

# 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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Guest Lecture at Aalto University, Maritime Risk and Safety Course, October 2022

# 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

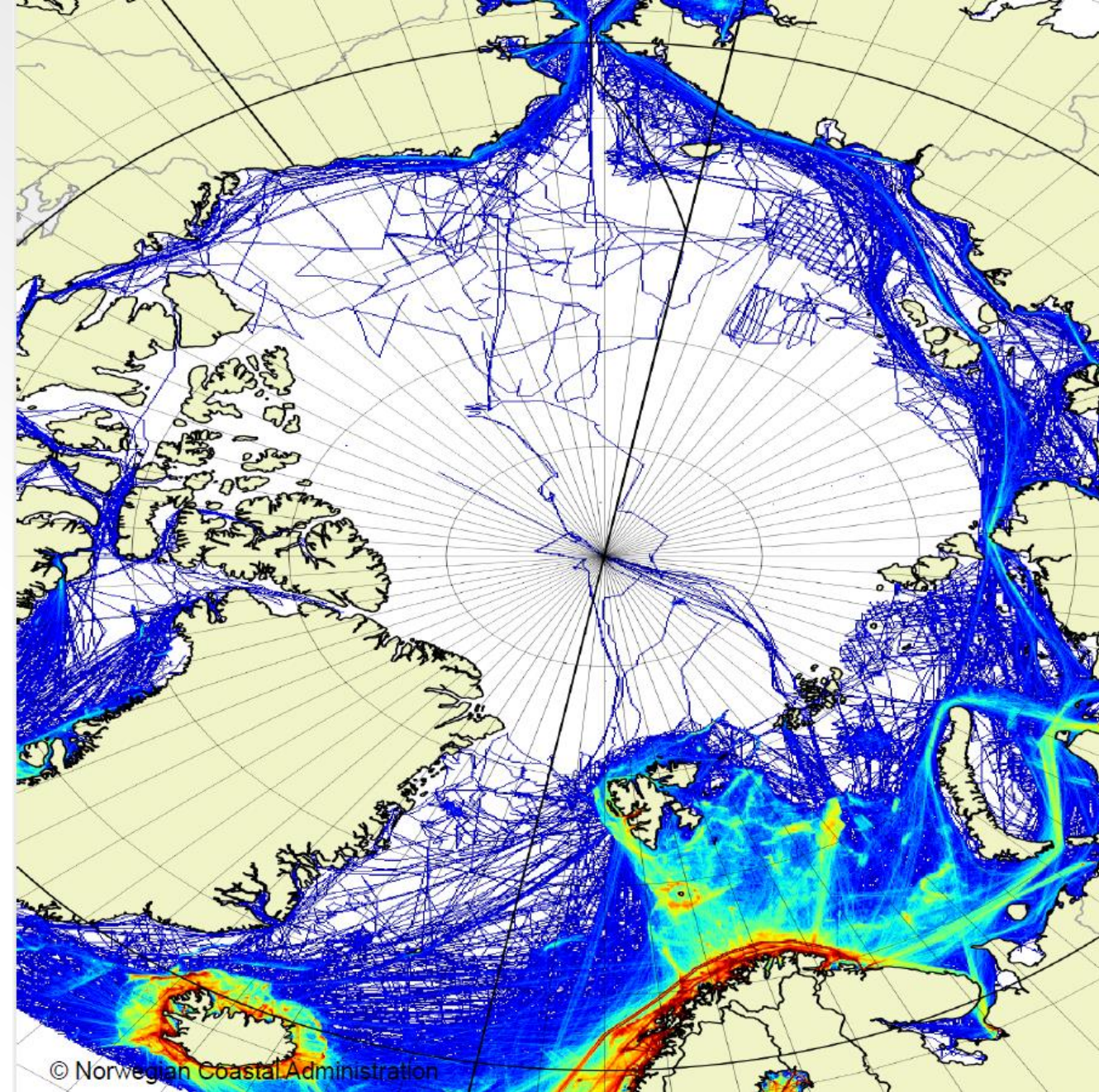




# MARITIME ACTIVITIES IN THE ARCTIC

# Maritime traffic in the Arctic is happening

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



Shipping

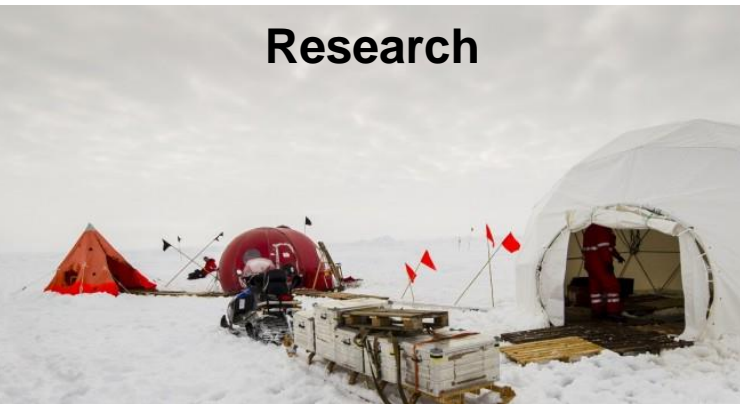


# Maritime-related activities in the Arctic

Tourism



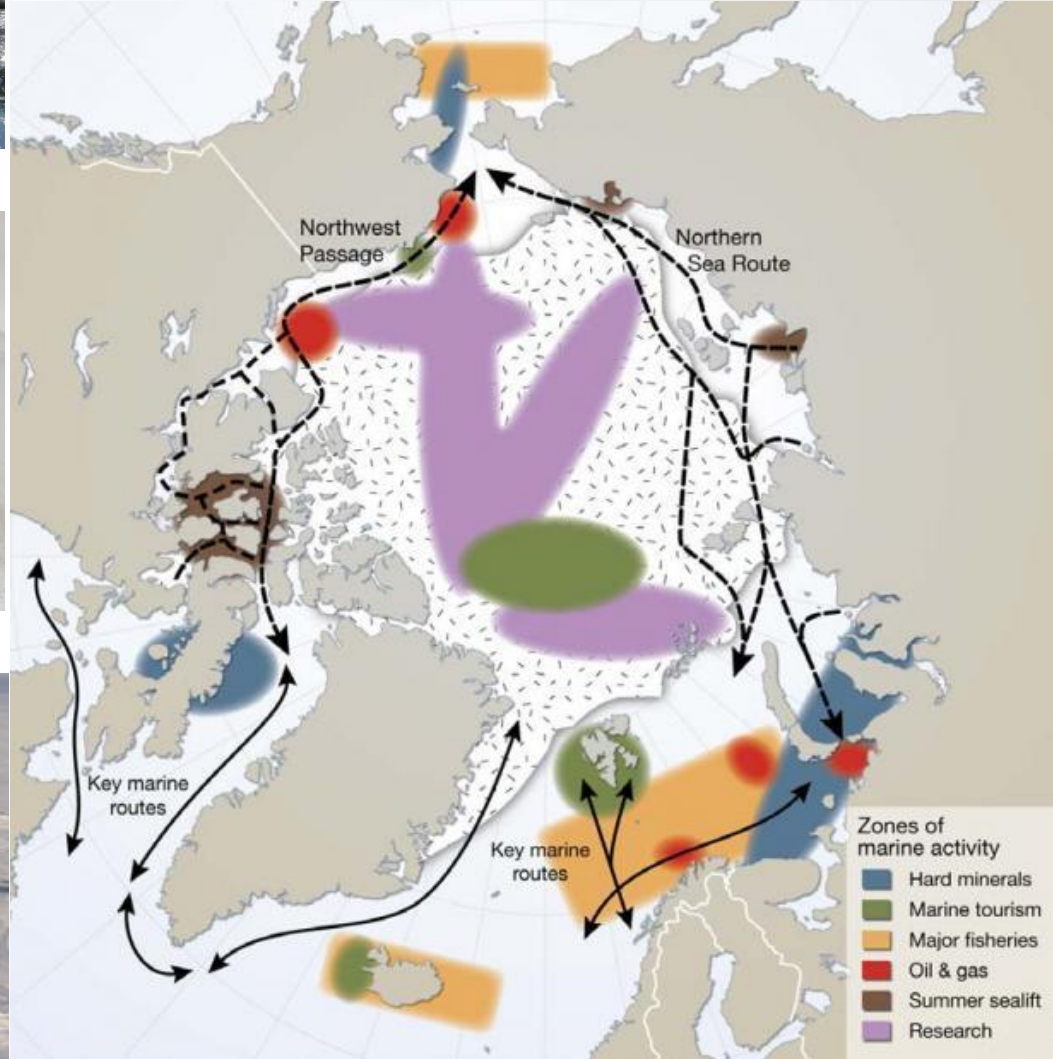
