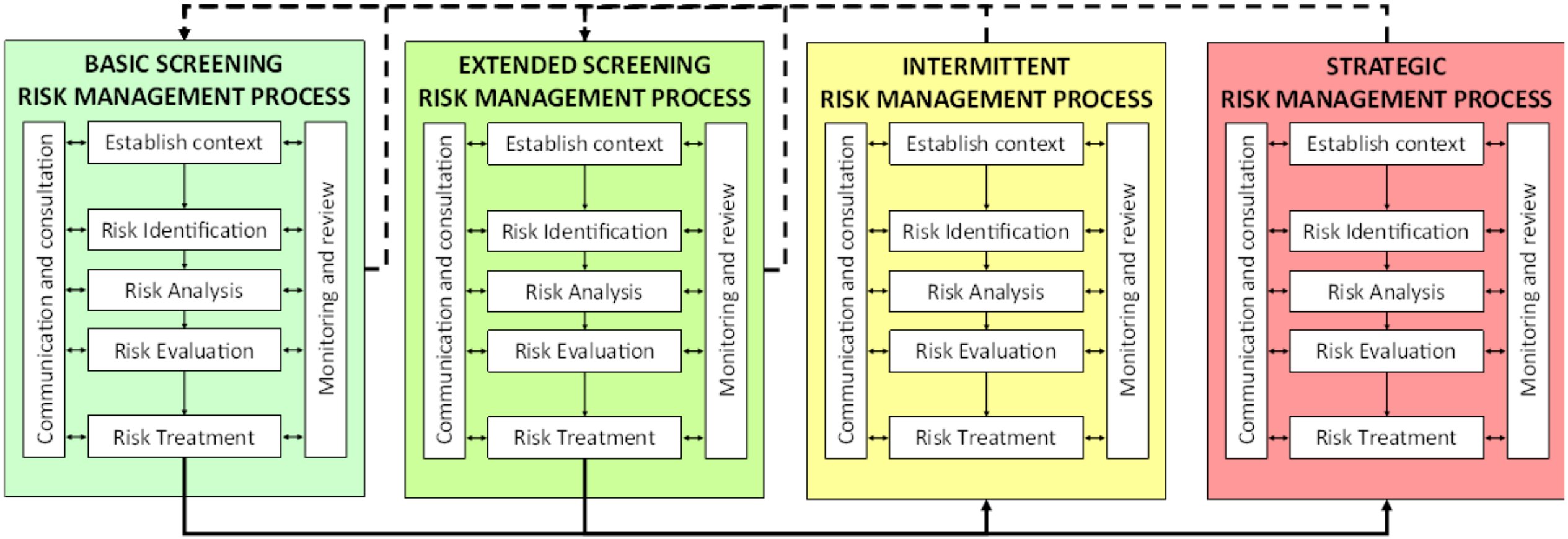
Secondary objective

Develop an intital framework and processes for managing risk in PPR activities

Three different time-scales and decision contexts

Screening (basic & extended)
Intermittent
Strategic

Implementing ISO31000 in PPR: Framework



Implementing ISO31000 in PPR
Basic Screening Risk Management Process

Screening risk management process ***Basic screening***	
Aim and purpose	Monitoring the evolution of risk levels of shipping activities in sea areas based on historic data
Type of decisions	Determining whether or not further risk management processes (typically extended screening or intermittent, possibly also strategic) need to be executed
Periodicity	Periodic and relatively frequent, e.g. annually or in conjunction with planned regional coordination meetings between PPR authorities

Implementing ISO31000 in PPR
Extended Screening Risk Management Process

Screening risk management process ***Extended screening***	
Aim and purpose	Anticipating the evolution of risk levels of shipping activities in sea areas based on the evolution of historic risk levels, as well as by systematically investigating changes in the external and internal context which may lead to future changes in risk levels, or lead to new and emerging risks
Type of decisions	Determining whether or not further risk management processes (typically strategic, possibly also intermittent) need to be executed
Periodicity	Periodic but relatively infrequent, e.g. every three to five years, or ad hoc depending on the findings of the basic screening process

Implementing ISO31000 in PPR
Intermittent Risk Management Process

Intermittent risk management process	
Aim and purpose	Understanding the pollution risks of shipping activities in sea areas, i.e. where what kinds of accidents are likely to happen, what would be the possible oil spills from those, where spills would drift to, what effects those would have to marine and coastal areas, and how effective the response is to those risks.
Type of decisions	Determining whether adjustments in the preparedness planning and/or response organization is needed, typically limited to relatively small adjustments to the fleet or operational procedures, within already available budgets.
Periodicity	Ad hoc, based on the outcome of the screening risk management process.

Implementing ISO31000 in PPR
Strategic Risk Management Process

Strategic risk management process	
Aim and purpose	Obtaining a holistic understanding the pollution risks of shipping and other marine activities in sea areas, i.e. where what kinds of accidents are likely to happen, what would be the possible oil spills from those, where spills would drift to, what effects those would have to marine and coastal areas, and how effective the response is to those risks.
Type of decisions	Determining whether changes in preparedness planning, response organization and/or traffic organization, are needed in light of risks, typically associated with major developments in the maritime transportation system. These changes may include large-scale investments in infrastructure or equipment, with possibly very large funding requirements, exceeding available operational budgets.
Periodicity	Ad hoc, based on the outcome of the screening risk management process (typically the extended screening process).

OpenRisk

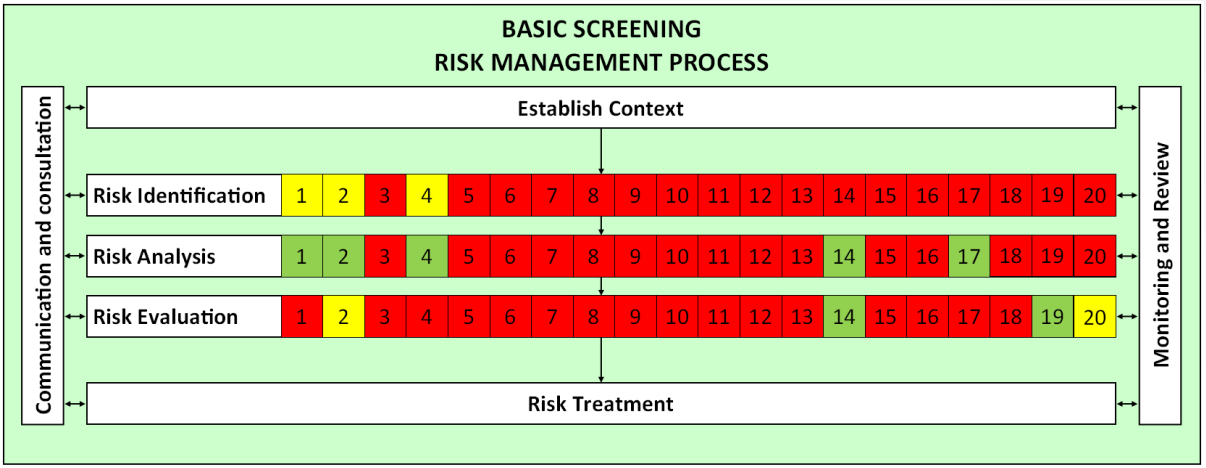
OPENRISK TOOLBOX FOR PPR RM

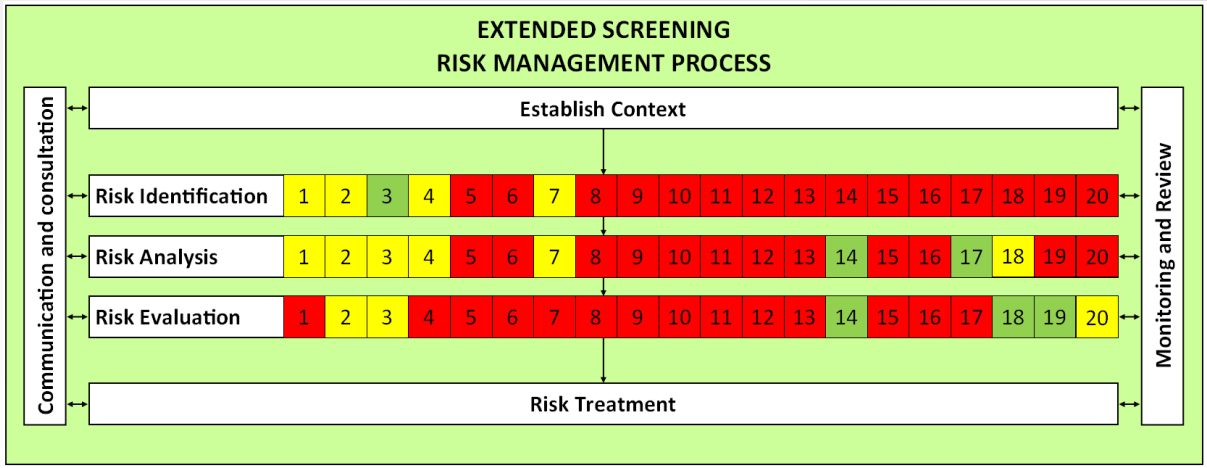
Implementing ISO31000 in PPR
Risk management questions relevant to PPR

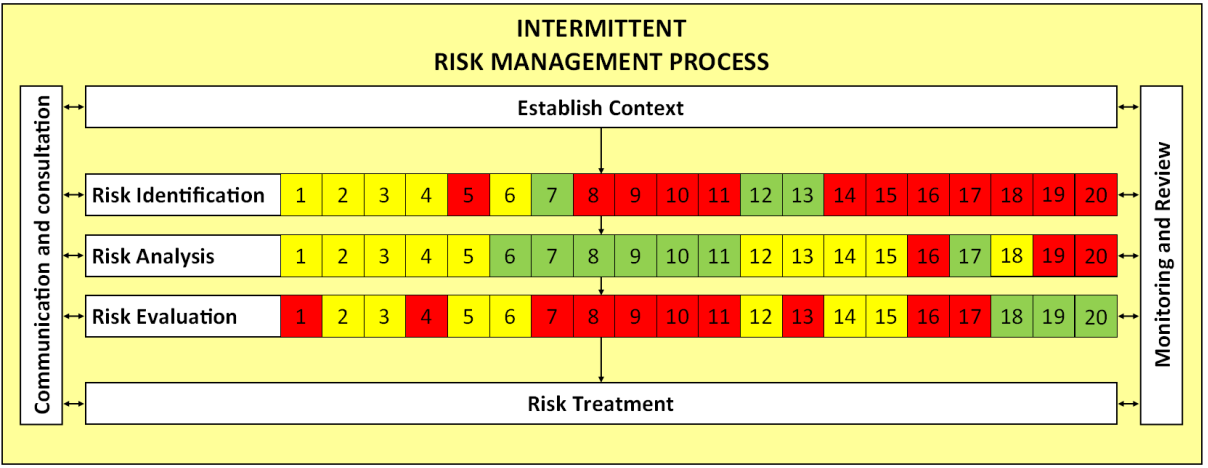
Tools support risk management questions such as:

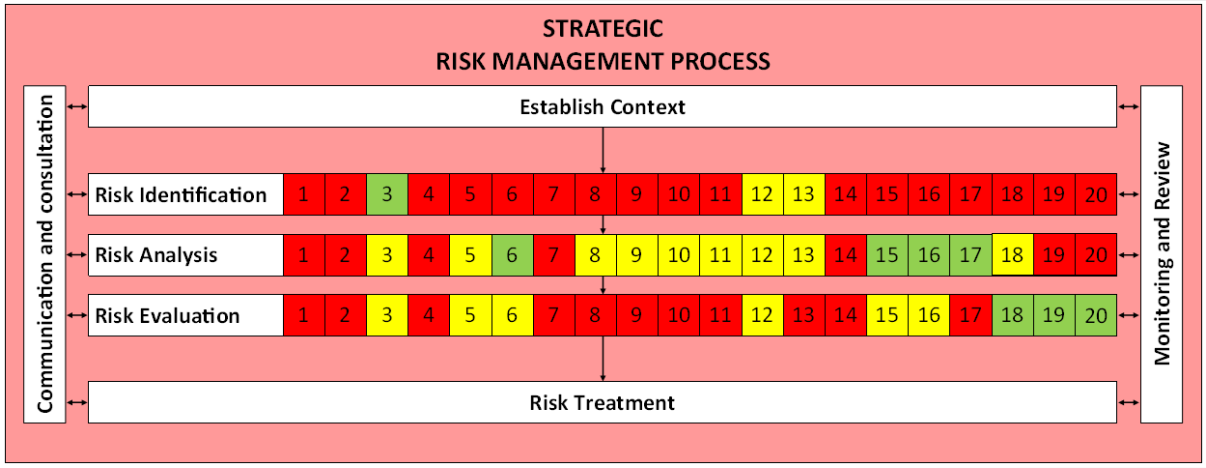
- Where are accidents likely to happen?
- When are accidents likely to happen?
- What kinds of accidents are likely to happen?
- What are the trends over time?
- What would be the likely oil spills in such accidents?
- Where would the oil drift to in the sea area?
- How effective is the mechanical recovery system to those risks?
- What risk controls are available to cost-effectively reduce the risk?
- How much can results of the risk analysis be relied on?
- How do different scenarios compare to one other in the different dimensions of risk?
- Are the risks acceptable?

Implementing ISO31000 in PPR
Tools matching the processes









OpenRisk Toolbox:
Specific tools for different risk management questions

ID	Tool	
1	ID	KystRisk
	Name	KystRisk
	Risk management questions	• Where are the historic accident risks in the sea area? • How do the risks develop over time?
2	ID	MarinRisk
	Name	MarinRisk
	Risk management questions	• Where are the historic accident risks in the sea area? • How do the risks develop over time?
3	ID	Delphi
	Name	Delphi Method
	Risk management questions	• What kinds of future hazards should be considered? • What are the associated risk levels?

OpenRisk Toolbox:
Specific tools for different risk management questions

ID	Tool	
4	ID	RiskData Hub
	Name	RiskData Hub
	Risk management questions	• Where are the historic accident risks in the sea area? • How do the risks develop over time?
5	ID	IWRAP Mk II
	Name	IALA Waterway Risk Assessment Programme
	Risk management questions	• What is the accident likelihood in different sea areas? • What accident scenarios are likely? • What is the effect of different risk control options on the risk level?
6	ID	PAWSA
	Name	Ports and Waterways Safety Assessment
	Risk management questions	• How important are different waterway factors as contributors to risk? • What is the effect of risk control options on the risk level?