Research



Fisheries



Mining

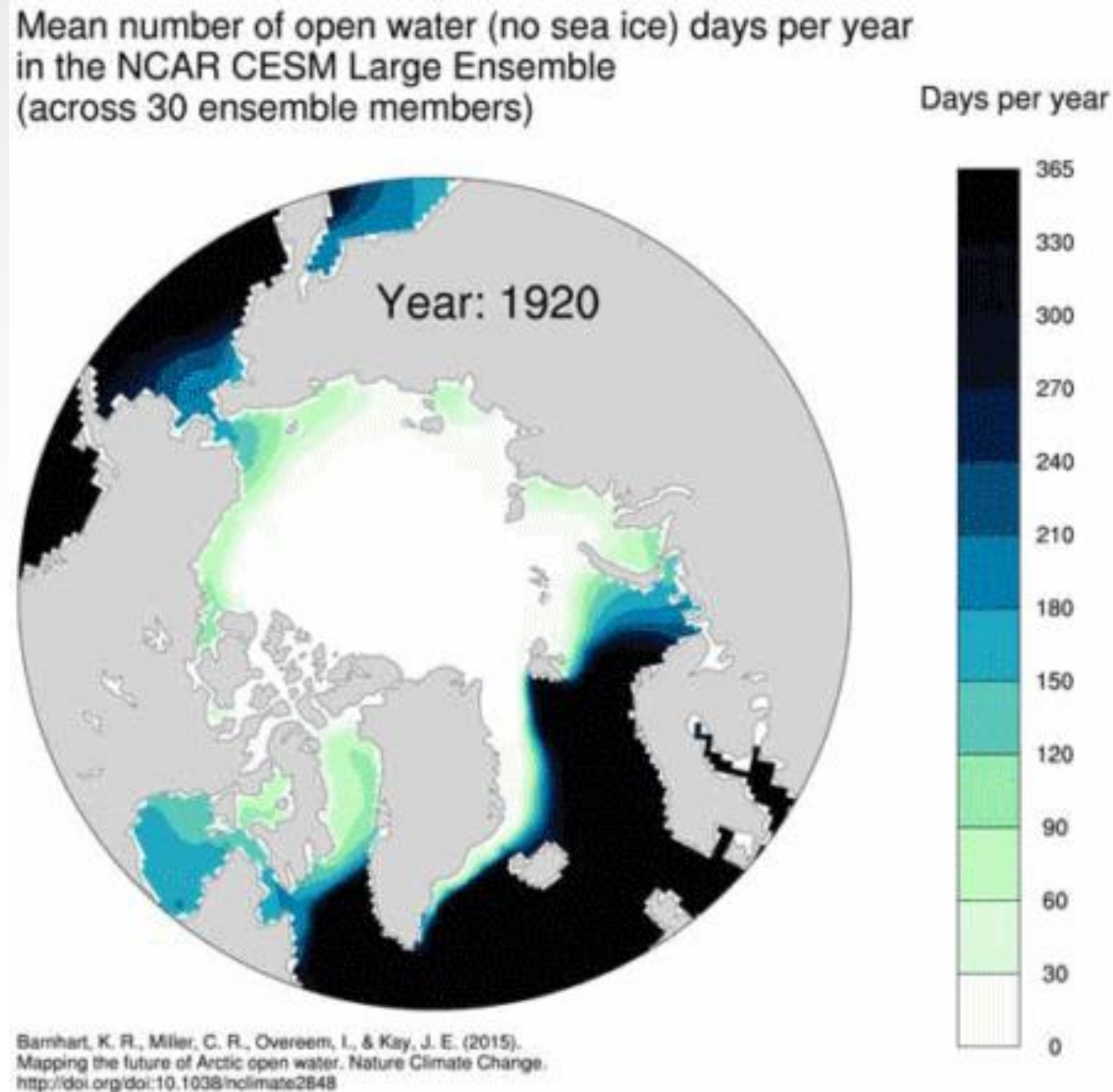


Offshore oil



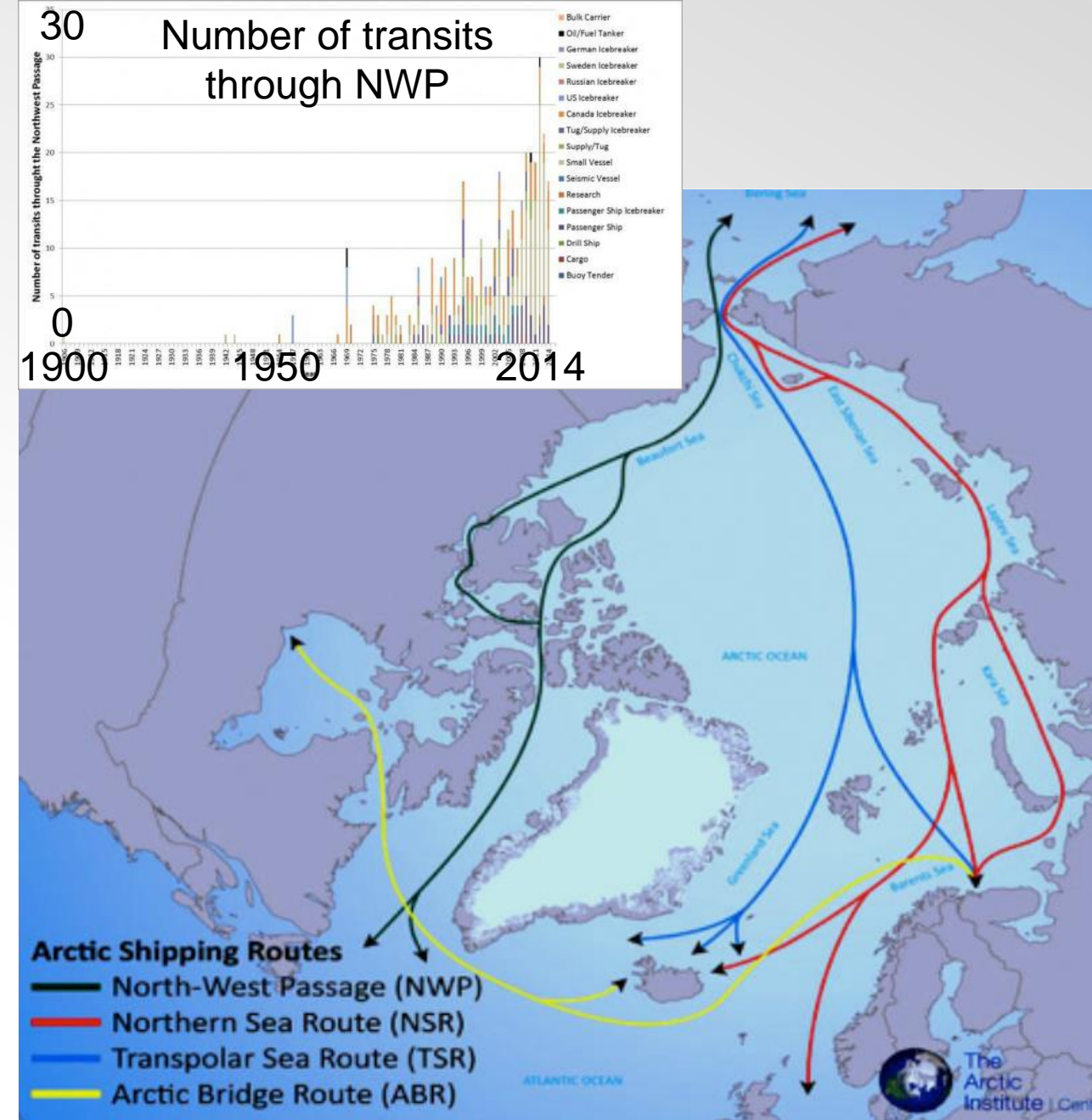
# Projected decrease of sea ice in the Arctic

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



# 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





# ACCIDENTS AND OIL SPILLS IN ARCTIC CONDITIONS



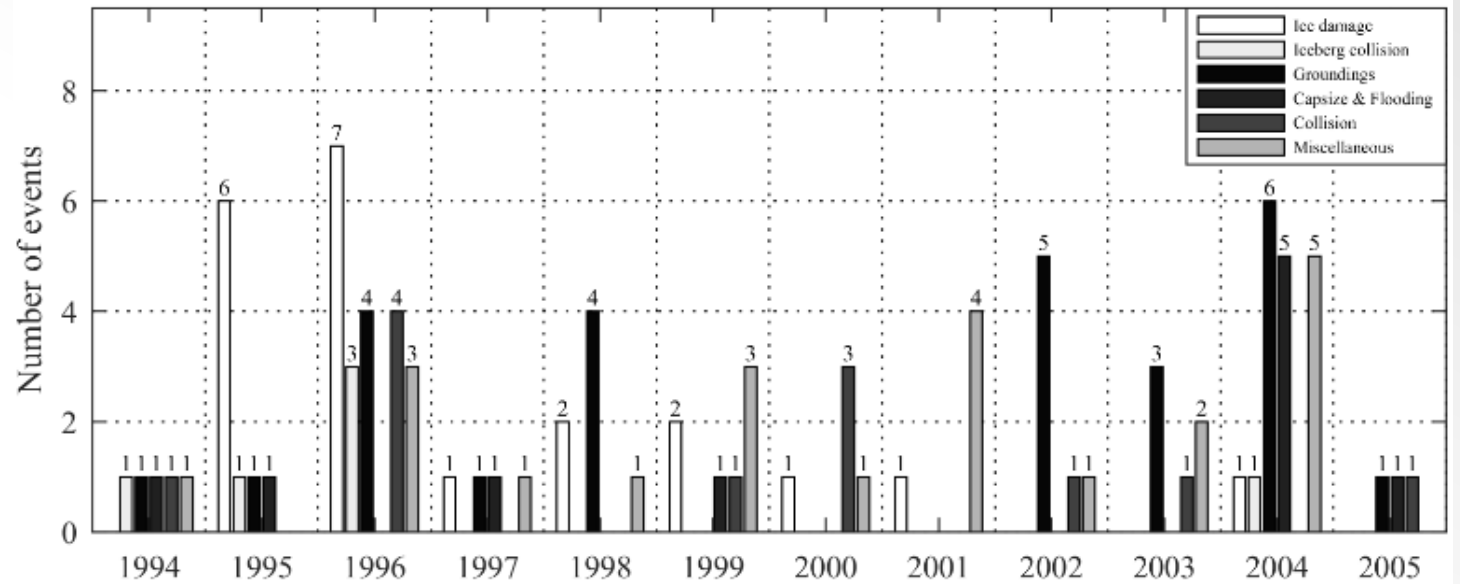
# Shipping accidents in Arctic Environment



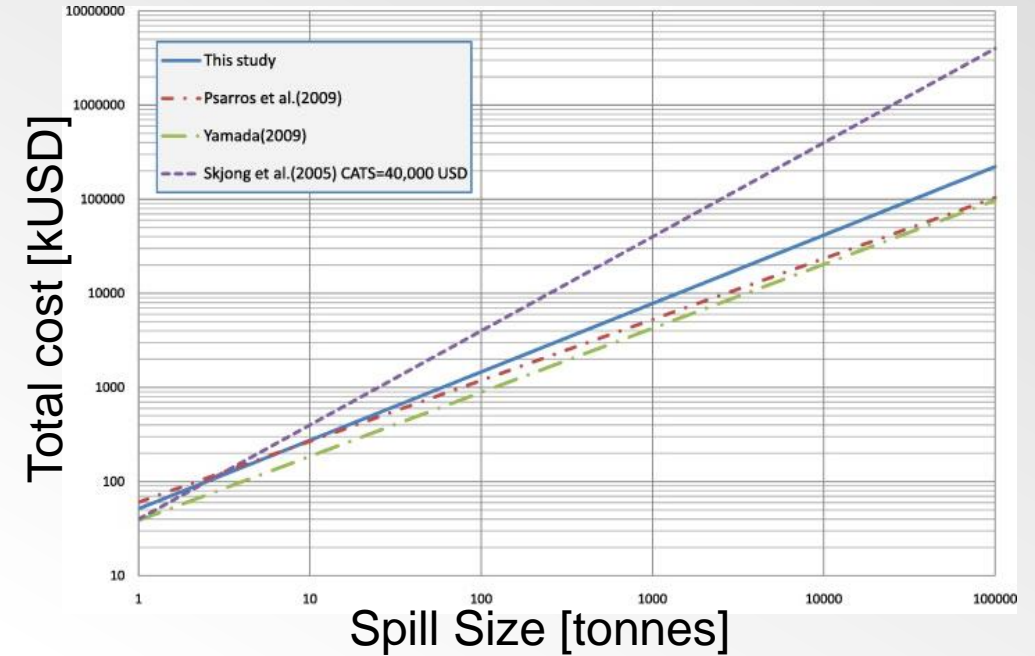
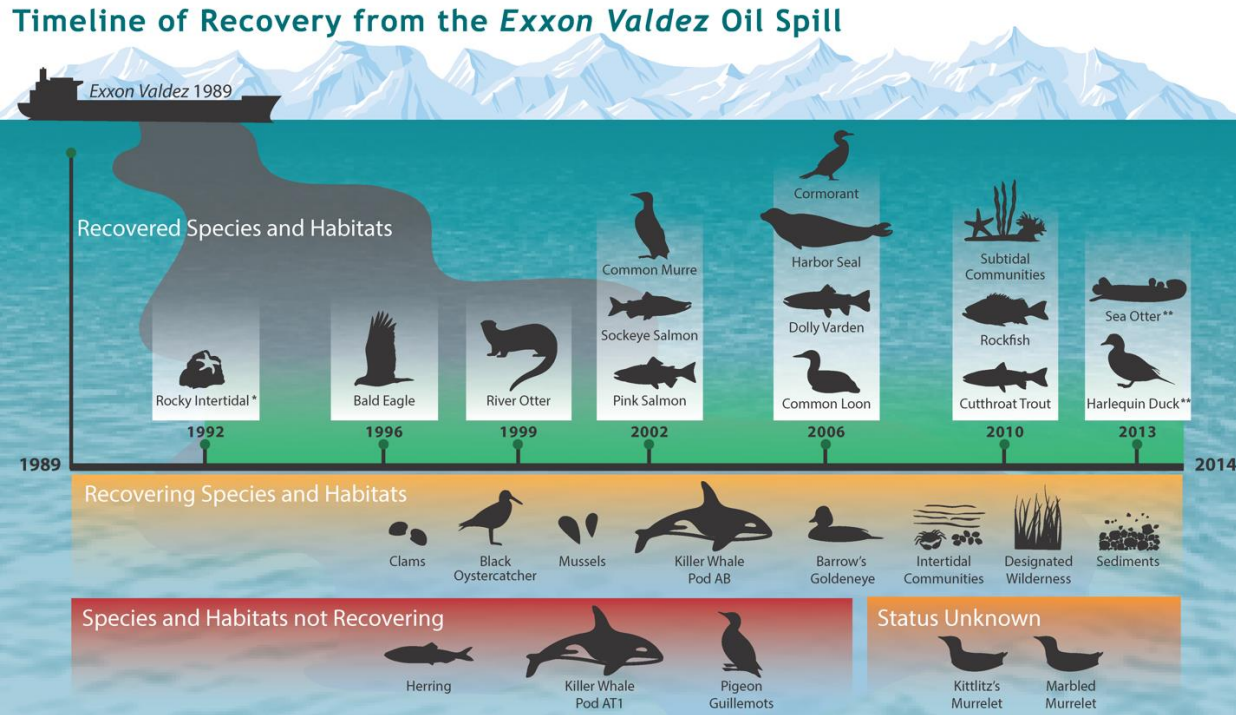
Clipper Adventurer  
Grounding, 2010



Accidents and incidents in the Arctic



# Impacts: Ecosystem, economic, media, local communities



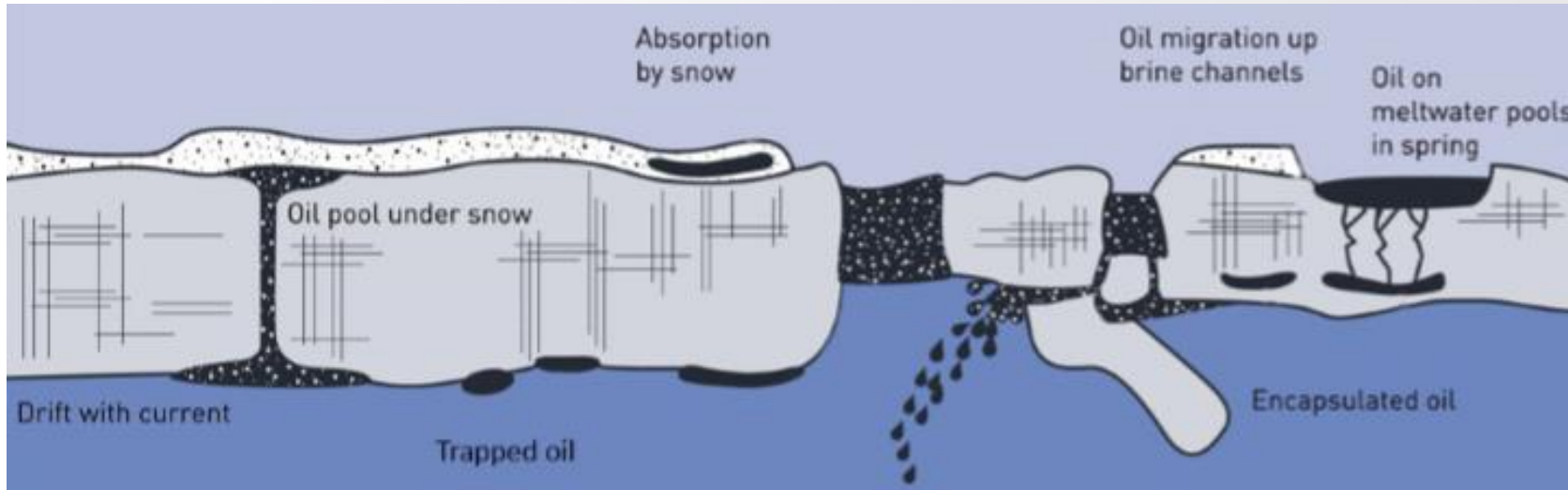
## Coast Guard seeks damages for Arctic cruise ship accident