OpenRisk Toolbox: Specific tools for different risk management questions

ID	Tool	
7	ID	ERC-M
	Name	Maritime Event Risk Classification Method
	Risk management questions	• What kinds of hazards occur in the sea area? • What is the risk level in different sea areas? • What accident scenarios are likely? • Which issues are contributing factors to the event occurrence?
8	ID	ADSAM-C/G
	Name	Accidental Damage and Spill Assessment Model for Collision & Accidental Damage and Spill Assessment Model for Grounding
	Risk management questions	• What size of oil spills can occur in a collision or grounding accident?
9	ID	SeaTrack Web
	Name	SeaTrack Web
	Risk management questions	• Where does the oil drift to in the sea area?

OpenRisk Toolbox: Specific tools for different risk management questions

ID	Tool	
10	ID	NG-SRW
	Name	Next Generation SmartResponse Web
	Risk management questions	• What size of oil spills can occur in a collision or grounding accident? • Where does the oil drift to in the sea area? • What are the consequences to the ecosystem and human use of marine space?
11	ID	ERSP Calculator, EBSP Calculator, and EDSP Calculator
	Name	Response System Planning Calculators
	Risk management questions	• What is the potential of the response system to recover, burn, or disperse the spilled oil?
12	ID	BowTie
	Name	BowTie Method
	Risk management questions	• Which factors contribute to the event occurrence and/or its consequences? • What is the effectiveness of different controls to mitigate risks?

OpenRisk Toolbox: Specific tools for different risk management questions

ID	Tool	
13	ID	FRAM
	Name	Functional Resonance Analysis Method
	Risk management questions	• Which system functions are responsible for the variation in the system performance?
14	ID	KPIs
	Name	Key Performance Indicators
	Risk management questions	• How important are different system indicators in regards event occurrence and/or consquences? • What is the performance of different system elements compared to target levels?
15	ID	SBOSRT
	Name	Spatial Bayesian Oil Spill Risk Tool
	Risk management questions	• What are the oil spill risks in the sea area? • What is the extent of ecological damage in different oil spill risk scenarios?

OpenRisk Toolbox: Specific tools for different risk management questions

ID	Tool	
16	ID	ISRAM
	Name	Integrated Strategic Risk Analysis Methods
	Risk management questions	• What are the oil spill risks in the sea area? • What size of spills can occur? • Where does the oil spill drift to in the sea area? • What are the consequences to the ecosystem and human use of marine space? • What is the effect of different risk control options on the risk level?
17	ID	SoE
	Name	Strength of Evidence Assessment Schemes
	Risk management questions	• How much can the results of the risk analysis be relied on? • How much evidence is there for the elements in the risk analysis?

OpenRisk Toolbox: Specific tools for different risk management questions

ID	Tool	
18	ID	RM-PCDS
	Name	Risk Matrices and Probability-Consequence Diagrams
	Risk management questions	• How do risks compare to one another in the different dimensions of risk?
19	ID	ALARP
	Name	As Low as Reasonably Practicable Principle
	Risk management questions	• Are the risks acceptable? • Should further risk control options be implemented?
20	ID	CBA
	Name	Cost-Benefit Analysis
	Risk management questions	• How cost-effective are different risk control options?

Implementing ISO31000 in PPR
Tool attributes for selecting suitable tool

2. MarinRisk

Risk management questions:

- Where are the historic accident risks in the sea area?
- How do the risks develop over time?

Attributes of tool:

Quantitative [Yes] Qualitative [No]

Resources needed [Low] Skills required [Low]

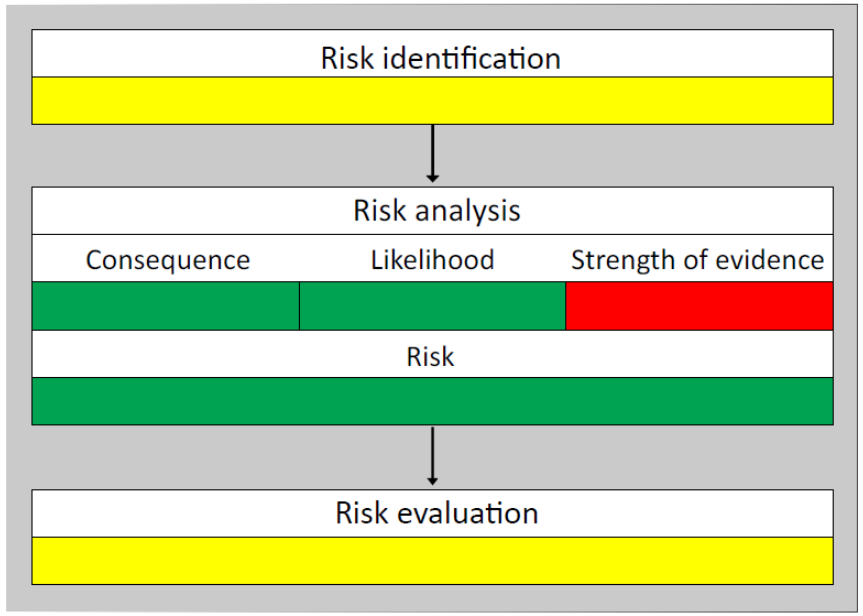
OpenRisk

Applicability for different risk management processes:

Basic screening ■ Extended screening ■

Intermittent ■ Strategic ■

Applicability for different risk assessment stages:



Notes: Strongly applicable = ■ Applicable = ■ Not applicable = ■

OpenRisk

EXAMPLE TOOL

ERC-M
MARITIME EVENT RISK CLASSIFICATION METHOD

ERC-M: Overview

- The Event Risk Classification (ERC) is a part of ARMS Methodology for Operational Risk Assessment.

- It was originally developed for aviation by the ARMS Working Group from 2007 to 2010.

- OpenRisk has developed consequence/probability matrices for environmental damages, loss of life or injuries and economic losses, and process for risk identification.

Source:
Valtteri Laine. 2018. Maritime Application of the Maritime ERC Method. 3rd OpenRisk Workshop, Valetta, Malta, 04.2018

ERC-M: Attributes

7. ERC-M

Risk management questions:

- What kinds of hazards occur in the sea area?
- What is the risk level in different sea areas?
- What accident scenarios are likely?
- Which issues are contributing factors to the event occurrence?

Attributes of tool:

Quantitative [No] Qualitative [Yes]

Resources needed [Medium] Skills required [Medium]

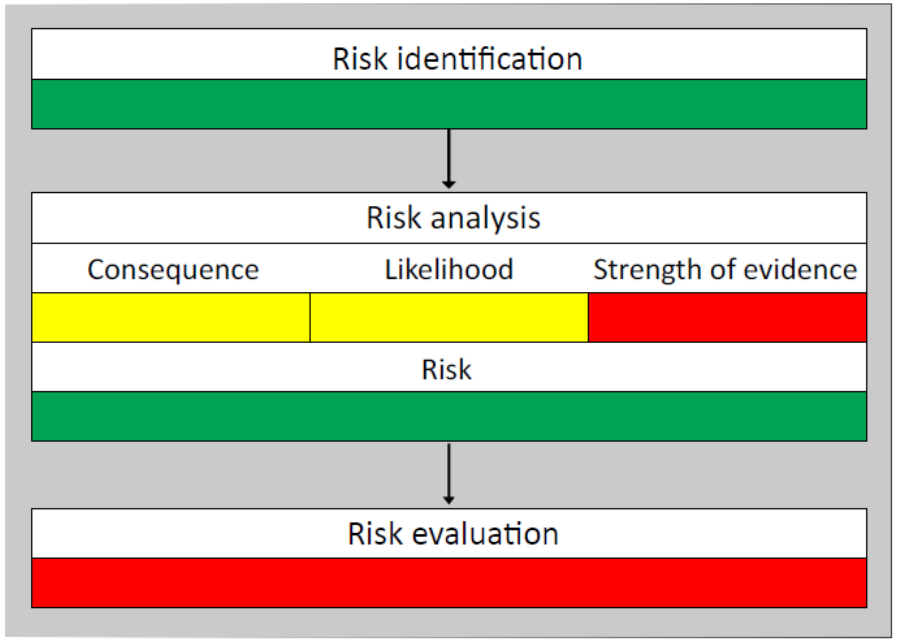
OpenRisk

Applicability for different risk management processes:

Basic screening Extended screening

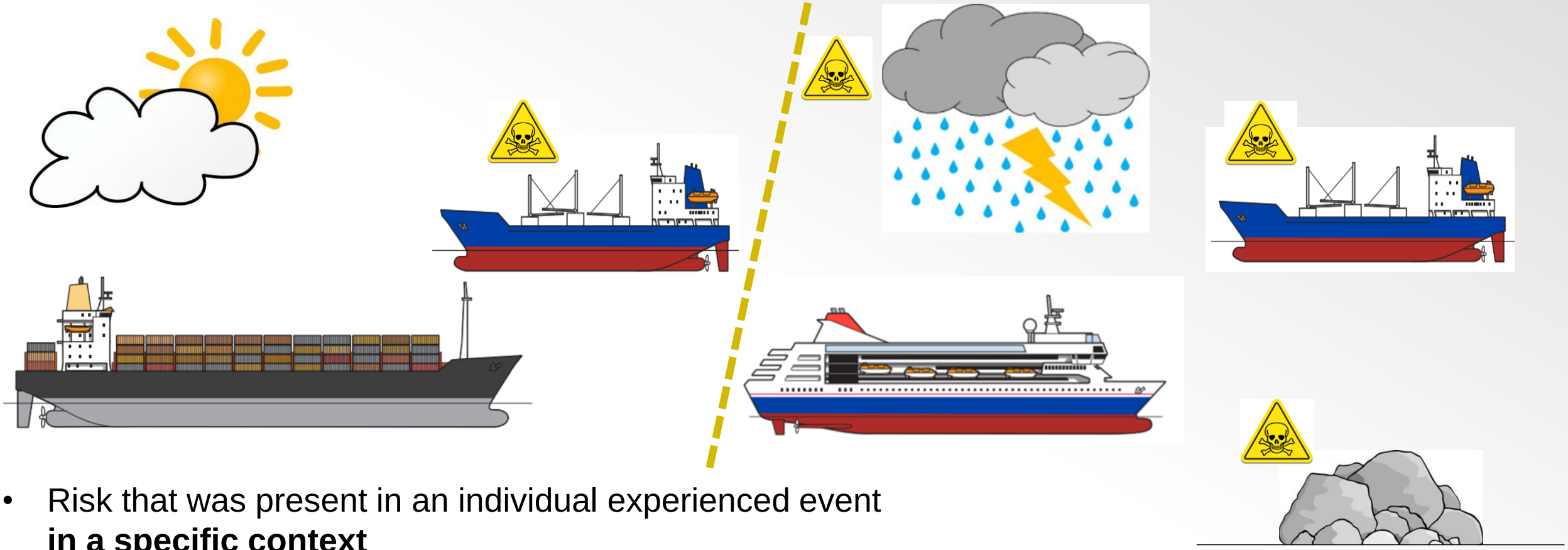
Intermittent Strategic

Applicability for different risk assessment stages:



Notes: Strongly applicable = Applicable = Not applicable =

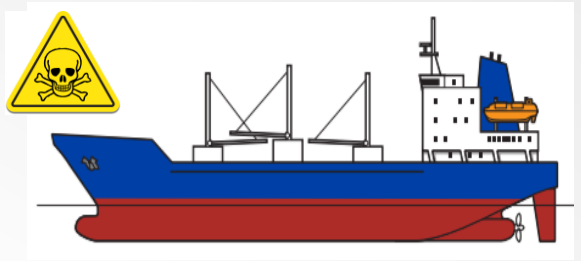
Event Risk

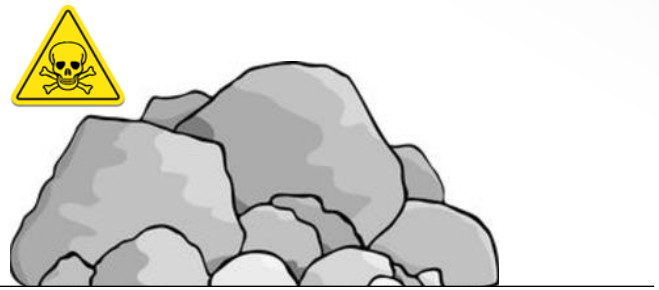


- Risk that was present in an individual experienced event **in a specific context**
- These contextual factors will influence both the probabilities and severity levels of outcomes

Source:
Valtteri Laine. 2018. Maritime Application of the Maritime ERC Method. 3rd OpenRisk Workshop, Valetta, Malta, 04.2018

Maritime Application of the ERC





Non-accident outcomes

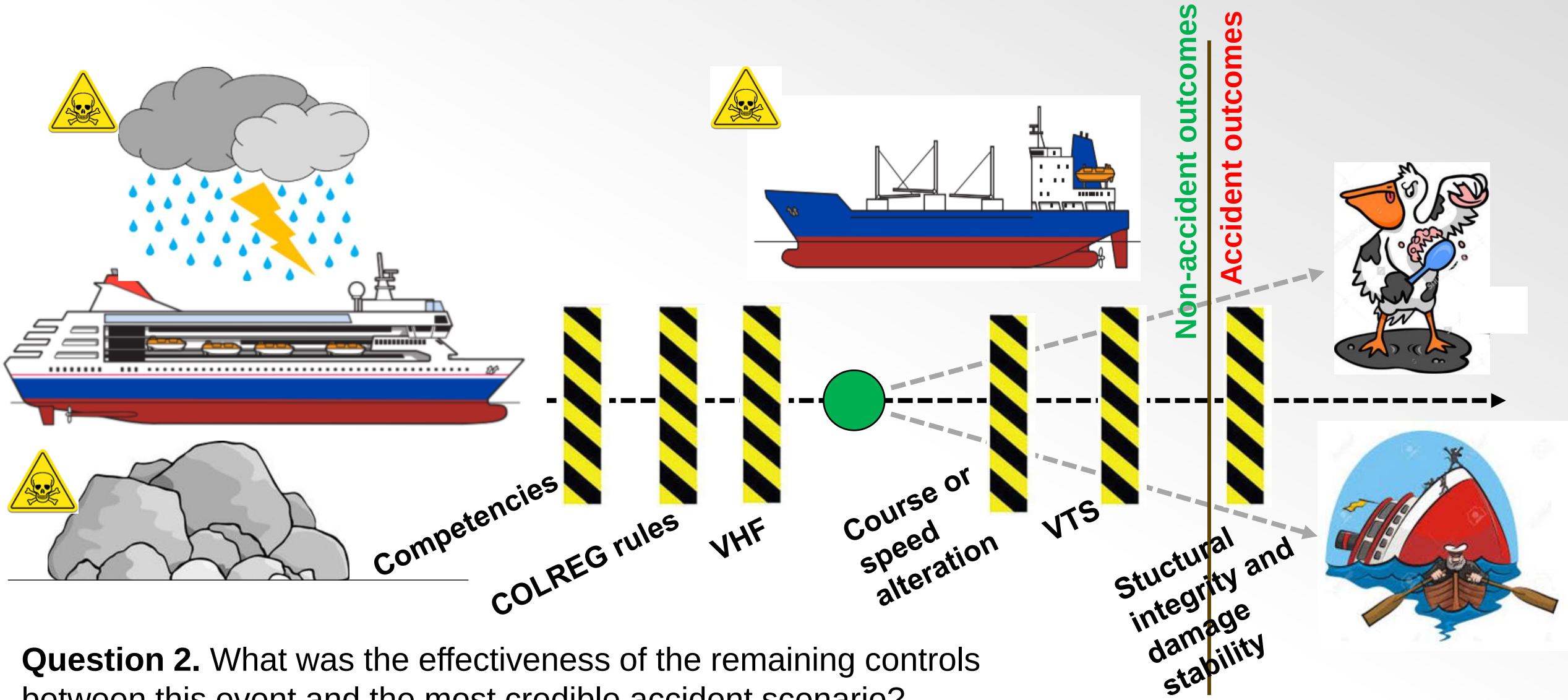
Accident outcomes

SCENARIO

Question 1. Had this event escalated into an accident outcome, what would have been the most credible outcome?