Clipper Adventurer hit uncharted sand bar in 2010

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



# Oil spill in ice: very complex



Frazil ice



Nilas



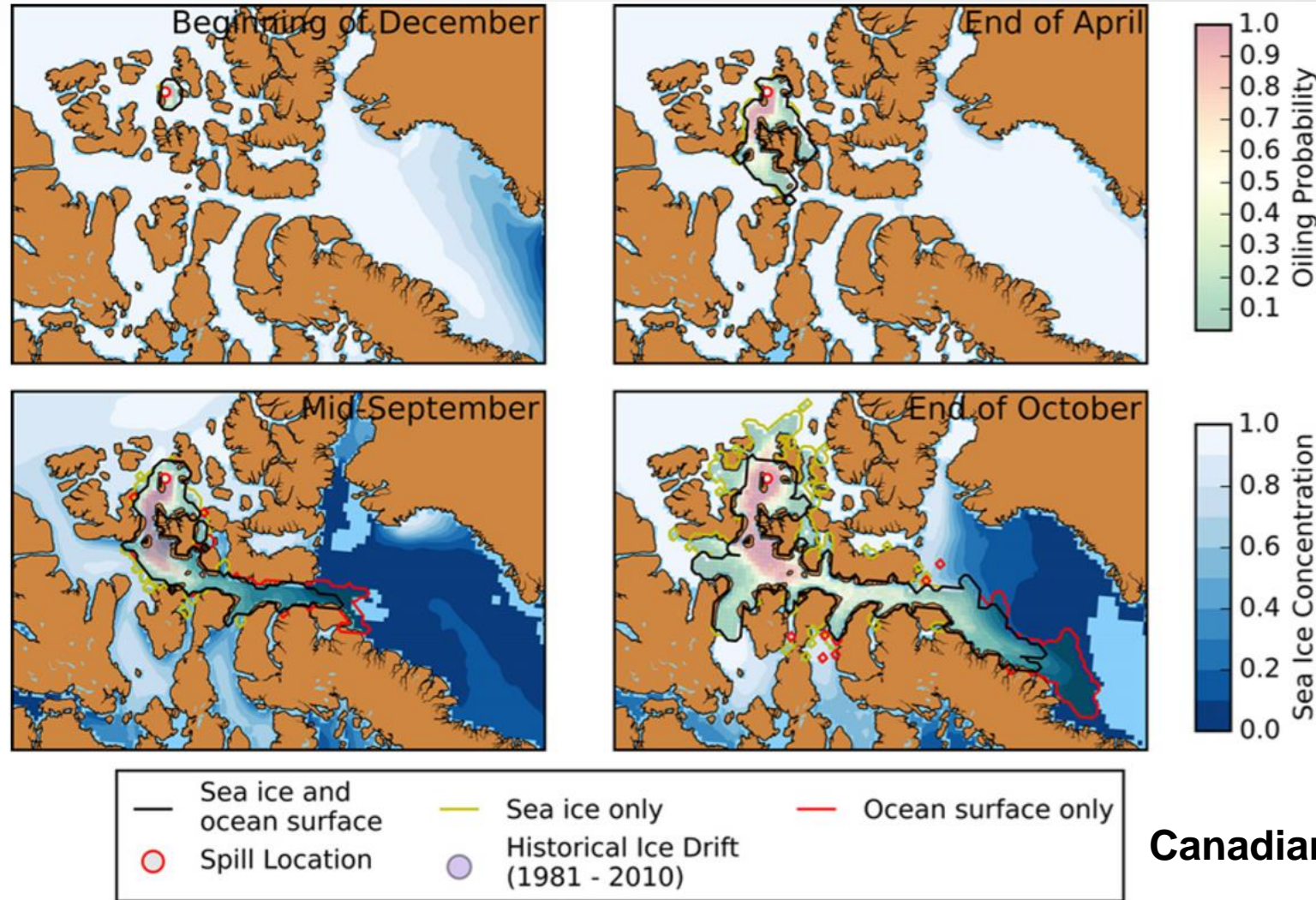
1st year ice



Melting ice

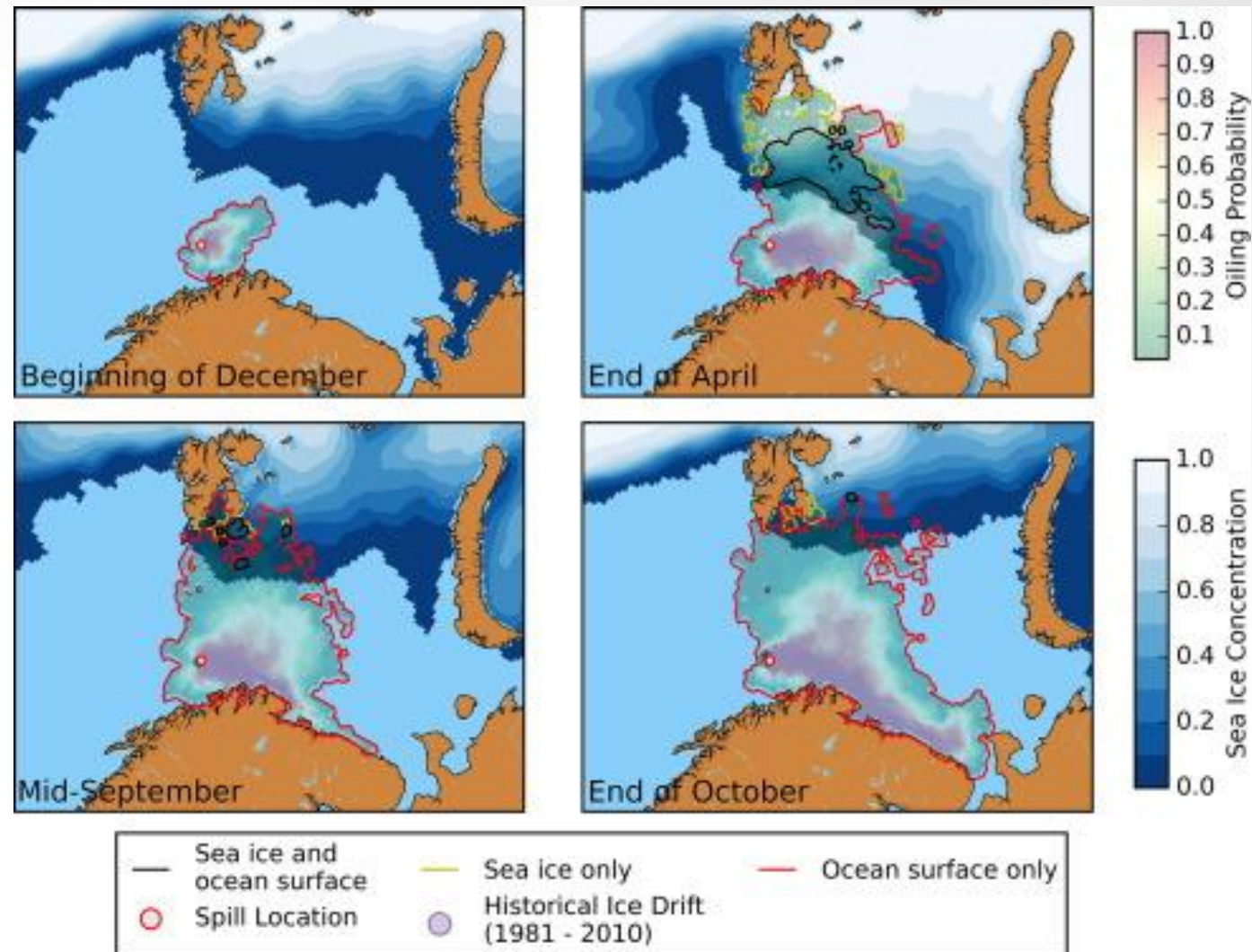


# A worst-case spill would lead to vast polluted areas



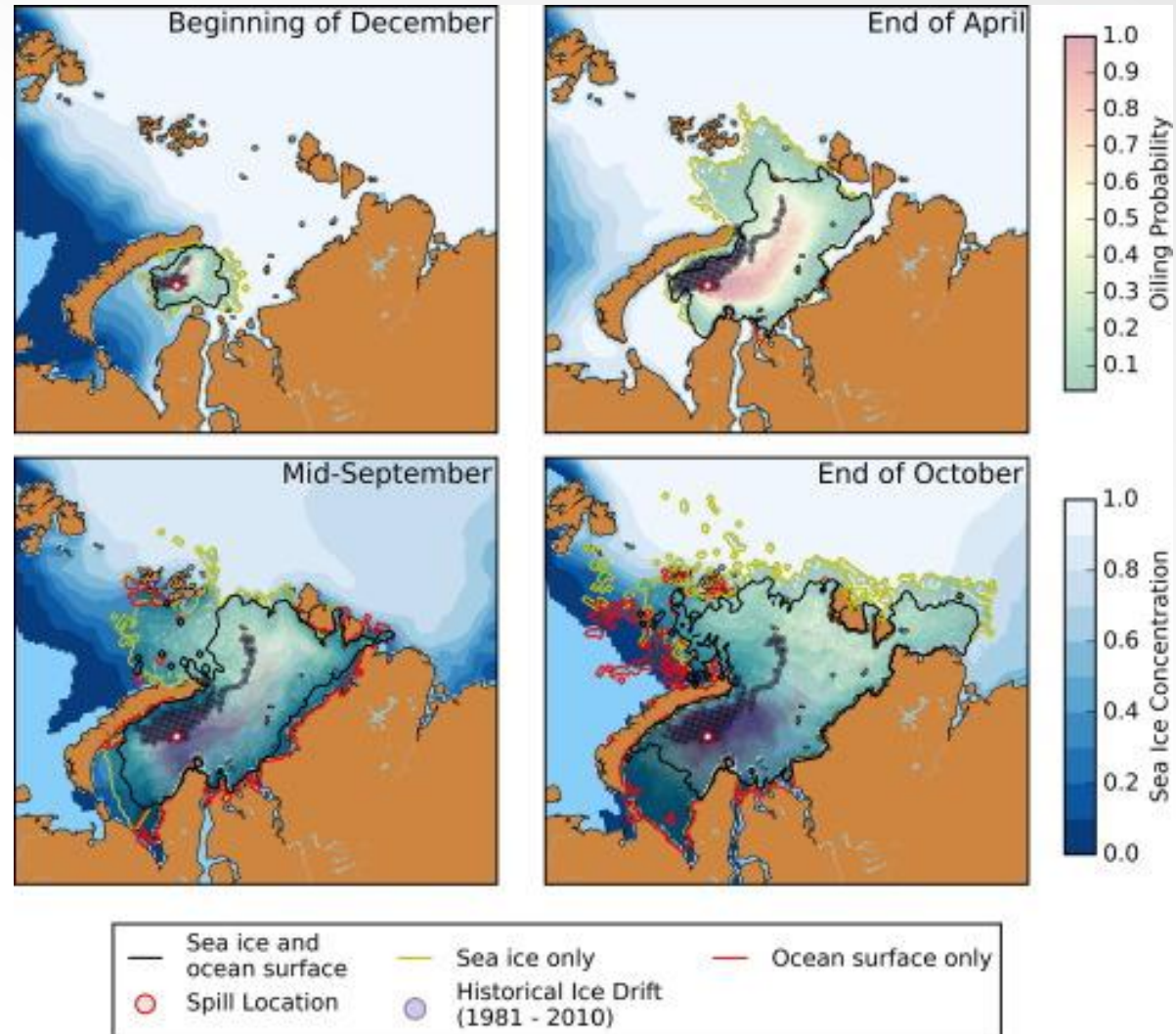
## Canadian Arctic Archipelago

# A worst-case spill would lead to vast polluted areas



**Barents Sea**

# A worst-case spill would lead to vast polluted areas



**Kara Sea**



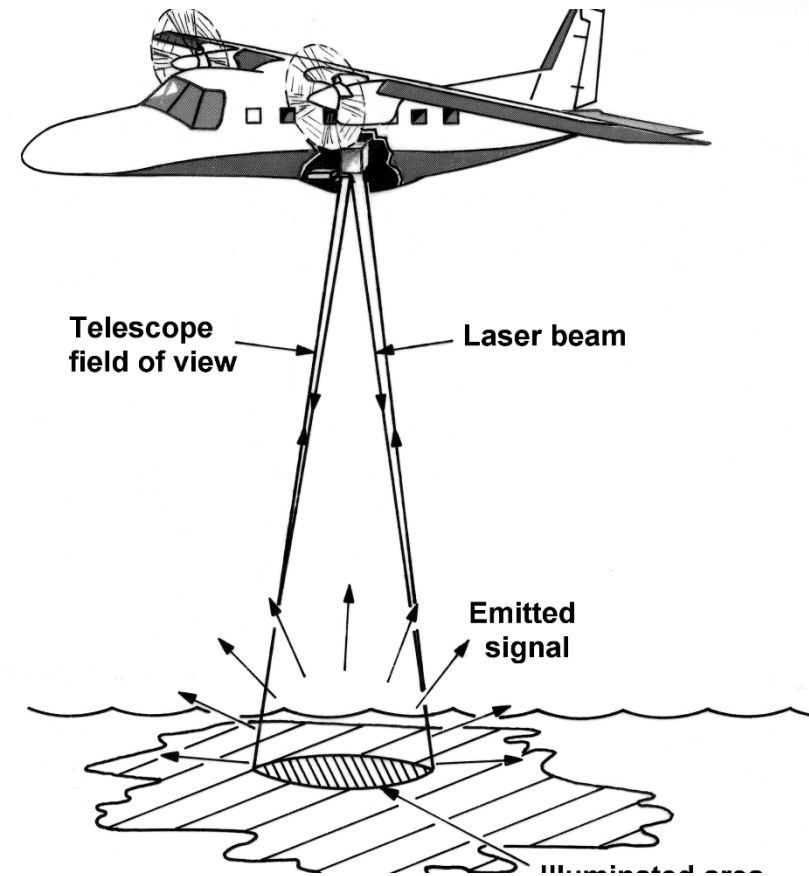
# OIL SPILL RESPONSE SYSTEM

# Oil spill response: complex socio-technical system

## Detection

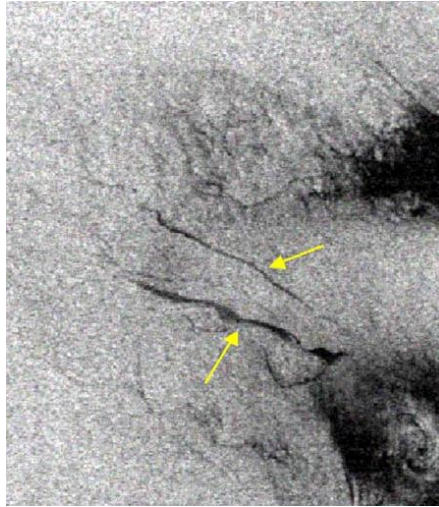
## Response operation

## Logistics





# Technologies for oil detection



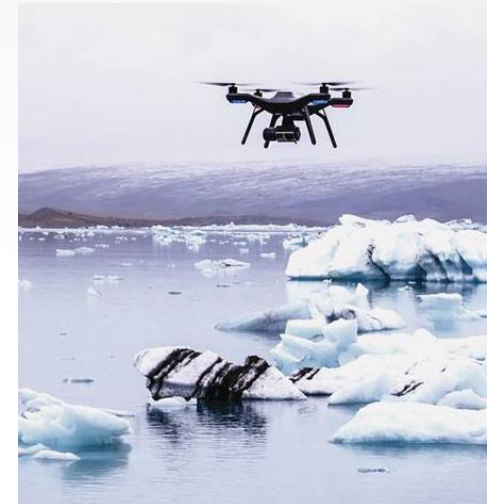
Sattelite remote sensing



Underwater surveillance



Ground-penetrating radar



Unmanned Aerial vehicle

# Technologies for oil response



**Mechanical recovery**

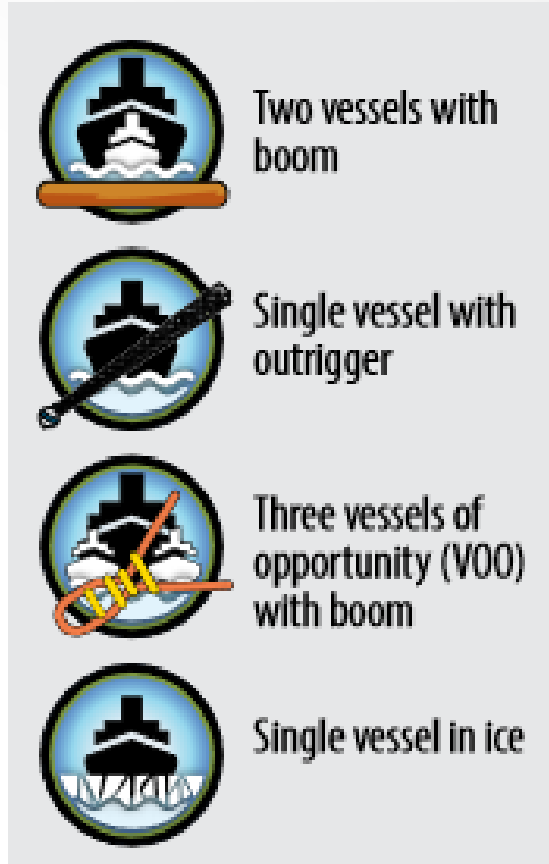


**Dispersant application**



**In-situ burning**

# Technologies for oil response



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

## Mechanical recovery



# Technologies for oil response



**Dispersants application**



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

# Technologies for oil response



**In-situ burning**



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



# CHALLENGES FOR OIL SPILL RESPONSE IN ARCTIC AREAS

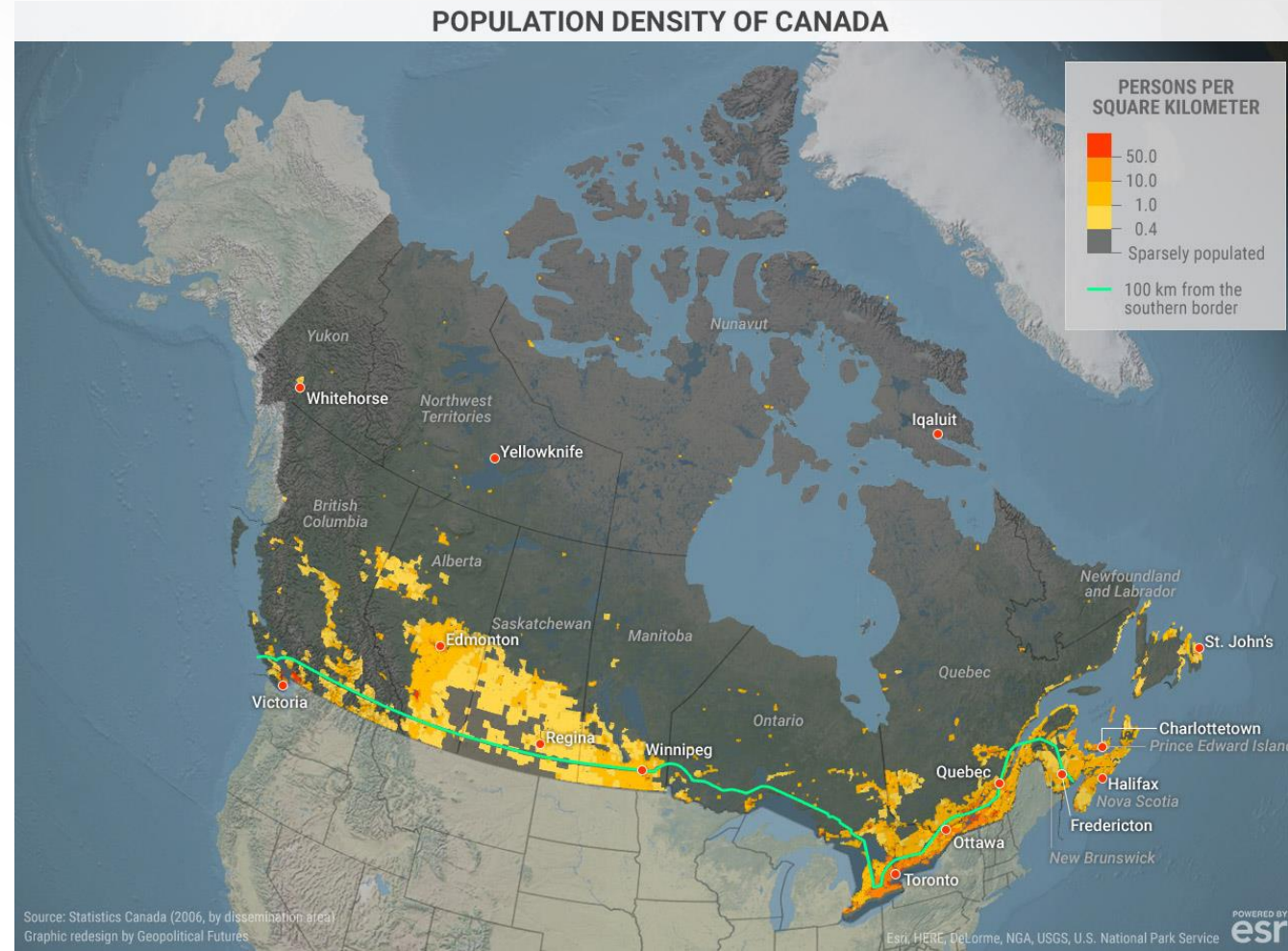
# Arctic features



Cold



Complex, dynamic ice



Remote, few people, lack of infrastructure

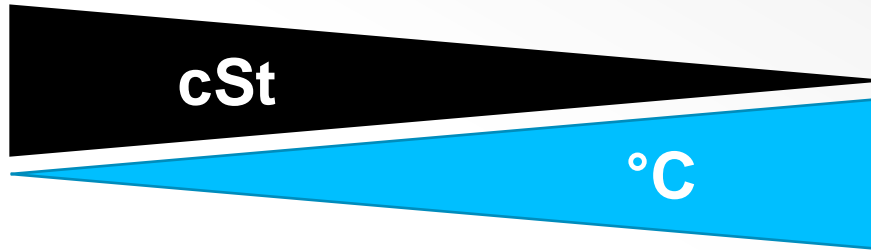


Unpredictable



Light conditions

# 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





# 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



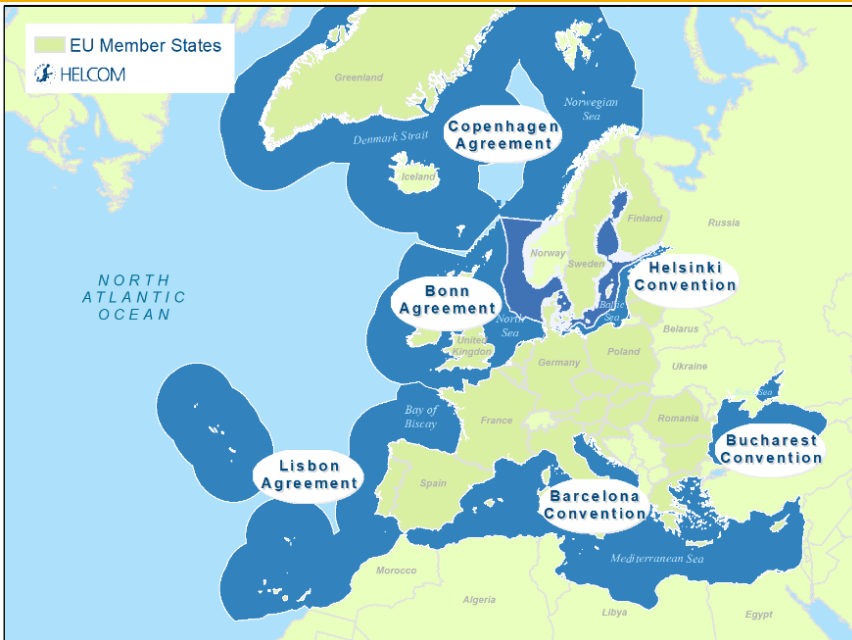
# Effects on and challenges to response: remoteness