Source:
Valtteri Laine. 2018. Maritime Application of the Maritime ERC Method. 3rd OpenRisk Workshop, Valetta, Malta, 04.2018

Maritime Application of the ERC



Question 2. What was the effectiveness of the remaining controls between this event and the most credible accident scenario?

Source:
Valtteri Laine. 2018. Maritime Application of the Maritime ERC Method. 3rd OpenRisk Workshop, Valetta, Malta, 04.2018

ERC-M Event Risk Classification Matrix Environmental consequences

Question 2: What was the effectiveness of the remaining barriers between this event and the most credible accident scenario?			
Effective	Limited	Minimal	Not effective
250	503	2 503	12 500
50	102	502	2 500
10	21	101	500
2	4	20	100
1			

Question 1. If this event had escalated into an accident outcome, what would have been the most credible outcome?							
EU POLSCALE Cathegory	Estimated quantity of oil on the shore >10.000 (m3)	Lenght of polluted coastline (km)	Transpandary scale of the incident	Duration of the emergency response	Environmental Severity Scale: Wildlife	Environmental Severity Scale: Vulnerable or Sensitive Areas	Economic Severity Scale
Catastrophic	> 10.000	> 100	International	> 6 months	Intensely affected over a wide area	Extensive loss of valuable habitats	Economic activities halted temporary
Severe	1.001 to 10.000	11 to 100	National	up to 6 months	Affected over many locations wide	Sevwere but not totalluy affected	Principal economic activities disrupted
Moderate	11 to 1.000	2 to 10	Regional	up to 1 month	Locally affected	Locally affected	Some activities disrupted to a small extent
Slight	0.1 to 10	up to 1	Local	up to 1 week	Affected but not significantly	Affected but not significantly	Limited and temporary disturbance
Zero or insignificant	< 0.1	0	-	> 1 day	NA	NA	NA

Effectiveness rating	Definition
Effective	An abnormal situation, more demanding to manage, but with still a considerable remaining safety margin.This could be a violation of the COLREG rules in a sea area with no other traffic nor range of rocks around for example.
Limited	An abnormal situation, more demanding to manage,but with still a considerable remaining safety margin. This could be a violation of the COLREG rules in a sea area, with some other traffic or range of rocks in a distance for example.
Minimal	Some barrier(s) were still in place but their total effectiveness s was 'minimal'. This could be a close near miss situation for example.
Not effective	An accident was not avoided, or the only thing separating the event from an accident was pure luck or exceptional skill, which is not trained nor required.

Source:
Valtteri Laine. 2018. Maritime Application of the Maritime ERC Method. 3rd OpenRisk Workshop, Valetta, Malta, 04.2018

ERC-M Event Risk Classification Matrix
Loss of life or injury

Effective	Limited	Minimal	Not effective	Nr of casualties or serious injuries	Typical accident scenarios
250	503	2 503	12 500	100 -	Major passenger ship accidents such as Estonia, Sewol and Scandinavian Star.
50	102	502	2 500	5 - 99	Accidents that have occured to passenger or cargo ships with several casualties.
10	21	101	500	1 - 4	Accidents that have occured small cargo ships, fissing vessels, tugs and the like, where the potential for loss of life is limited.
2	4	20	100	Less serious injuries	Less serious injuries for crew members or passengers e.g. fractures or minor wounds that have occured during a groundin, contact and like.
1				Zero or insignificant	Any event which could not escalate into loss of life or injuries (e.g. diversion, delay, small violation)

Effectiveness rating	Definition
Effective	An abnormal situation, more demanding to manage, but with still a considerable remaining safety margin.This could be a violation of the COLREG rules in a sea area with no other traffic nor range of rocks around for example.
Limited	An abnormal situation, more demanding to manage,but with still a considerable remaining safety margin.This could be a violation of the COLREG rules in a sea area, with some other traffic or range of rocks in a distance for example.
Minimal	Some barrier(s) were still in place but their total effectiveness s was 'minimal'. This could be a close near miss situation for example.
Not effective	An accident was not avoided, or the only thing separating the event from an accident was pure luck or exceptional skill, which is not trained nor required.

Source:
Valtteri Laine. 2018. Maritime Application of the Maritime ERC Method. 3rd OpenRisk Workshop, Valetta, Malta, 04.2018

ERC-M Event Risk Classification Matrix Economic losses

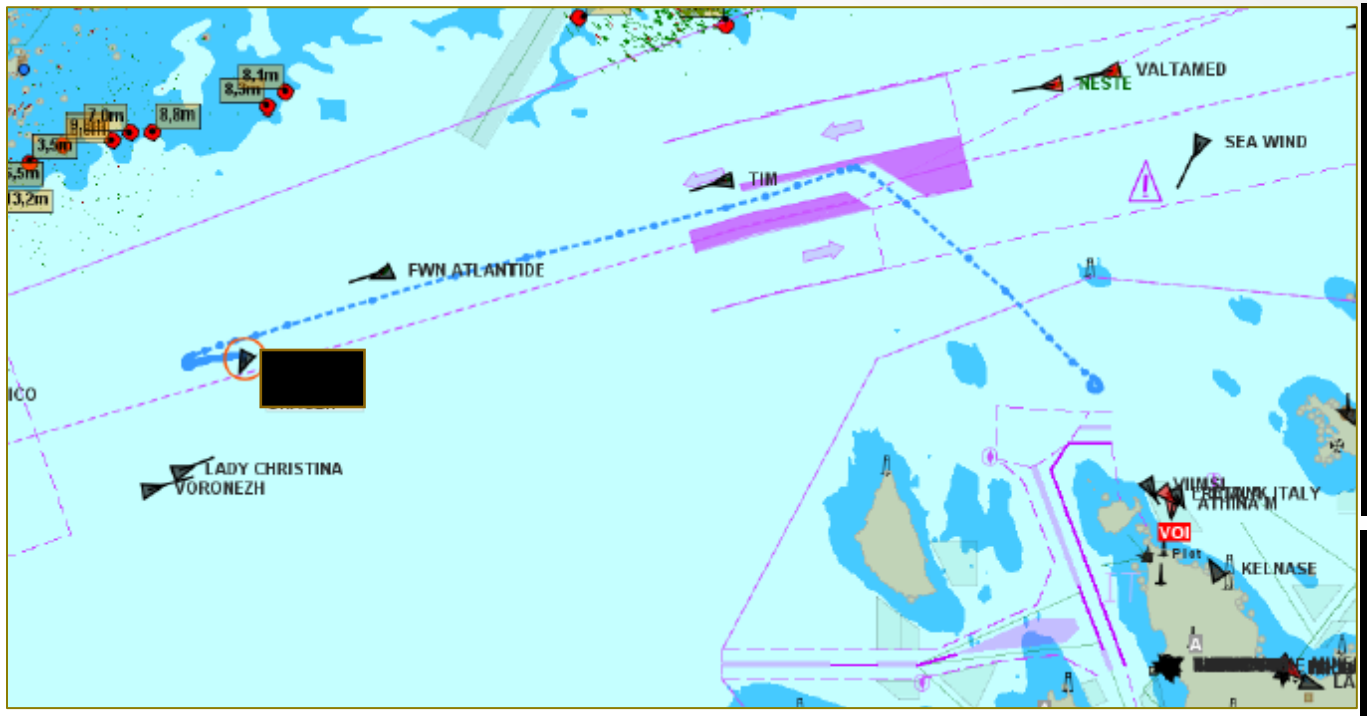
Effective	Limited	Minimal	Not effective
250	503	2 503	12 500
50	102	502	2 500
10	21	101	500
2	4	20	100
1			

Cathegory of consequences	Typical insurance claims and examples
Catastrophic	Hull & Machinery up to 750 000 000 € or P&I up to 100 000 000 € Examples: Costa Concordia, Prestige and Erika
Very serious casualty to ships, cargo or severe damages to third party	Hull & Machinery up to 120 000 000 € or P&I up to 20 000 000 € Examples: total losses, wreck removals, rescue operations and collisions
Serious casualty to ships, cargo or moderate damages to third party	Hull & Machinery up to 1 000 000 € or P&I up to 300 000 € Examples: basic dry docking due to grounding or slight enironmental damages
Less serious casualty to ships or cargo	Cargo & Liability 10 000-50 000 € or Hull & Machinery 30 000-100 000 € Examples: Minor damages to ship, ship's equipment or cargo.
Zero or insignificant	Any event which could not escalate into economical losses.

Effectiveness rating	Definition
Effective	An abnormal situation, more demanding to manage, but with still a considerable remaining safety margin. This could be a violation of the COLREG rules in a sea area with no other traffic nor range of rocks around for example.
Limited	An abnormal situation, more demanding to manage,but with still a considerable remaining safety margin. This could be a violation of the COLREG rules in a sea area, with some other traffic or range of rocks in a distance for example.
Minimal	Some control(s) were still in place but their total effectiveness s was 'minimal'. This could be a close near miss situation for example.
Not effective	An accident was not avoided, or the only thing separating the event from an accident was pure luck or exceptional skill, which is not trained nor required.

Source:
Valtteri Laine. 2018. Maritime Application of the Maritime ERC Method. 3rd OpenRisk Workshop, Valetta, Malta, 04.2018

ERC-M Example 1



Environmental Impact

Effective	Limited	Minimal	Not effective
250	503	2 503	12 500
50	102	502	2 500
10	21	101	500
2	4	20	100
1			

Loss of Life or Injuries

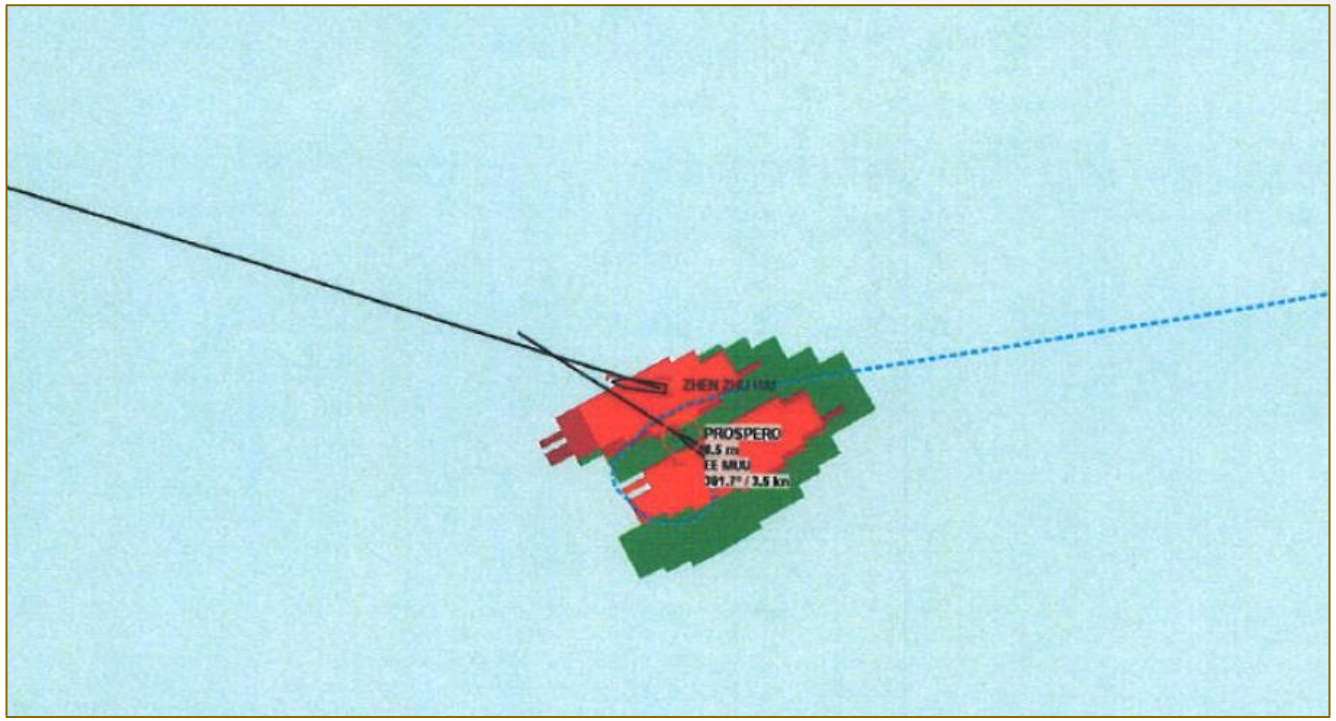
Effective	Limited	Minimal	Not effective
250	503	2 503	12 500
50	102	502	2 500
10	21	101	500
2	4	20	100
1			

Economical Losess

Effective	Limited	Minimal	Not effective
250	503	2 503	12 500
50	102	502	2 500
10	21	101	500
2	4	20	100
1			

Source:
Valtteri Laine. 2018. Maritime Application of the Maritime ERC Method. 3rd OpenRisk Workshop, Valetta, Malta, 04.2018

ERC-M Example 2



Environmental Impact

Effective	Limited	Minimal	Not effective
250	503	2 503	12 500
50	102	502	2 500
10	21	101	500
2	4	20	100
1			