## Challenges to practical operations

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



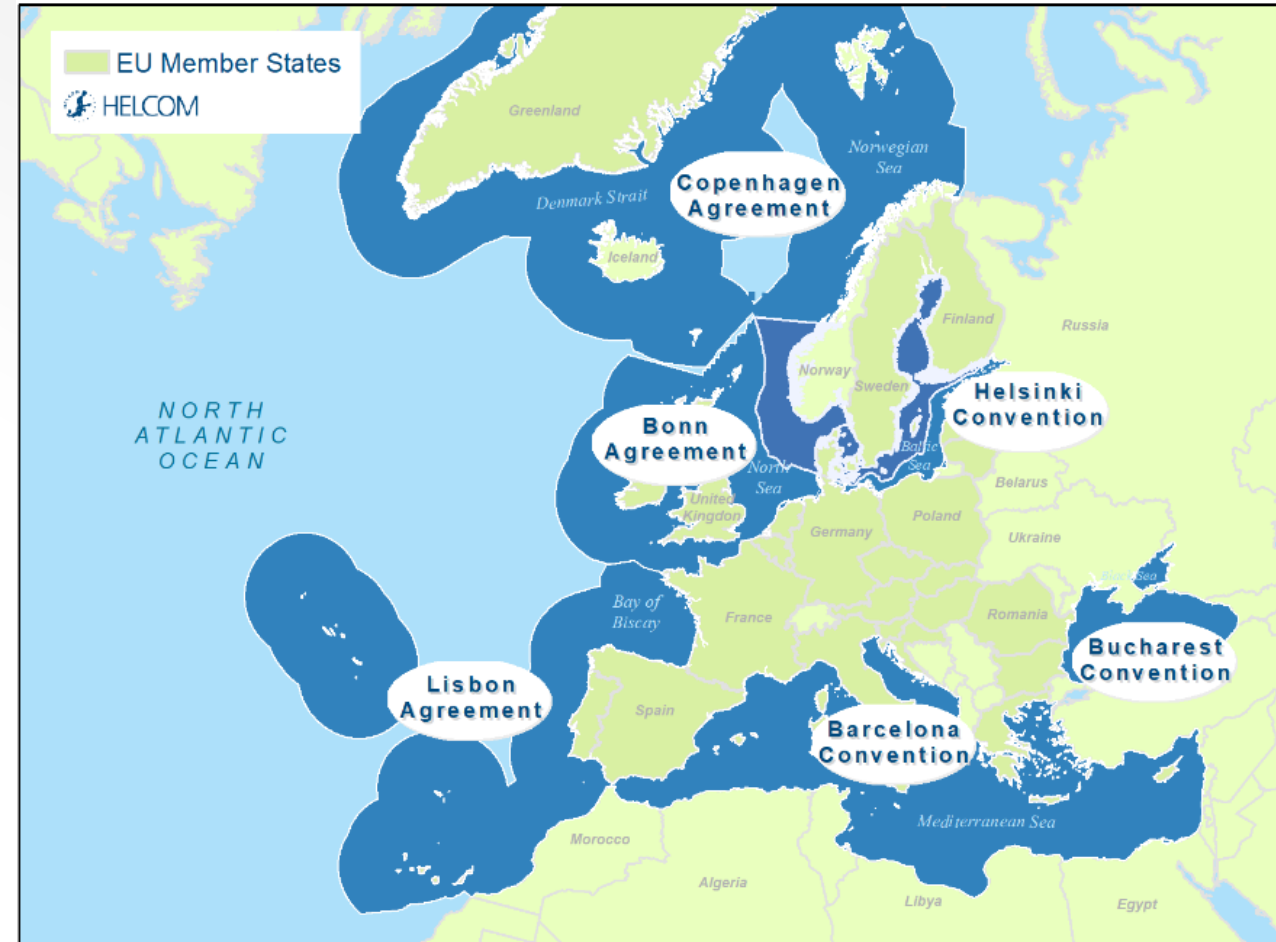


# NEED FOR POLLUTION PREPAREDNESS AND RESPONSE RISK MANAGEMENT GUIDELINES AND TOOLS



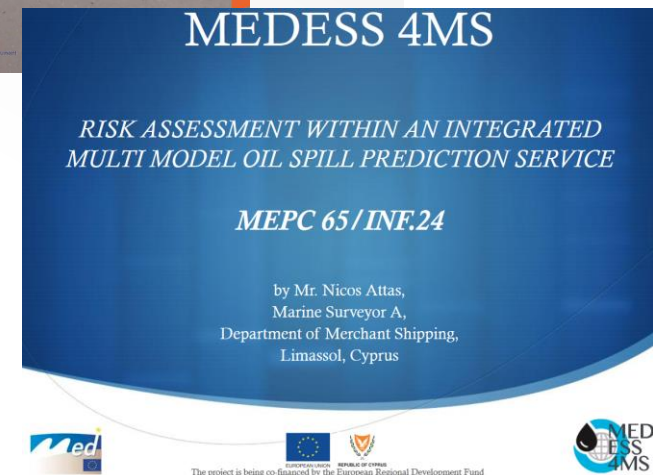
# Regional Response Agreements in Europe

- 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 provisions 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

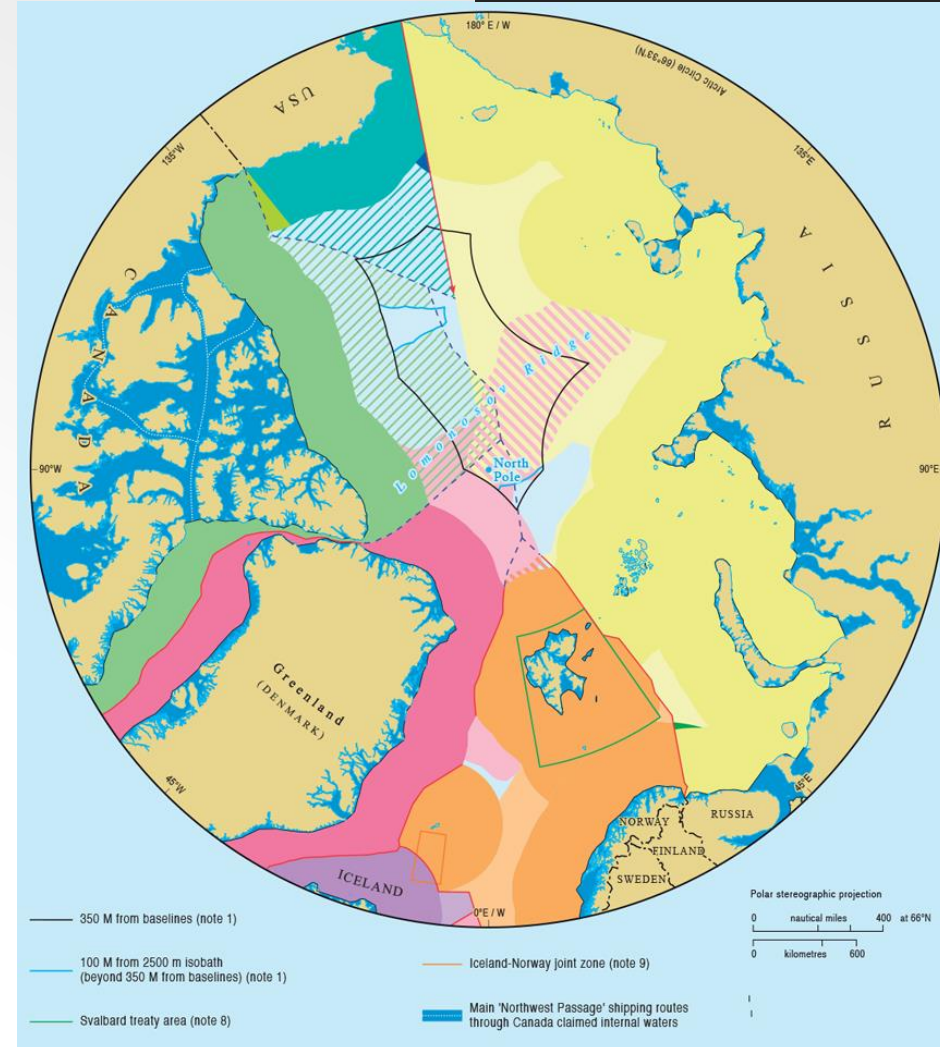


COWI

# 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



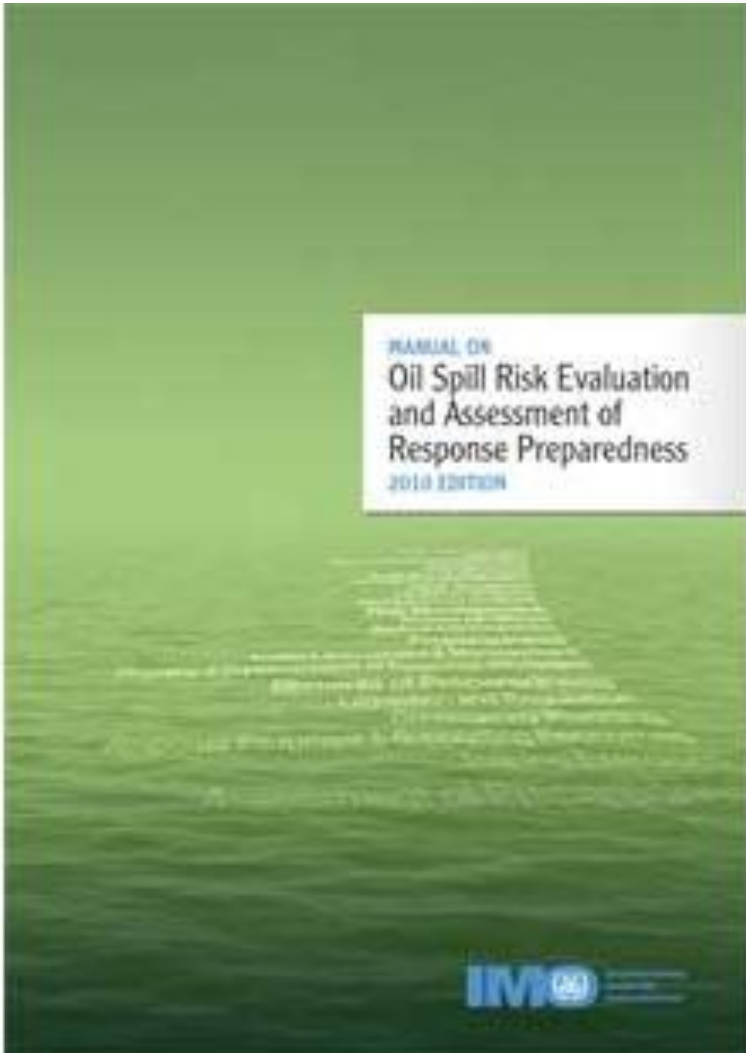




## **OPENRISK GUIDELINES FOR PPR RM**

# **OpenRisk**



# There are existing guidelines for maritime risk



  INTERNATIONAL MARITIME ORGANIZATION **E**

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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 MSC/Circ.1180  
MEPC/Circ.474  
25 August 2005  
T5/1.01