Loss of Life or Injuries

Effective	Limited	Minimal	Not effective
250	503	2 503	12 500
50	102	502	2 500
10	21	101	500
2	4	20	100
1			

Economical Losess

Effective	Limited	Minimal	Not effective
250	503	2 503	12 500
50	102	502	2 500
10	21	101	500
2	4	20	100
1			

Source:
Valtteri Laine. 2018. Maritime Application of the Maritime ERC Method. 3rd OpenRisk Workshop, Valetta, Malta, 04.2018

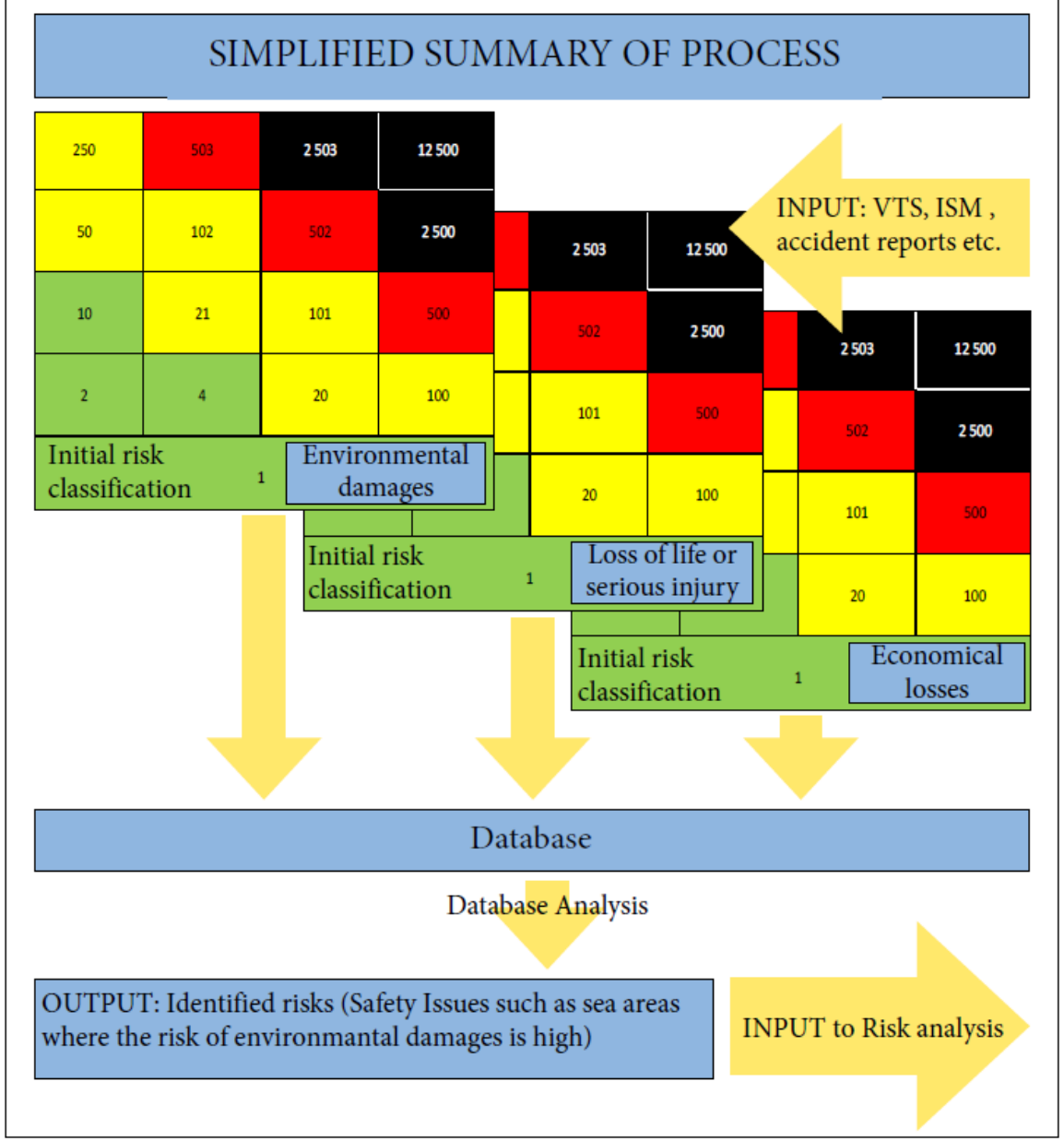
Process

Data Collection

- VTS Incident Reports
- Marine Casualty Reports
- Accident Investigation Reports
- Pilotage Reports

Structured Database

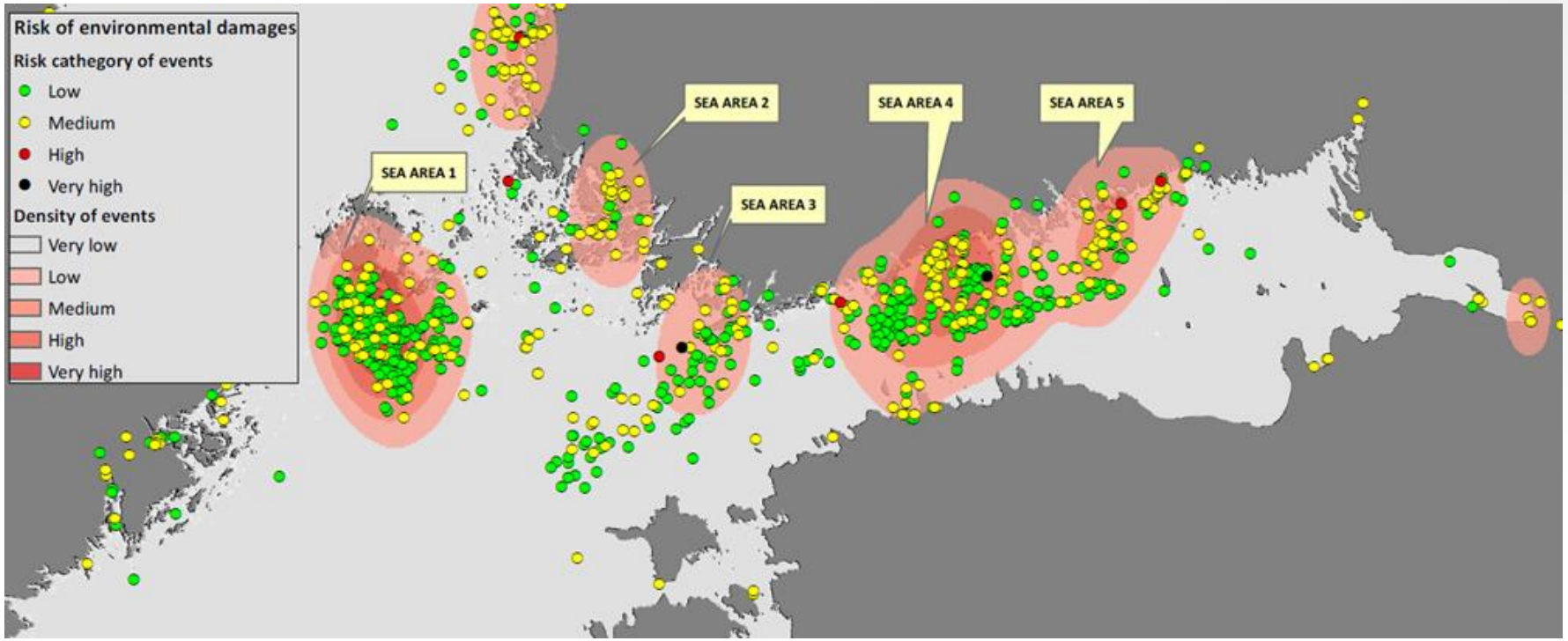
- Date
- Location
- Weather conditions
- IMO number
- Accident type (grounding/collision/contact/fire/…)



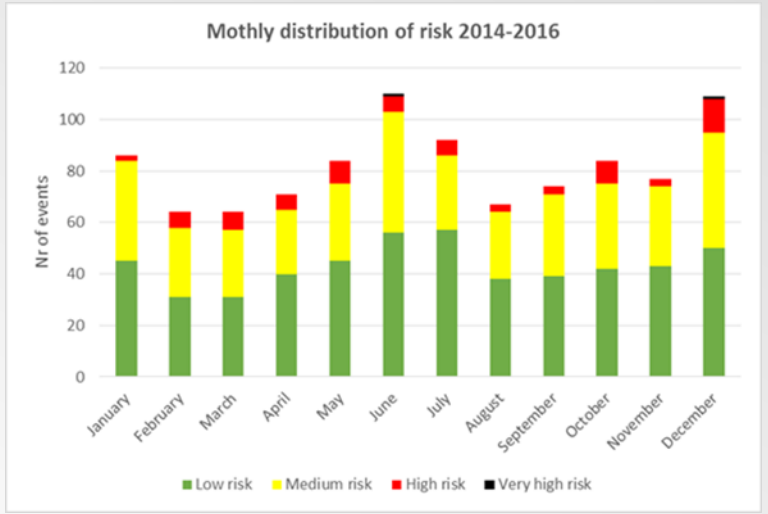
Source:
Valtteri Laine. 2018. Maritime Application of the Maritime ERC Method. 3rd OpenRisk Workshop, Valetta, Malta, 04.2018

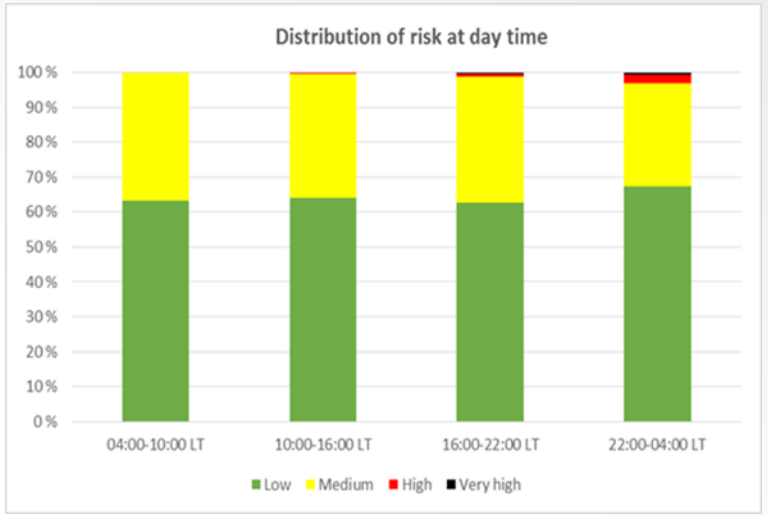
Examples
Finnish Gulf of Finland and Archipelago Sea

Questions: Where are accidents likely to occur? When?



The events in the Gulf of Finland from 2014 to 2016 (N=983).





Source:
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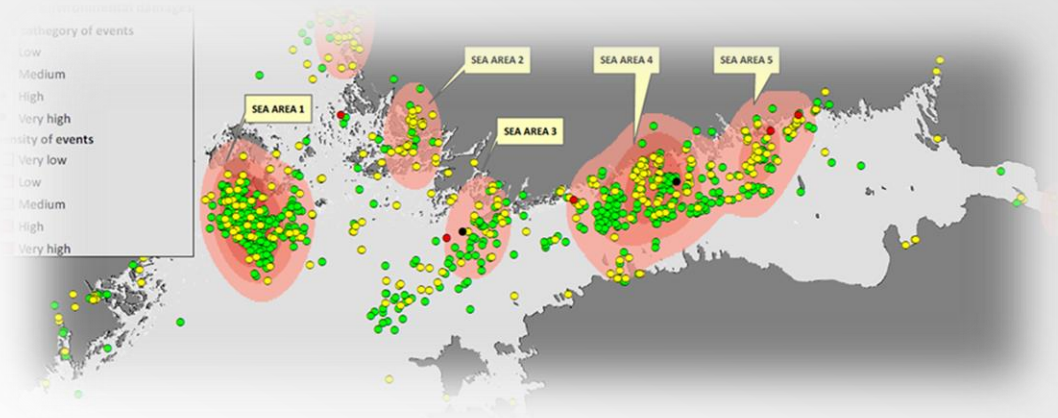
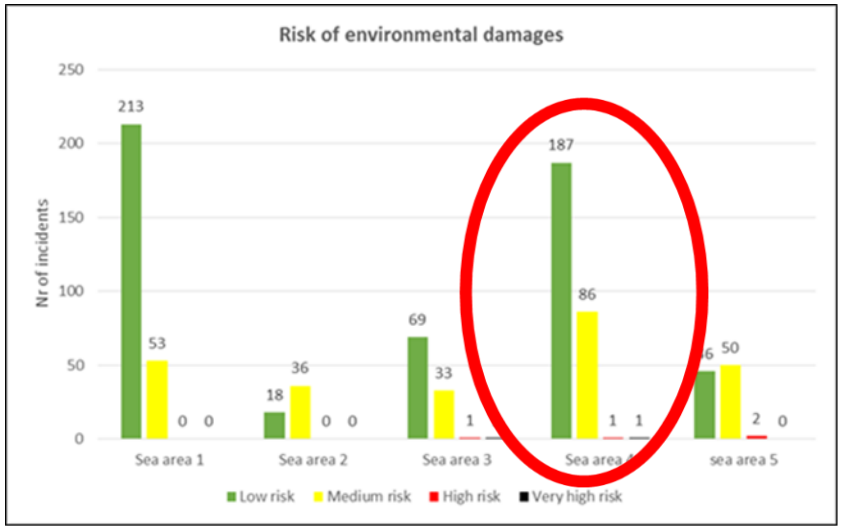
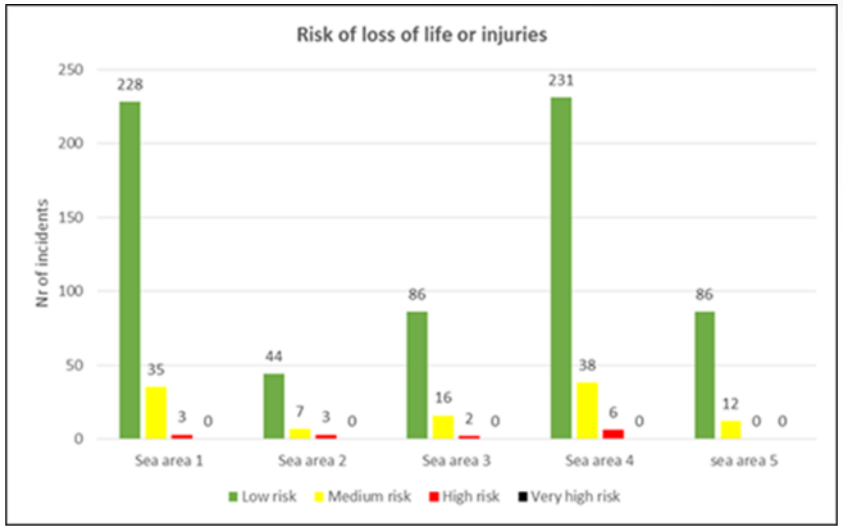
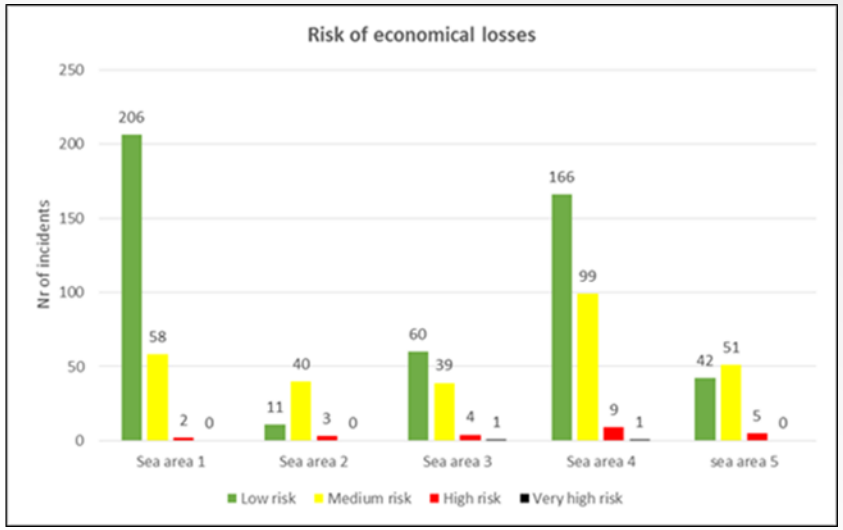
Examples
Finnish Gulf of Finland and Archipelago Sea

Question: What are the priority areas?





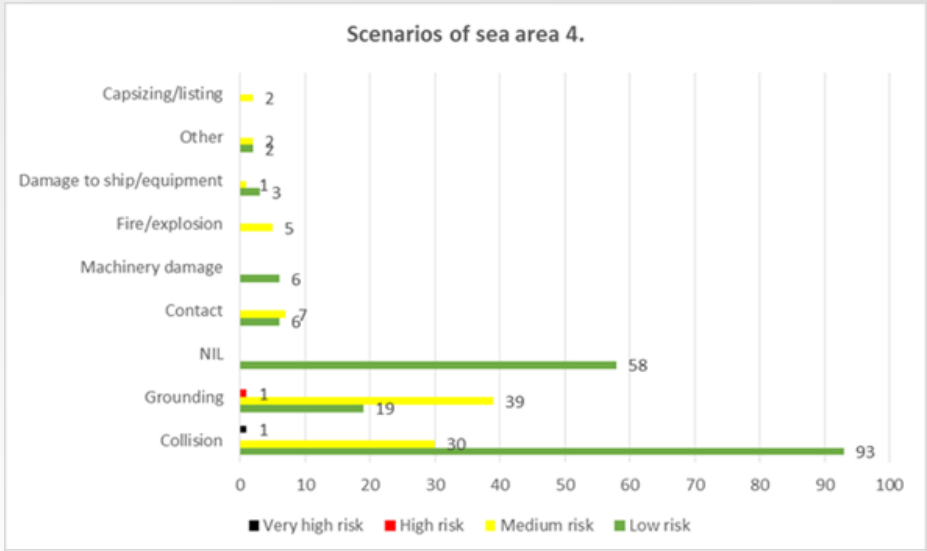


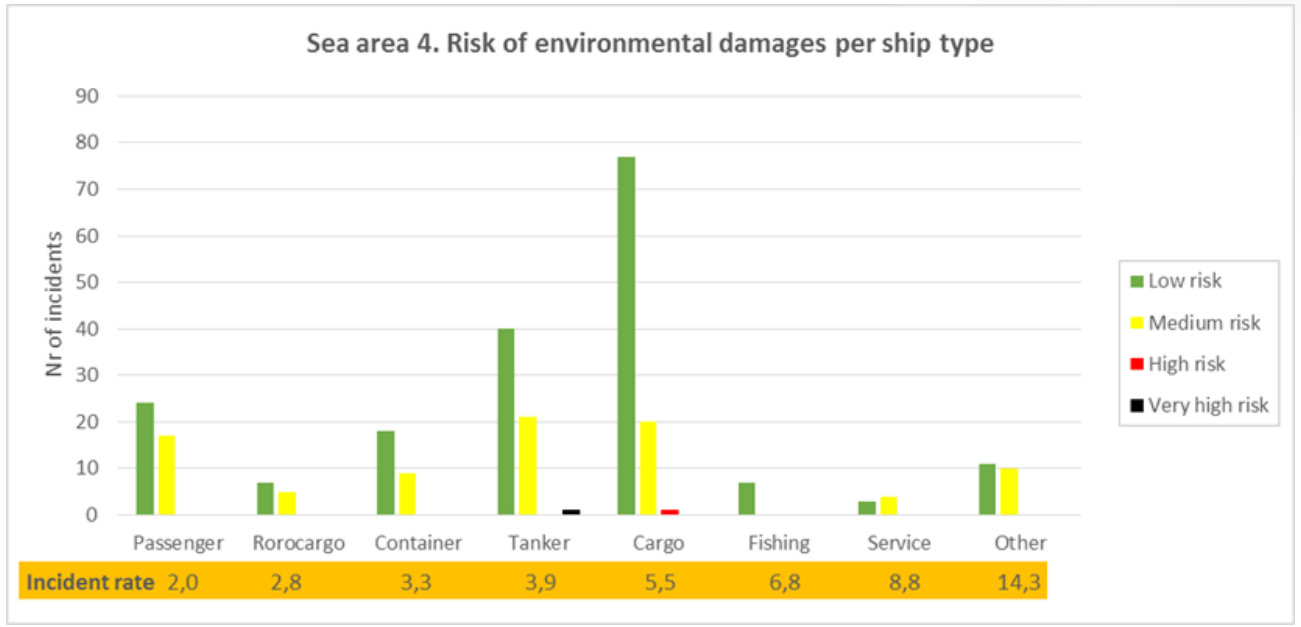


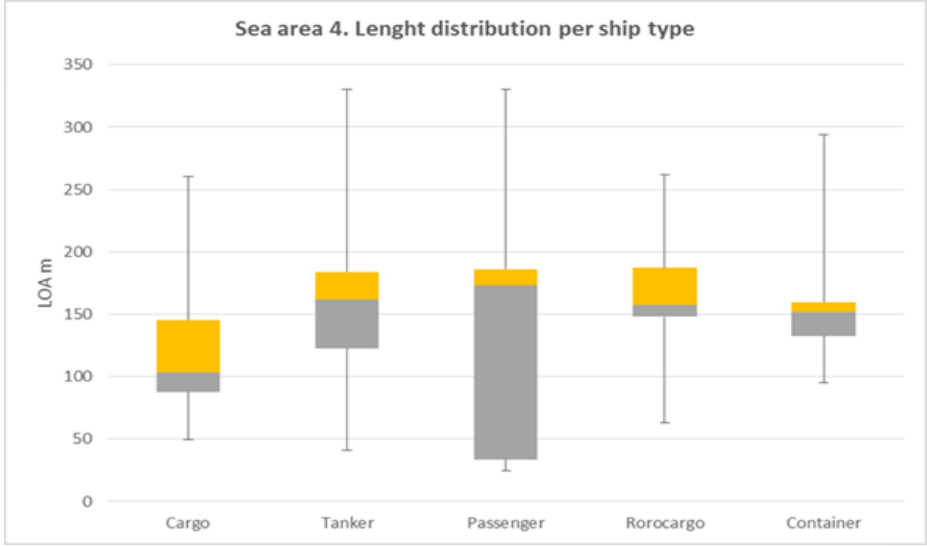
Source:
Valtteri Laine. 2018. Maritime Application of the Maritime ERC Method. 3rd OpenRisk Workshop, Valetta, Malta, 04.2018

Examples
Finnish Gulf of Finland and Archipelago Sea

Questions:
What are dominant ship types for ecological impacts?
What are dominant accident / incident types?
What ship sizes are involved?







Source:
Valtteri Laine. 2018. Maritime Application of the Maritime ERC Method. 3rd OpenRisk Workshop, Valetta, Malta, 04.2018

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EXAMPLE TOOL

ADSAM
ACCIDENTAL DAMAGE and SPILL ASSESSMENT MODEL

ADSAM: Attributes

8. ADSAM

Risk management questions:

- What size of oil spills can occur in a collision or grounding accident?

Attributes of tool:

Quantitative [Yes] Qualitative [No]

Resources needed [Low] Skills required [Medium]

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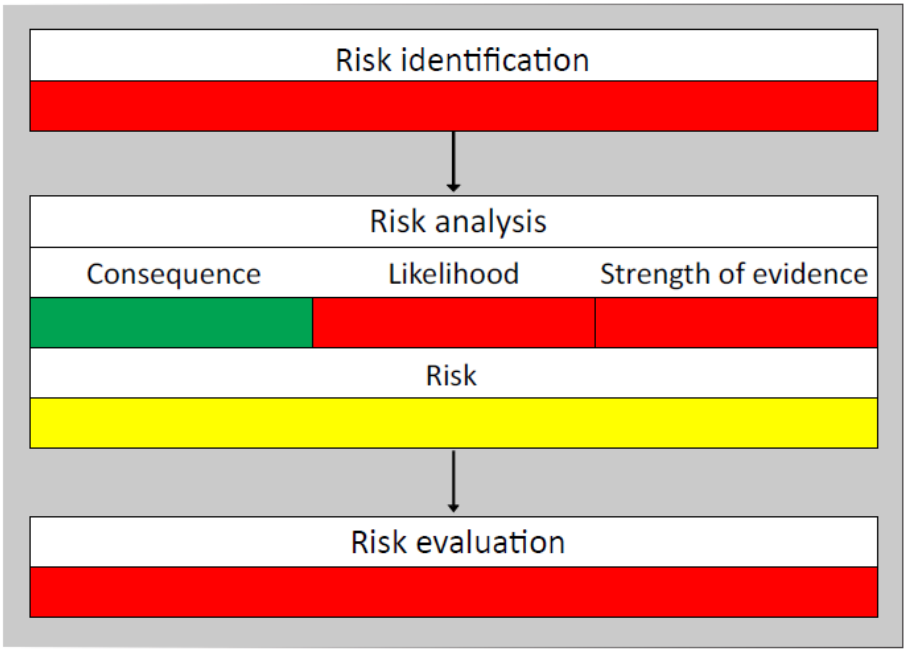
Applicability for different risk management processes:

Basic screening Extended screening

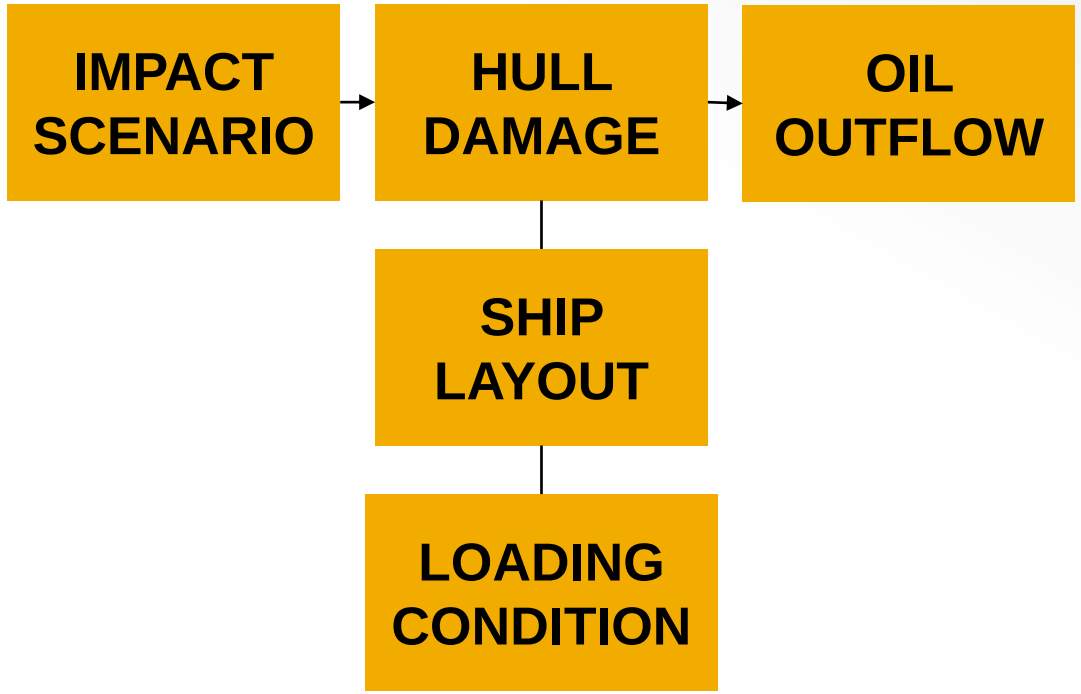
Intermittent Strategic

Applicability for different risk assessment stages:

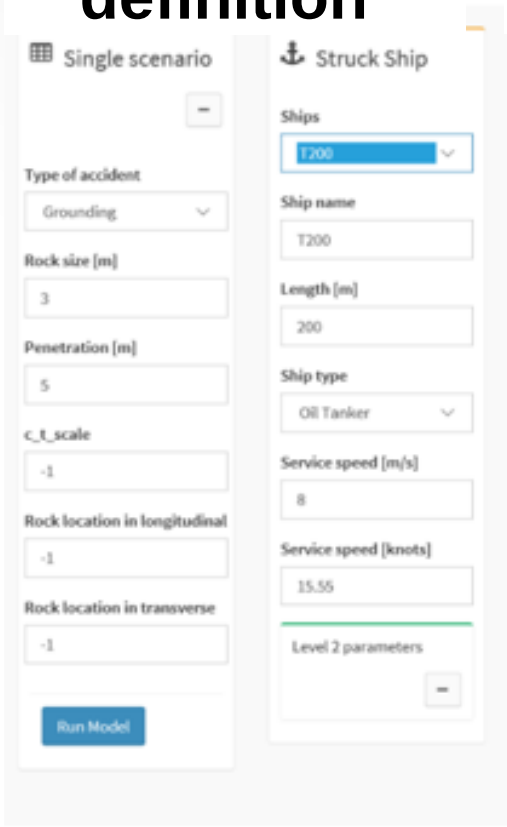


Notes: Strongly applicable = Applicable = Not applicable =

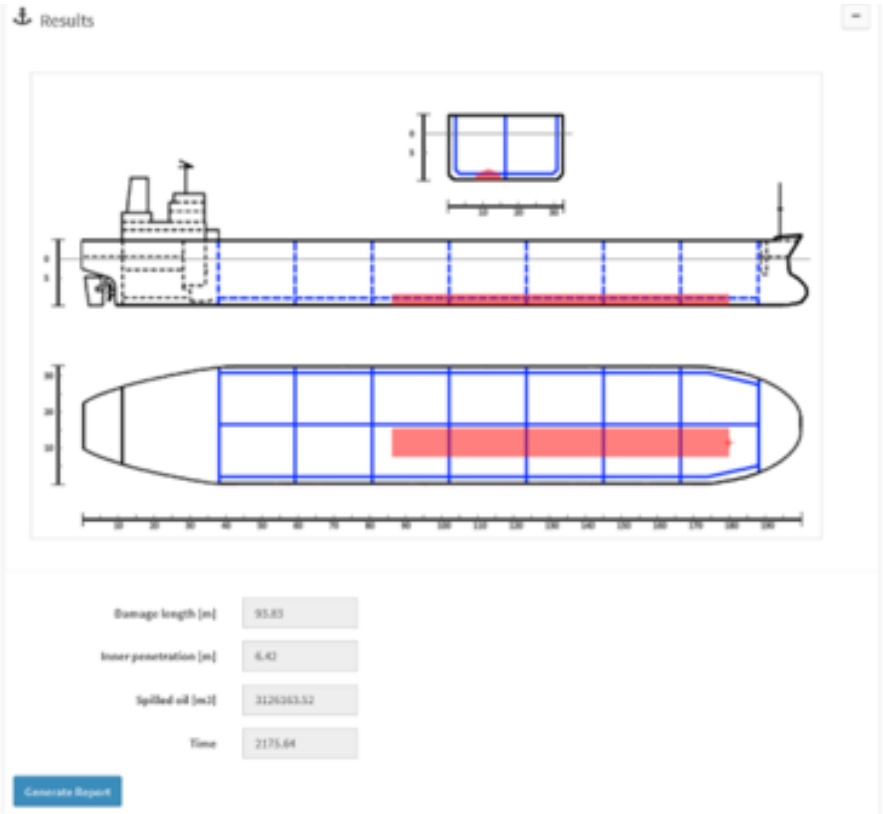
ADSAM: Overview



A. Accident scenario definition



B. Visual representation of grounding damage extent



Source:
Tabri K., Heinvee M., Laanearu J., Kollo M., Goerlandt F. 2018. Marine Pollution Bulletin 135:963-976,

Accidental Damage and Spill Assessment Model

IMPACT SCENARIO → **HULL DAMAGE** → **OIL OUTFLOW**

SHIP LAYOUT

LOADING CONDITION

Definition of accident scenario (tanker size, speed, rock depth,…)

a) Input parameters

Single scenario

Type of accident: Grounding

Rock size [m]: 3

Penetration [m]: 5

c_t_scale: -1

Rock location in longitudinal: -1

Rock location in transverse: -1

Run Model

Struck Ship

Ships: T200

Ship name: T200

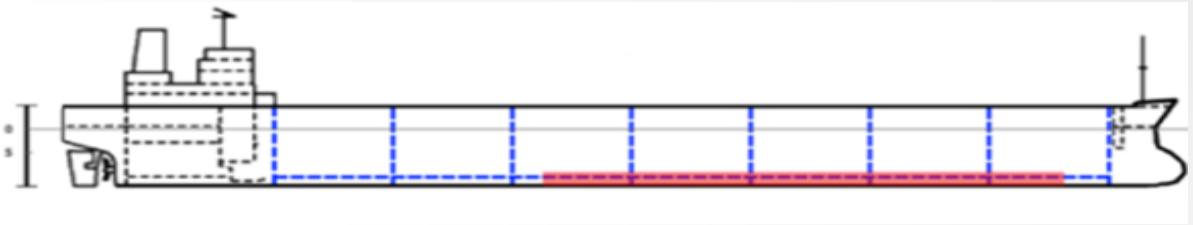
Length [m]: 200

Ship type: Oil Tanker

Service speed [m/s]: 8

Service speed [knots]: 15.55

Level 2 parameters



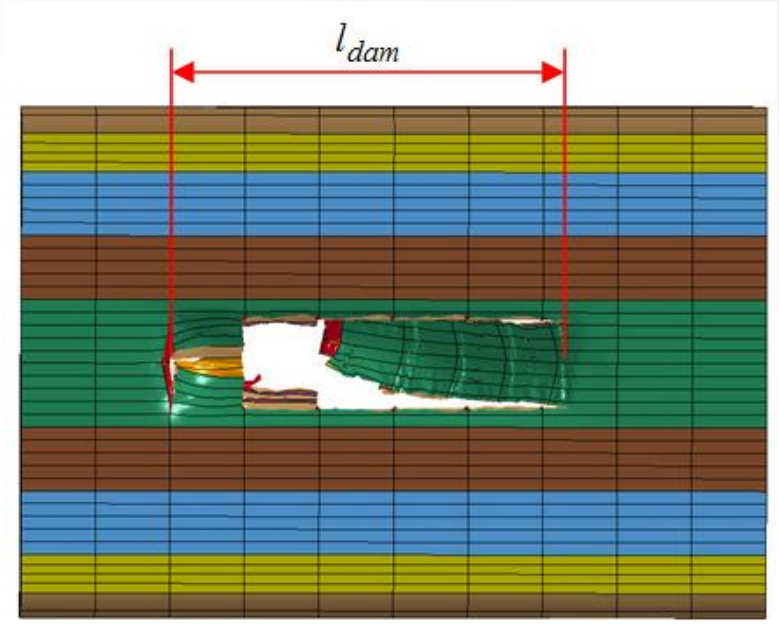
Source:
Tabri K., Heinvee M., Laanearu J., Kollo M., Goerlandt F. 2018. Marine Pollution Bulletin 135:963-976,

Accidental Damage and Spill Assessment Model

IMPACT SCENARIO → HULL DAMAGE → OIL OUTFLOW

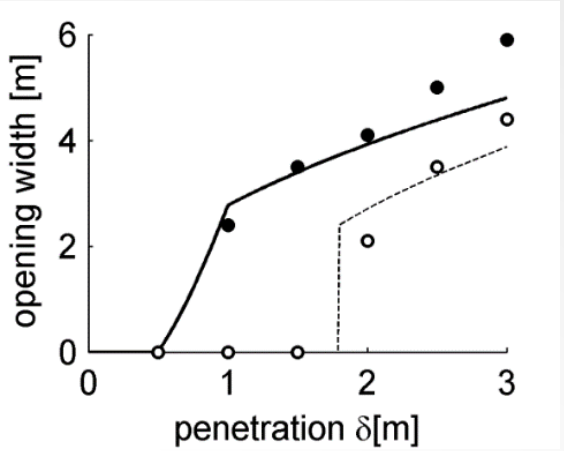
HULL DAMAGE
- SHIP LAYOUT
- LOADING CONDITION

Calculation of damage size in accident scenario (depth, width, length)



Finite Element calculations

Simple criterion for damage extent



Source:
Tabri K., Heinvee M., Laanearu J., Kollo M., Goerlandt F. 2018. Marine Pollution Bulletin 135:963-976,

Accidental Damage and Spill Assessment Model

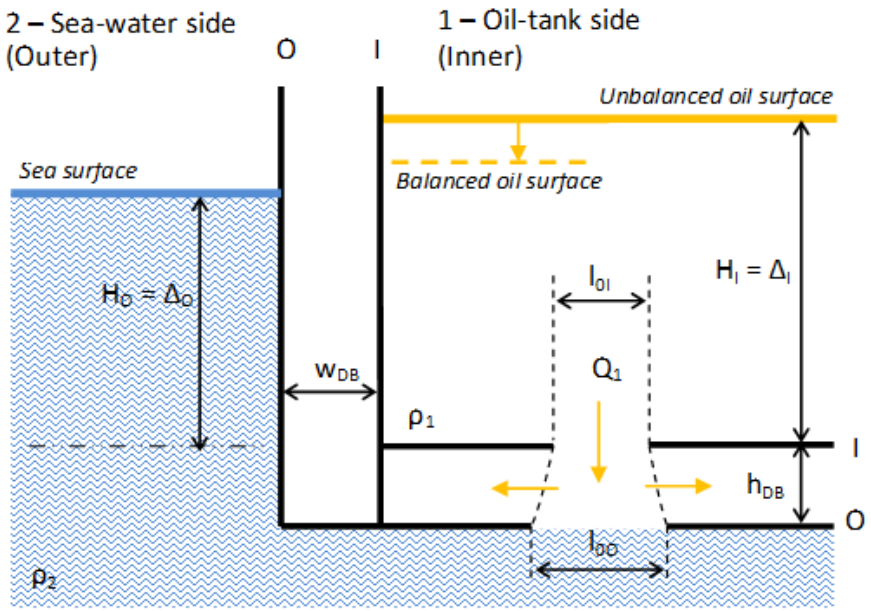
IMPACT SCENARIO → **HULL DAMAGE** → **OIL OUTFLOW**

SHIP LAYOUT

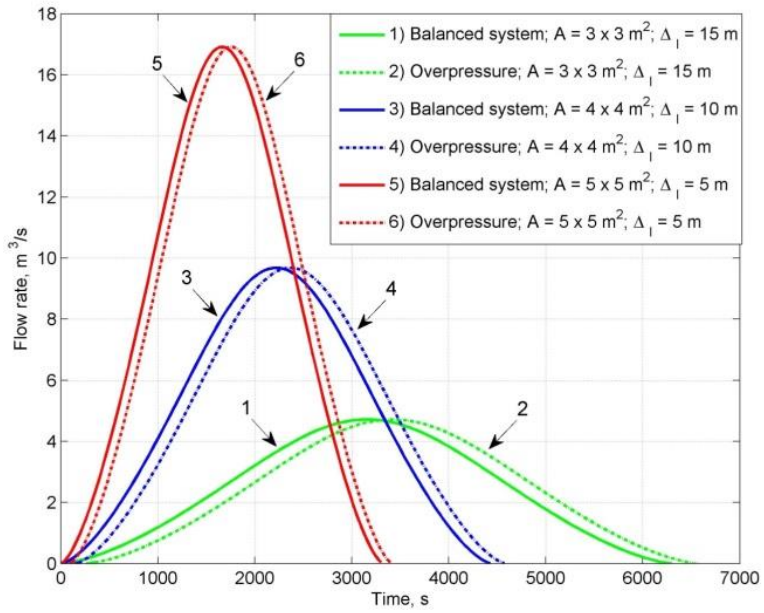
LOADING CONDITION

Calculation of oil outflow resulting from accidental damage size

Scenario definition



Oil outflow as function of time based on hydrostatic balance



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Source:
Tabri K., Heinvee M., Laanearu J., Kollo M., Goerlandt F. 2018. Marine Pollution Bulletin 135:963-976,

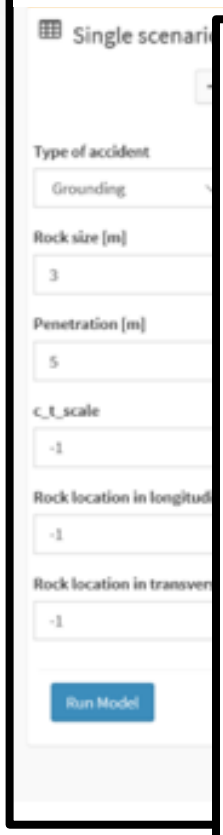
Accidental Damage and Spill Assessment Model

IMPACT SCENARIO → **HULL DAMAGE** → **OIL OUTFLOW**

HULL DAMAGE → **SHIP LAYOUT**

SHIP LAYOUT → **LOADING CONDITION**

A. Accident



B. Grounding damage extent

C. Grounding scenario report

Ship parameters

Name	T200	Block coefficient	0,77
Type	Oil Tanker	Mass [kg]	61615,32
Length [m]	200,00	Tanks (longitudinal)	7
Service speed [m/s]	8,00	Tanks (transverse)	2
Service speed [knots]	15,60	Tanks total	14
Breadth [m]	32,93	Double bottom height [m]	2,00
Draft (fully loaded) [m]	12,15	Breadth of double hull [m]	2,00
Depth [m]	17,40	Cargo type	Crude oil
Deadweight [t]	51807,96	Cargo density	865,00

Scenario

Rock size [m]	4,00	Rock location (longitudinal)	-1,00
Penetration [m]	3,00	Rock location (transverse)	-1,00
c_t_scale	-1,00		

Damage

Length [m]	93,83
Inner width [m]	6,42
Outer width [m]	8,02

Oil spill

Volume (m^3)	3126163,52
Duration	2175,64

Source:
Tabri K., Heinvee M., Laanearu J., Kollo M., Goerlandt F. 2018. Marine Pollution Bulletin 135:963-976,