**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.



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



Co-financed by the EU – Civil Protection Financial Instrument

# 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





## 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.**

**Flexible 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

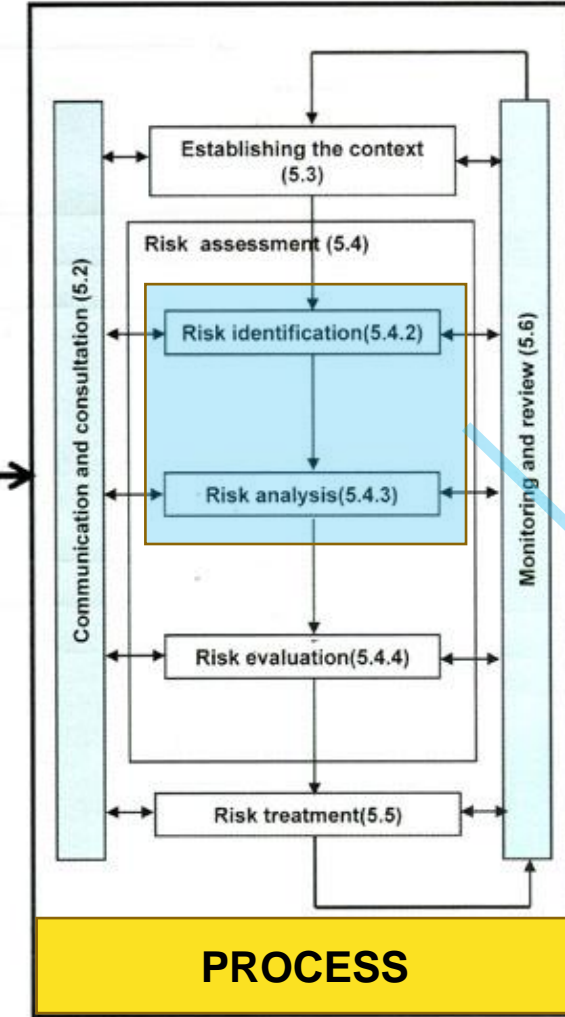
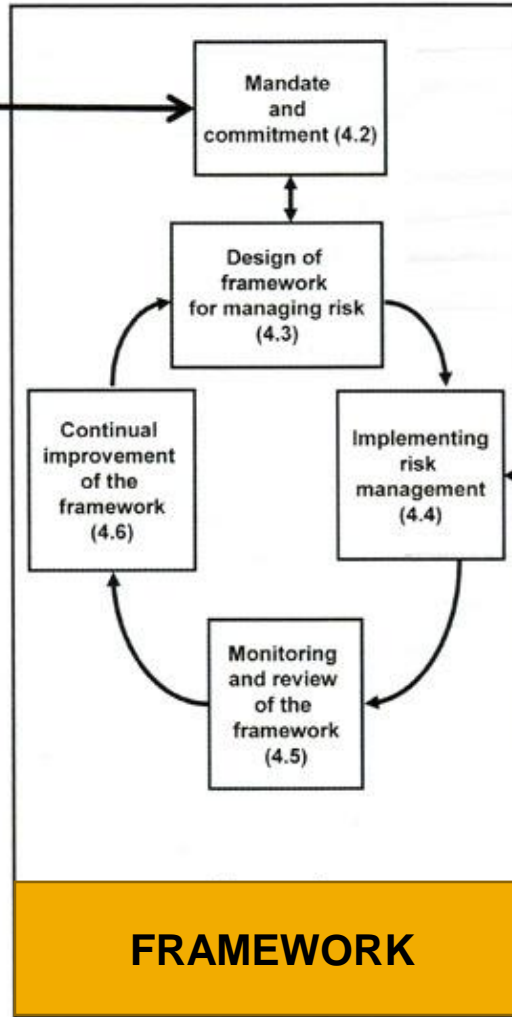
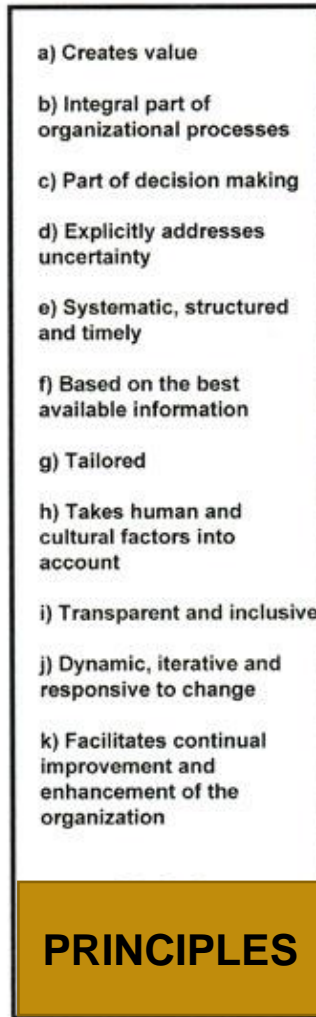
Coordinated activities to direct and control an organization with regard to risk.

- 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



**PROCESS**  
Steps to assess risk and take action

**FRAMEWORK**  
Embedding risk assessment in organization



# 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

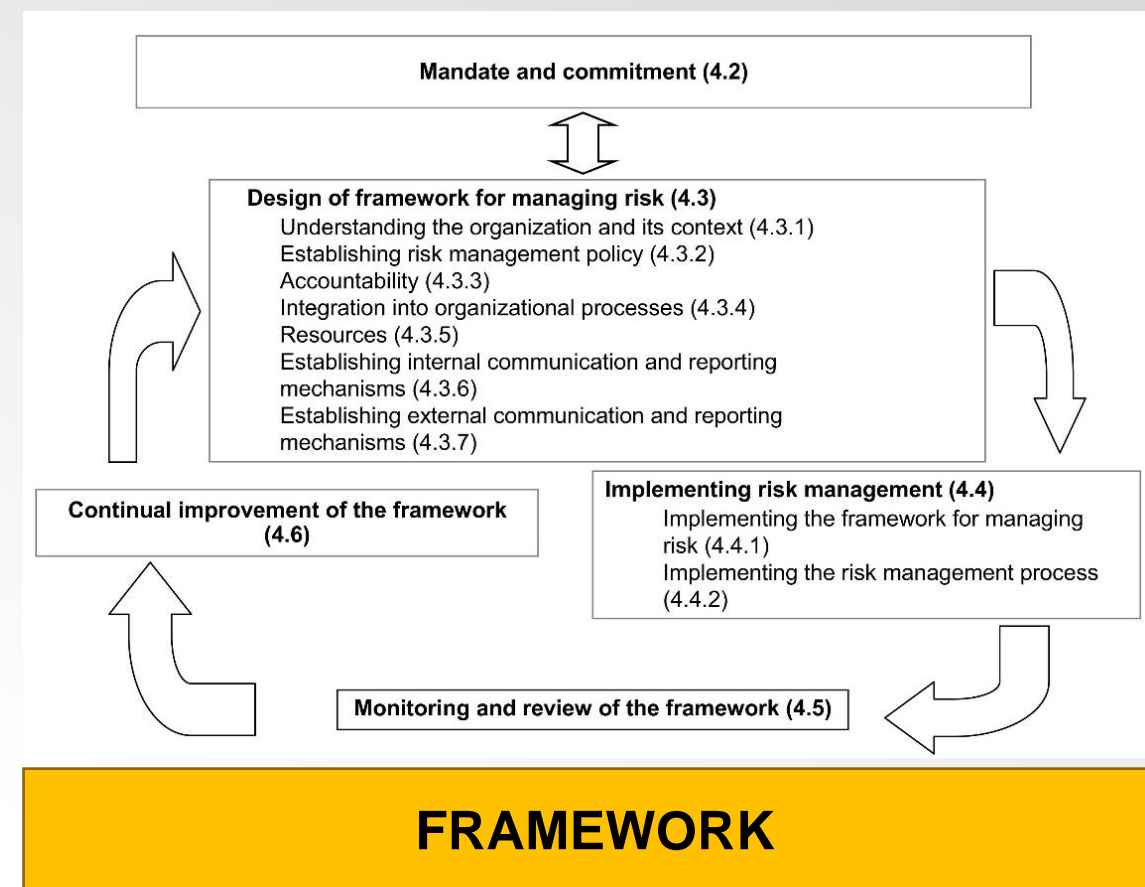
**Flexible application  
when implementing  
for PPR**

- a) Creates value
- b) Integral part of 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 and enhancement of the organization