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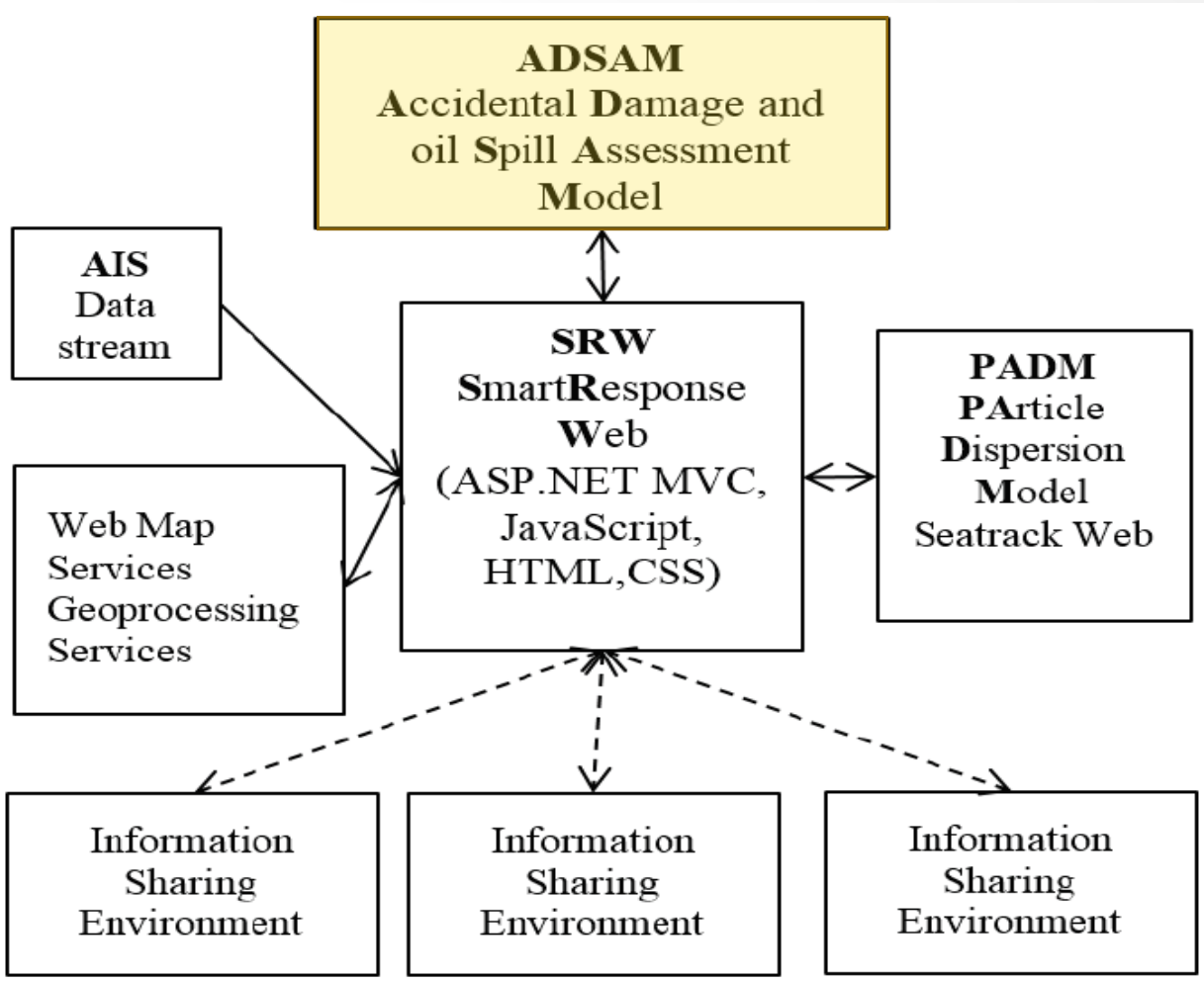
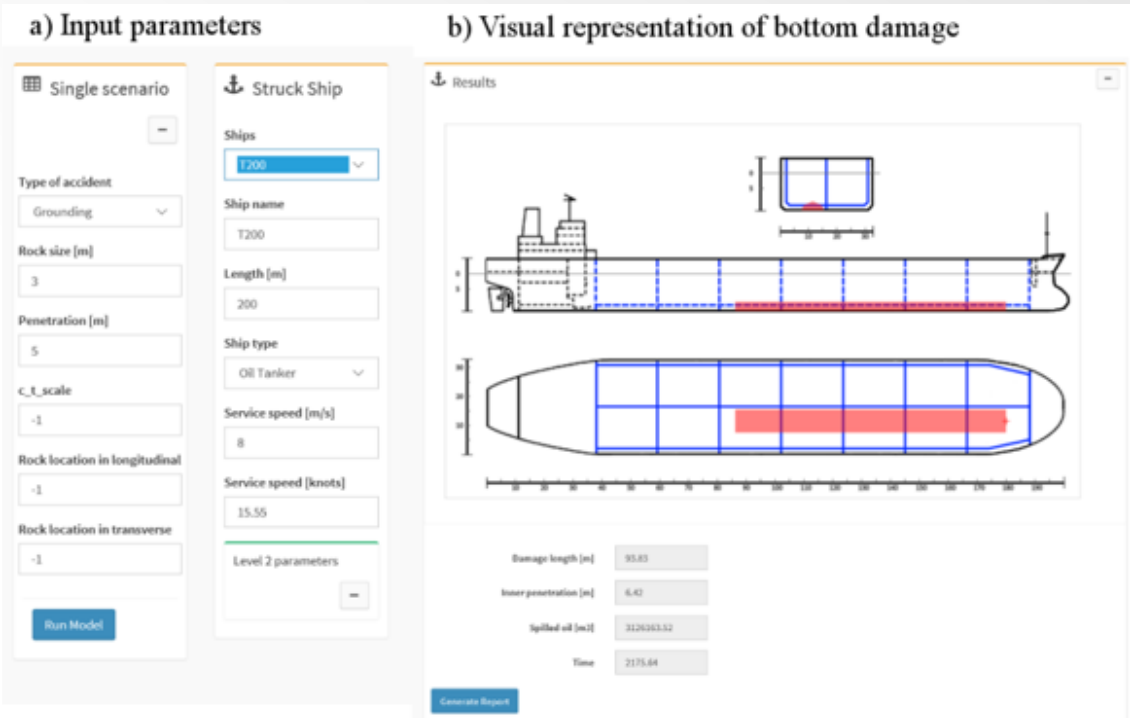
EXAMPLE TOOL

NG-SRW
NEXT-GENERATION SMART RESPONSE WEB

Accidental Damage and Spill Assessment Model

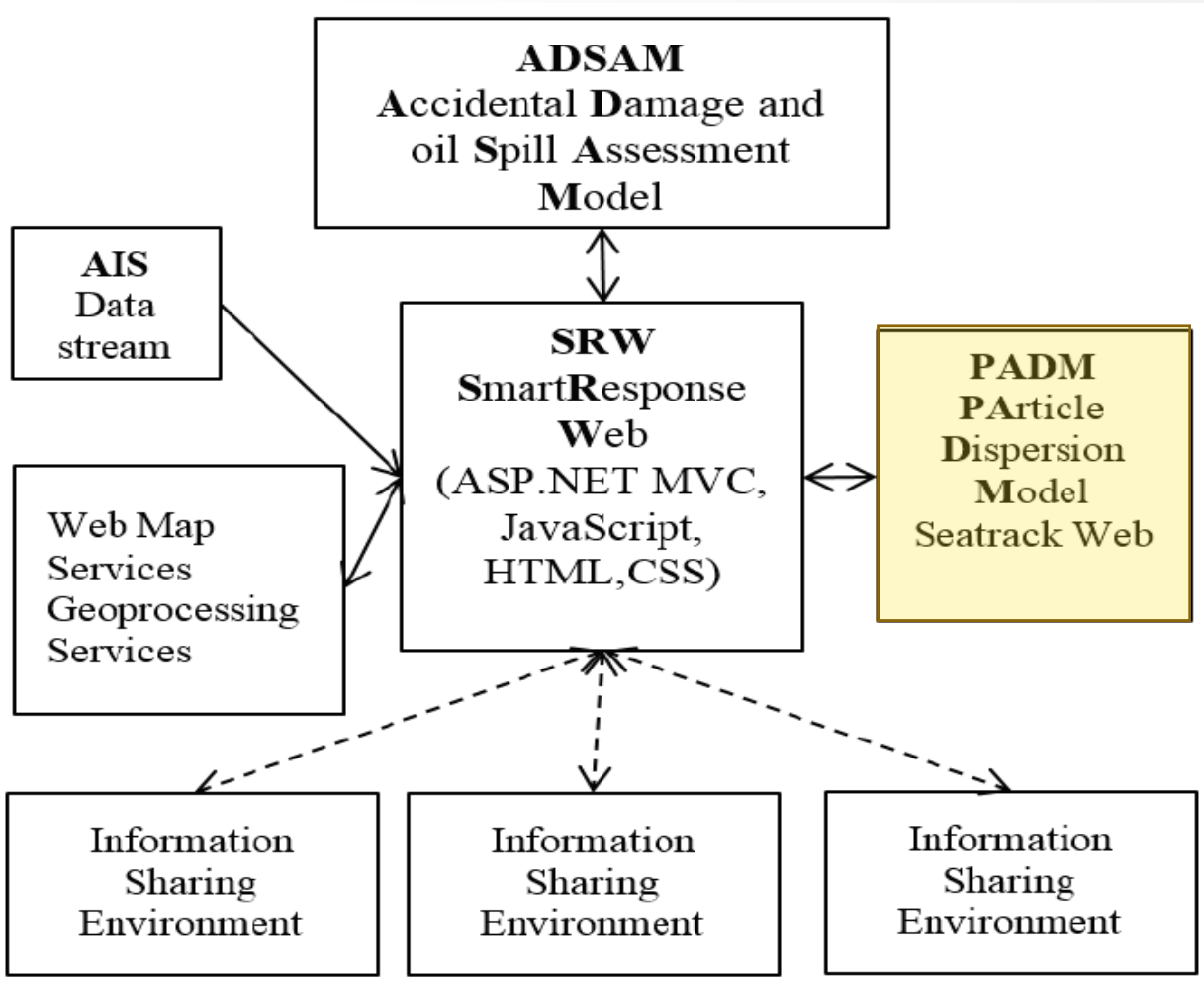


ADSAM
Calculation of accidental oil outflow (volume, time)

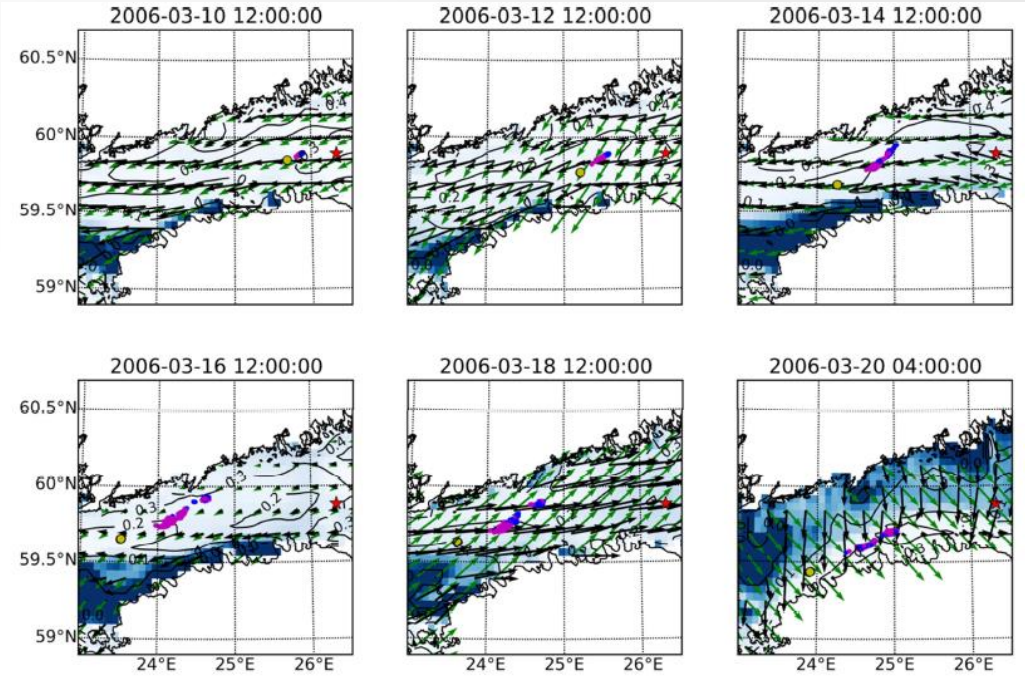


Source:
Fetissov M., Aps R., Tabri K., Höglund A., Goerlandt F. 2018. Marine Pollution Bulletin, *in preparation.*

Accidental Damage and Spill Assessment Model

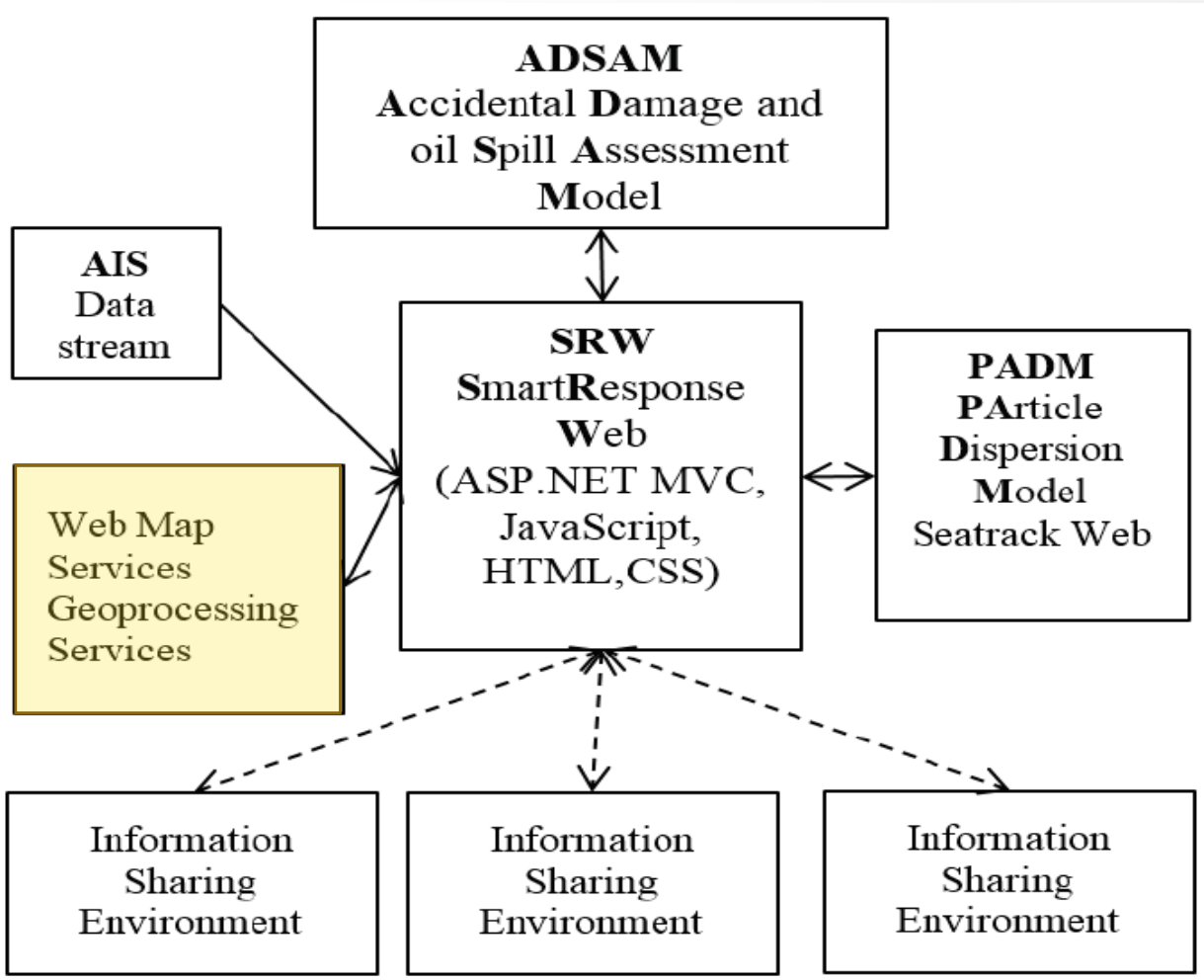


PADM (Particle Dispersion Model)
Calculation of oil drift in the sea
(implemented in SeaTrack Web)

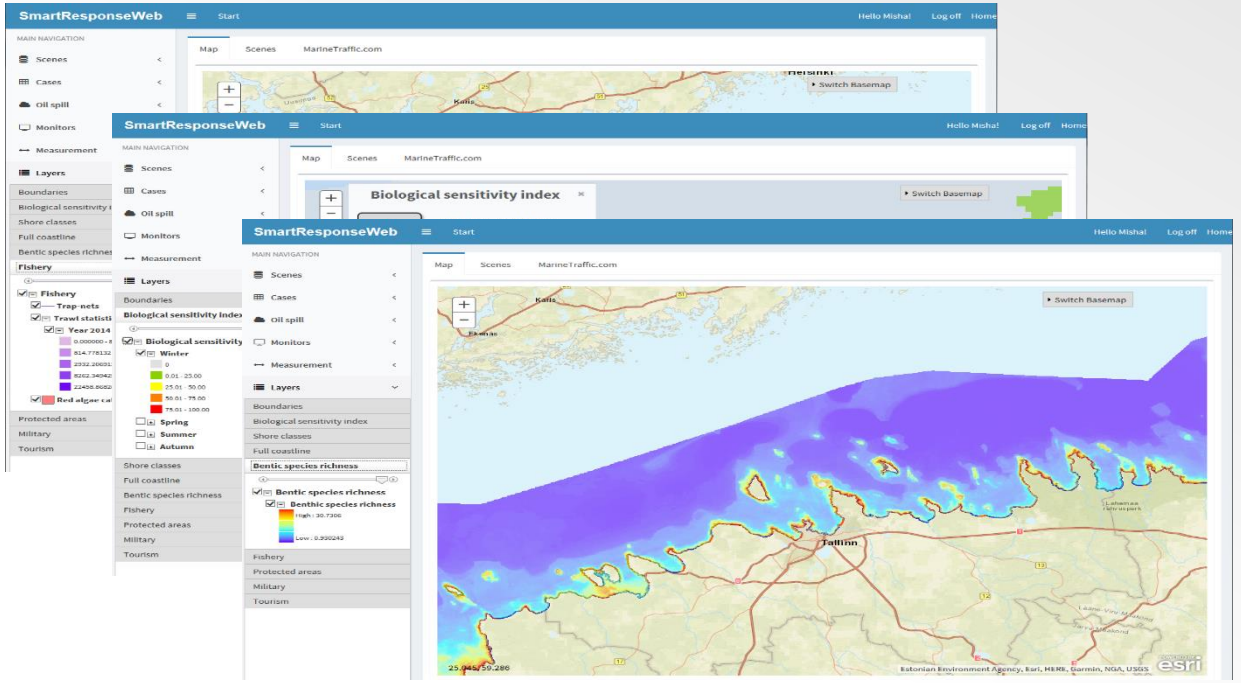


Source:
Fetissov M., Aps R., Tabri K., Höglund A., Goerlandt F. 2018. Marine Pollution Bulletin, *in preparation.*

Accidental Damage and Spill Assessment Model



Web Map Services
Display of information layers related to use of marine space



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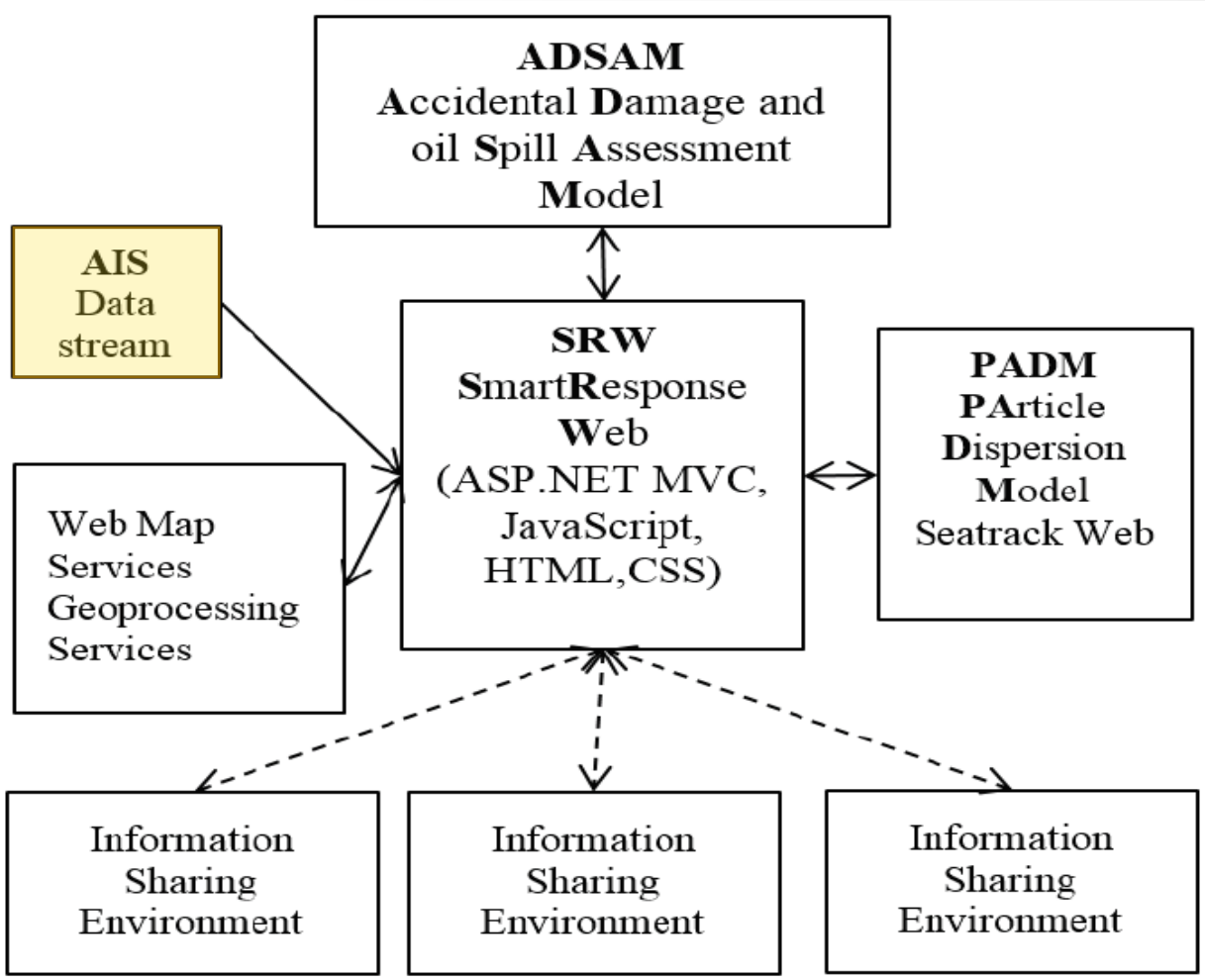
Fetissov M., Aps R., Tabri K., Höglund A., Goerlandt F. 2018. Marine Pollution Bulletin, *in preparation.*

Accidental Damage and Spill Assessment Model

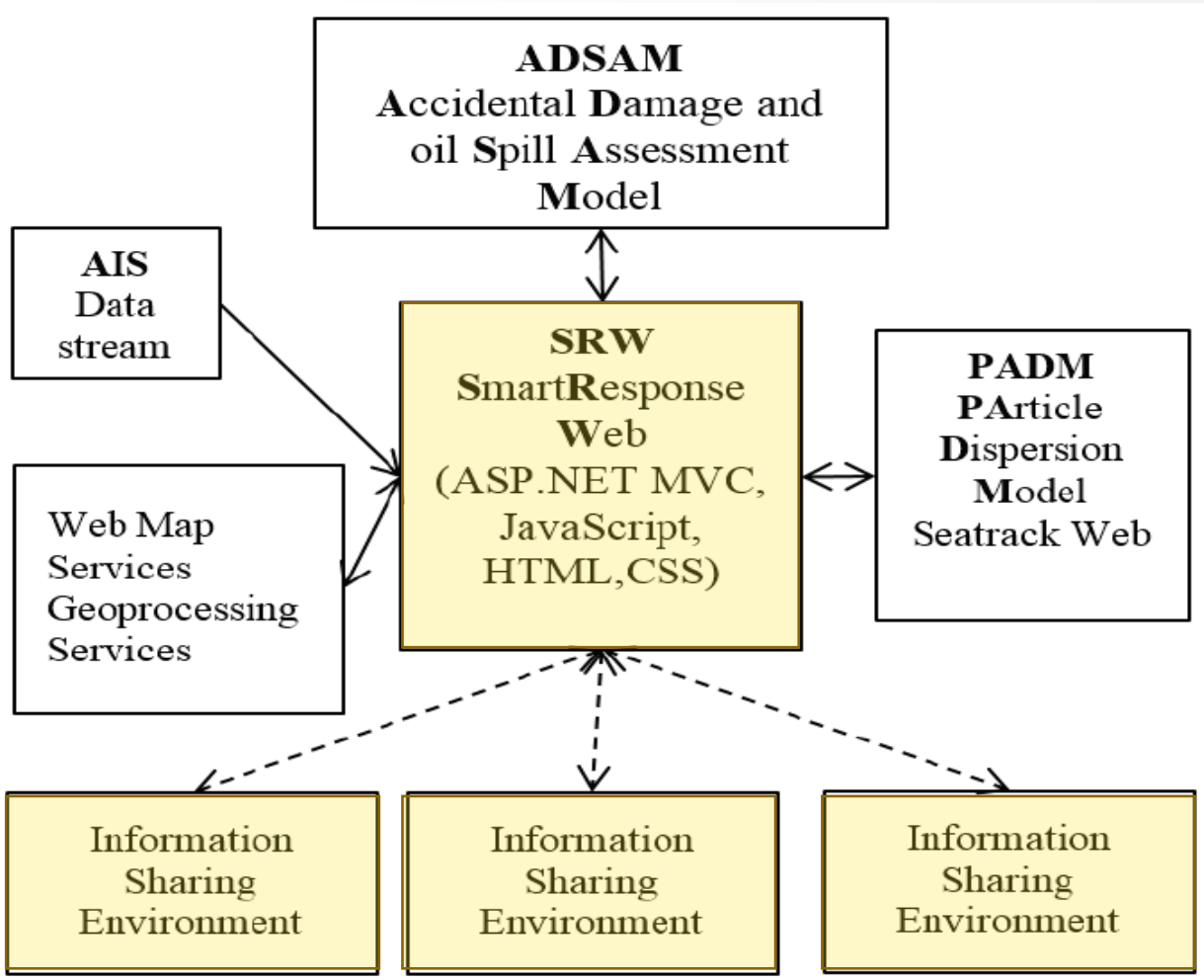


AIS data stream
Display information from Automatic Identification System (ship traffic)

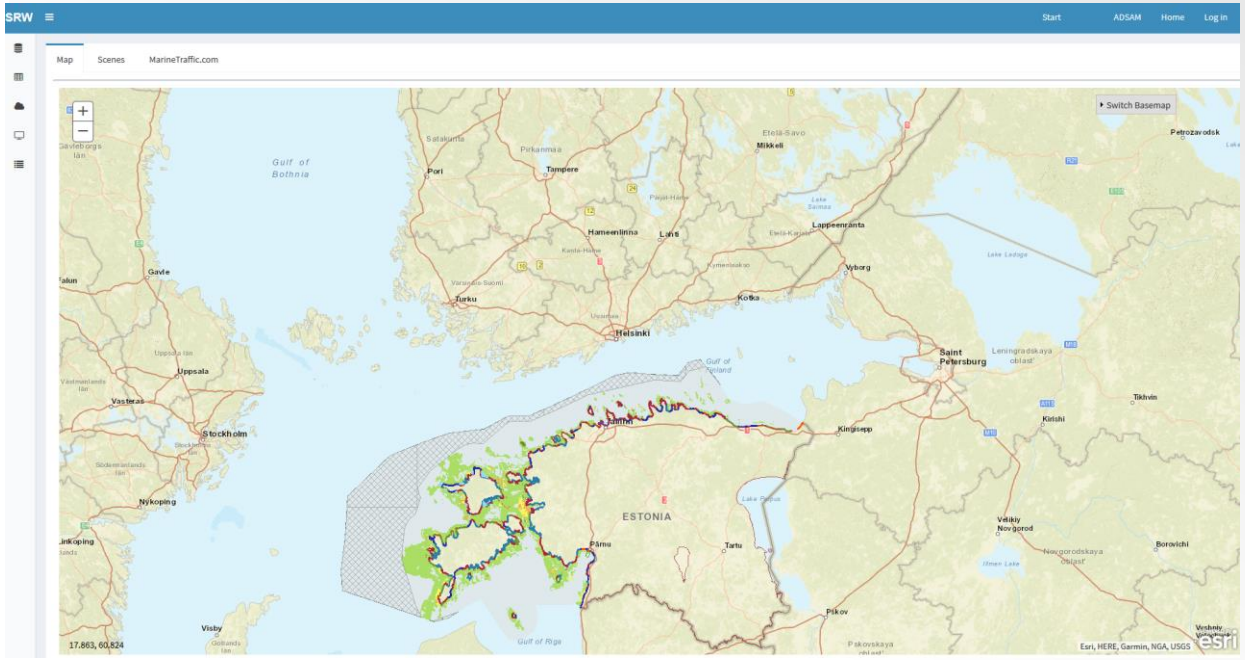
For operational response planning

Source:
Fetissov M., Aps R., Tabri K., Höglund A., Goerlandt F. 2018. Marine Pollution Bulletin, *in preparation.*

Accidental Damage and Spill Assessment Model



Next Generation-SmartResponse Web Information integration and summary



Source:
Fetissov M., Aps R., Tabri K., Höglund A., Goerlandt F. 2018. Marine Pollution Bulletin, *in preparation.*

Questions?

floris.goerlandt@dal.ca

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