**PRINCIPLES**

# 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).

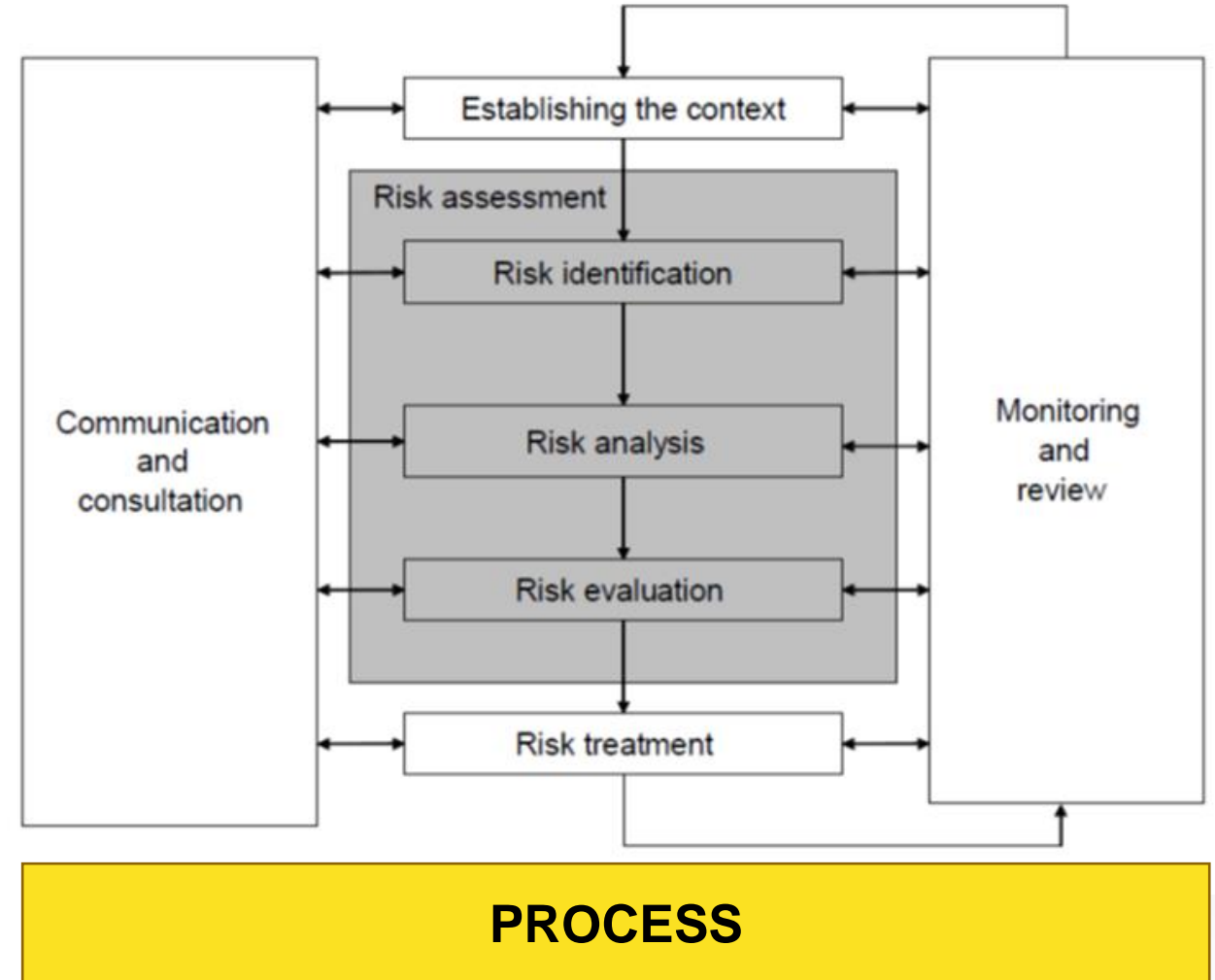


**Flexible application  
when implementing  
for PPR**

# 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

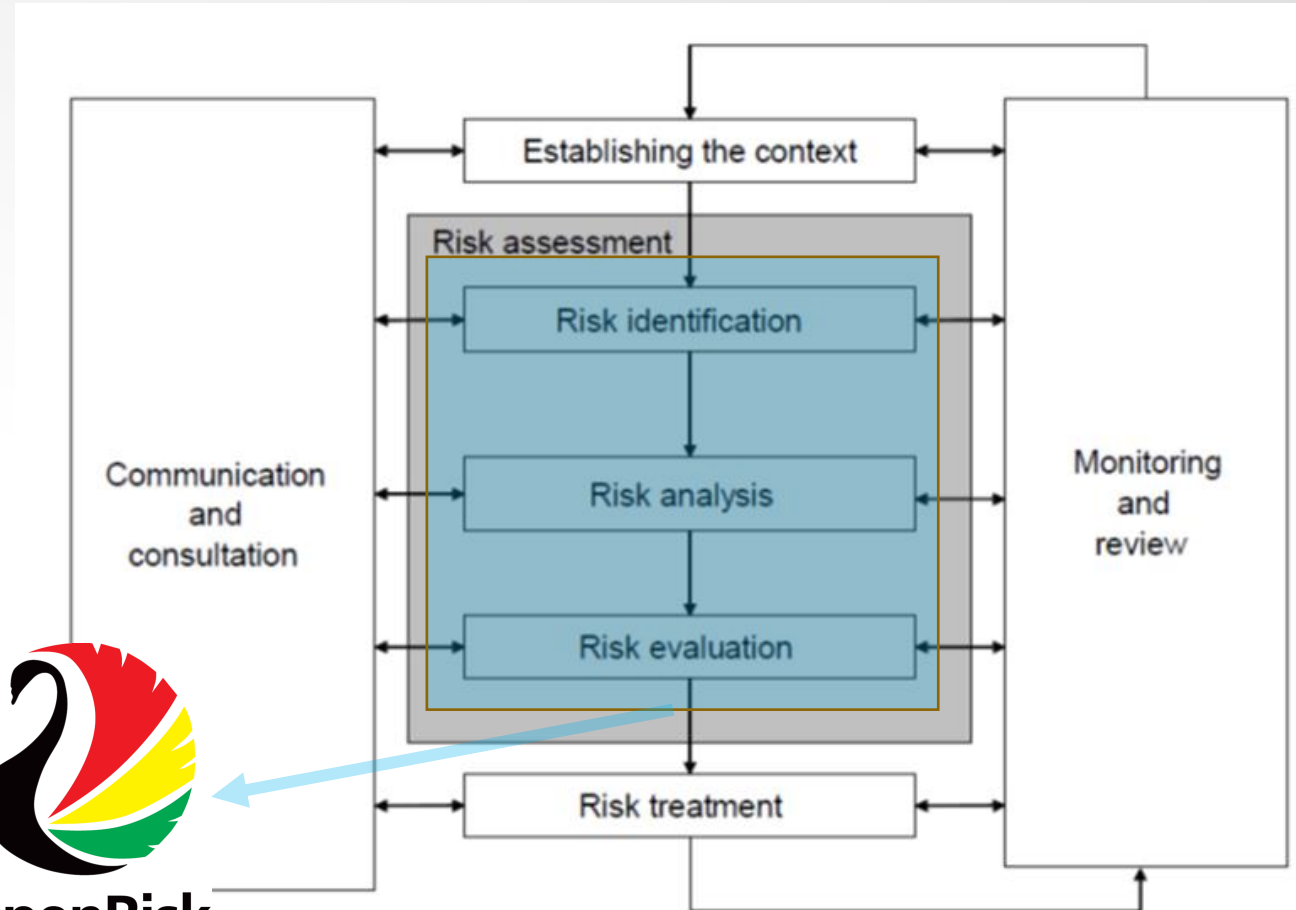
Establishes a revised vocabulary to accompany ISO 31000.

## 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**





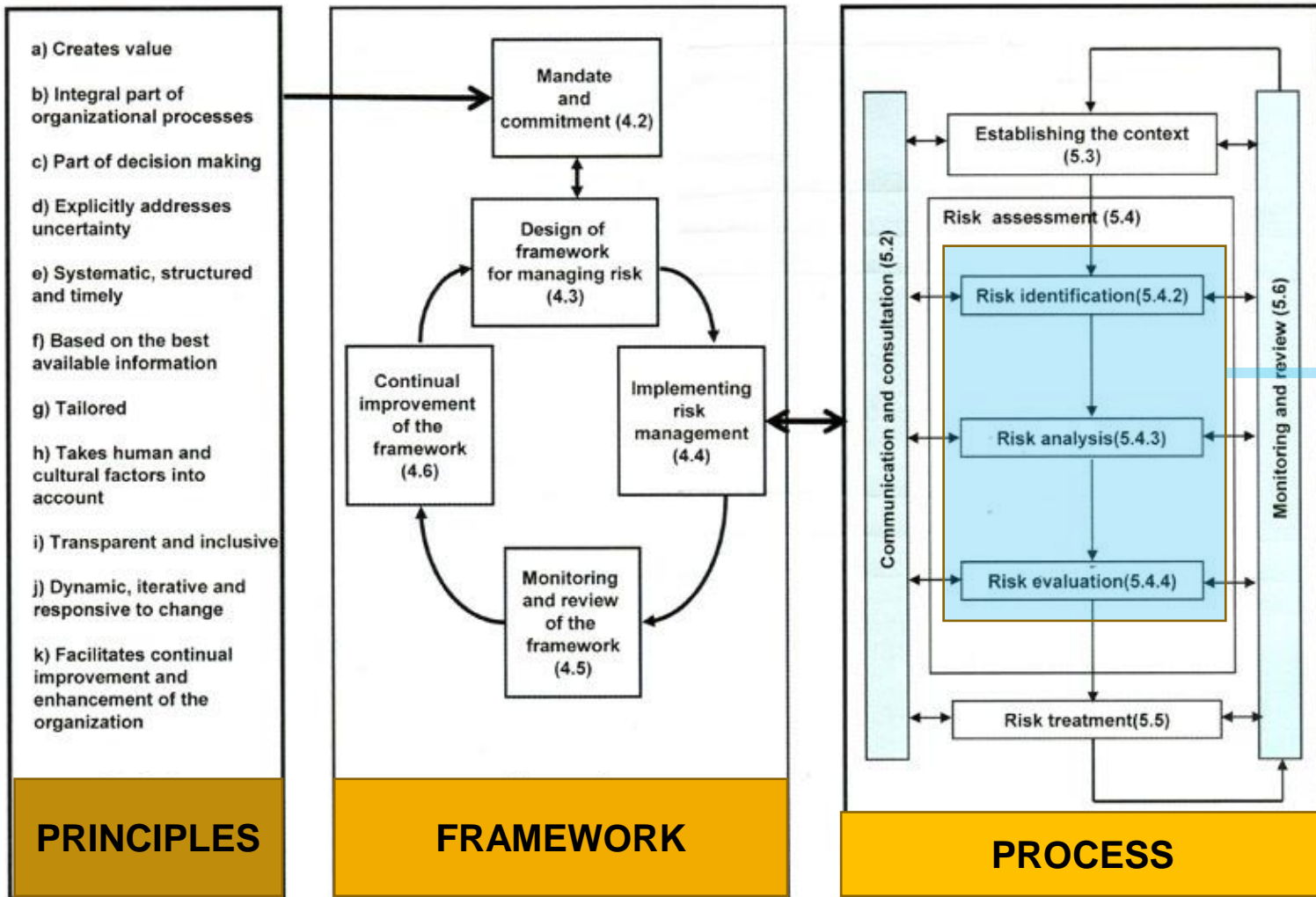
# OpenRisk

## OPENRISK OBJECTIVES IN CONTEXT OF ISO31000

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

 Co-financed by the EU – Civil Protection Financial Instrument

# Scope and focus of OpenRisk: Primary Objective

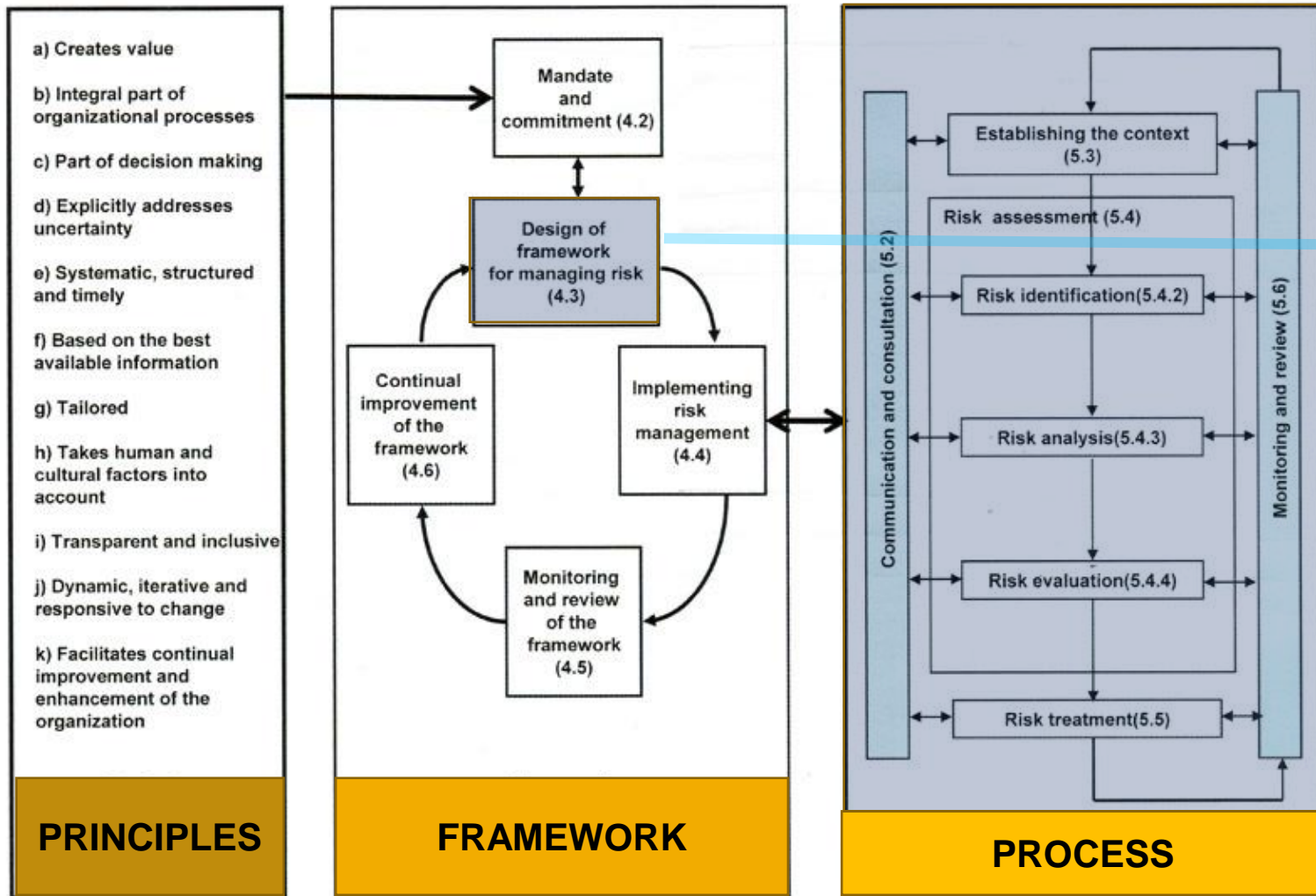


**Primary objective**

Develop a toolbox for PPR risk management



# Scope and focus of OpenRisk: Secondary Objective



## Secondary objective

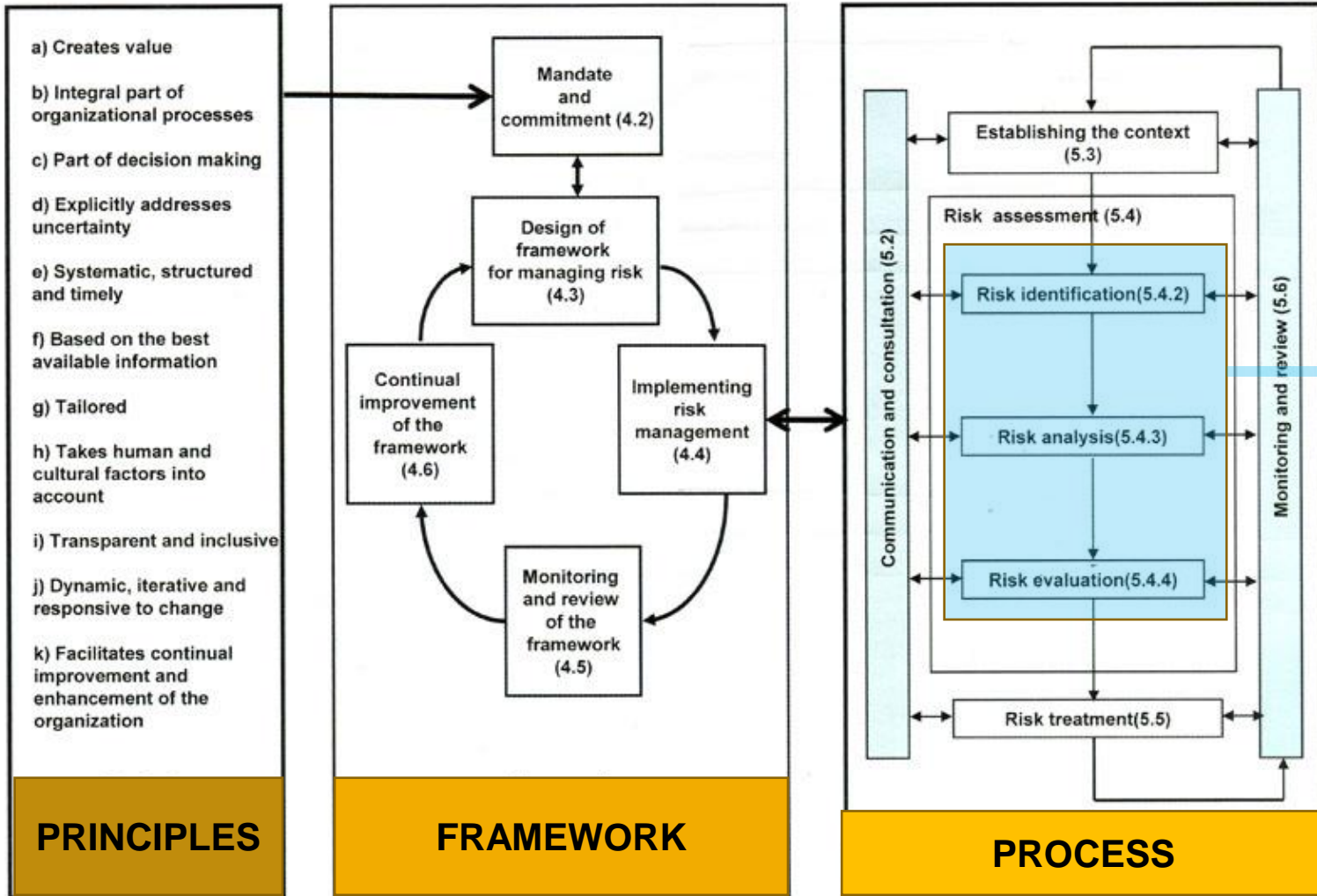
Develop an initial framework and processes for managing risk in PPR activities

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





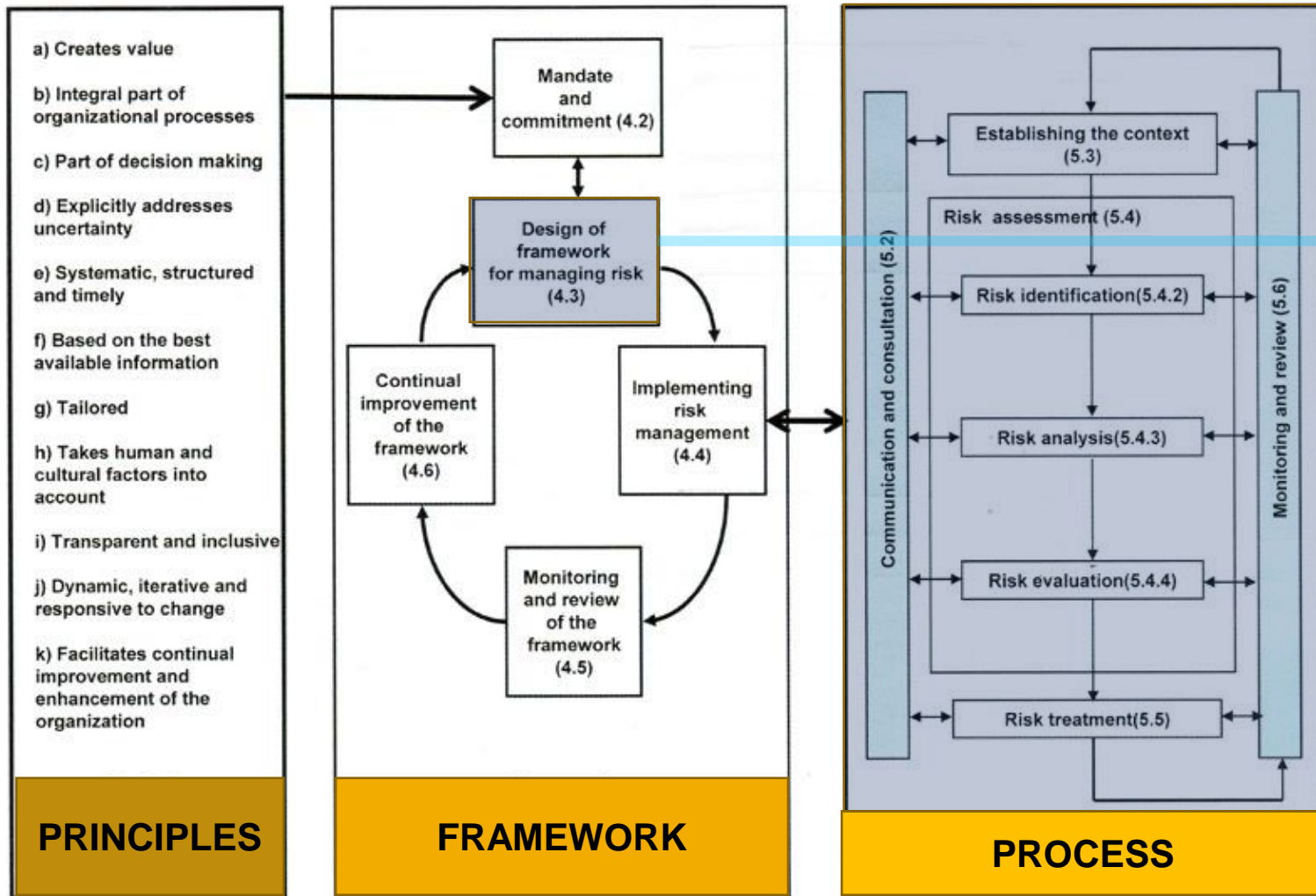
# OpenRisk

## IMPLEMENTING ISO31000 IN PPR: FRAMEWORK

OPEN-SOURCE TOOLS FOR REGIONAL RISK ASSESSMENTS TO  
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# Scope and focus of OpenRisk: Secondary Objective



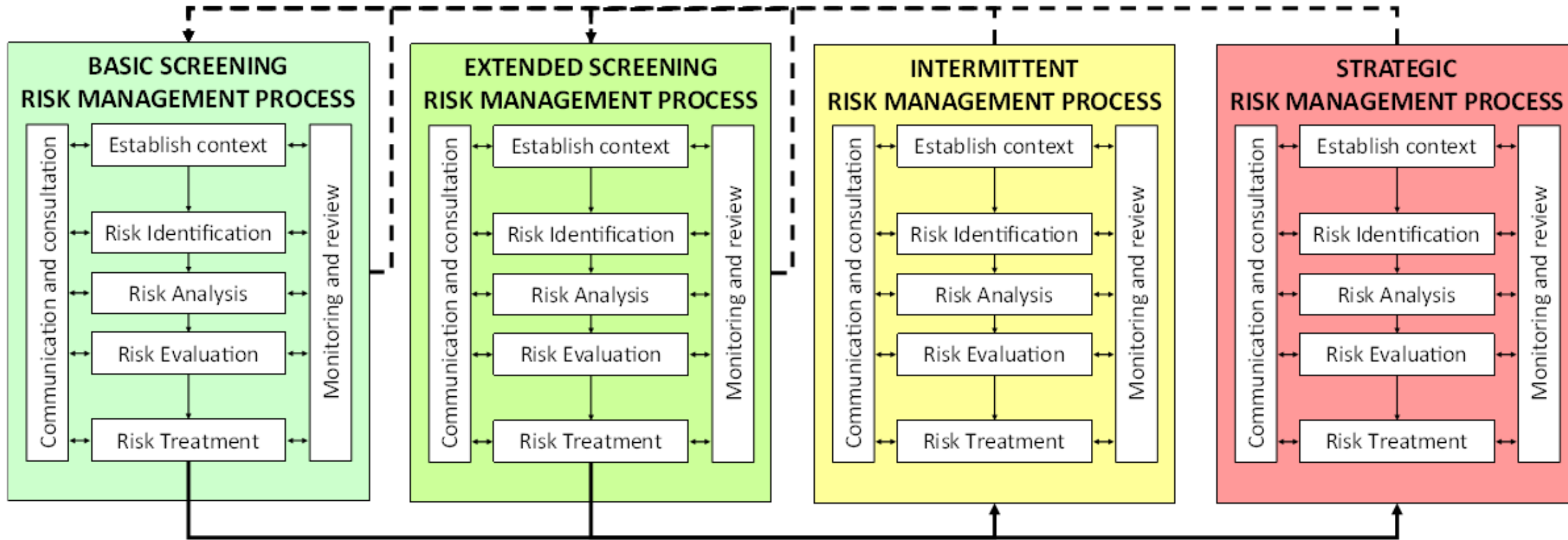
## Secondary objective

Develop an initial 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 TOOLBOX FOR PPR RM

# OpenRisk

# Implementing ISO31000 in PPR

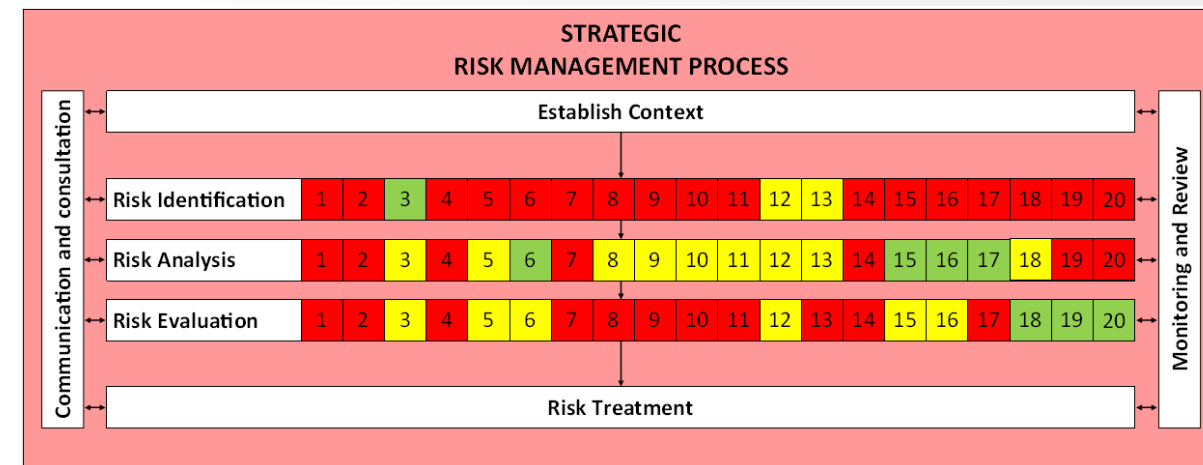
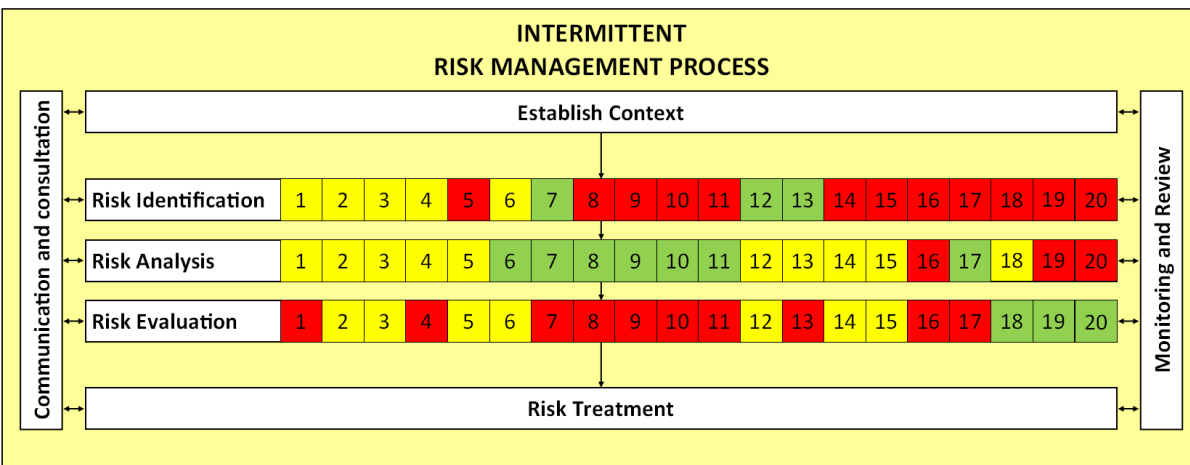
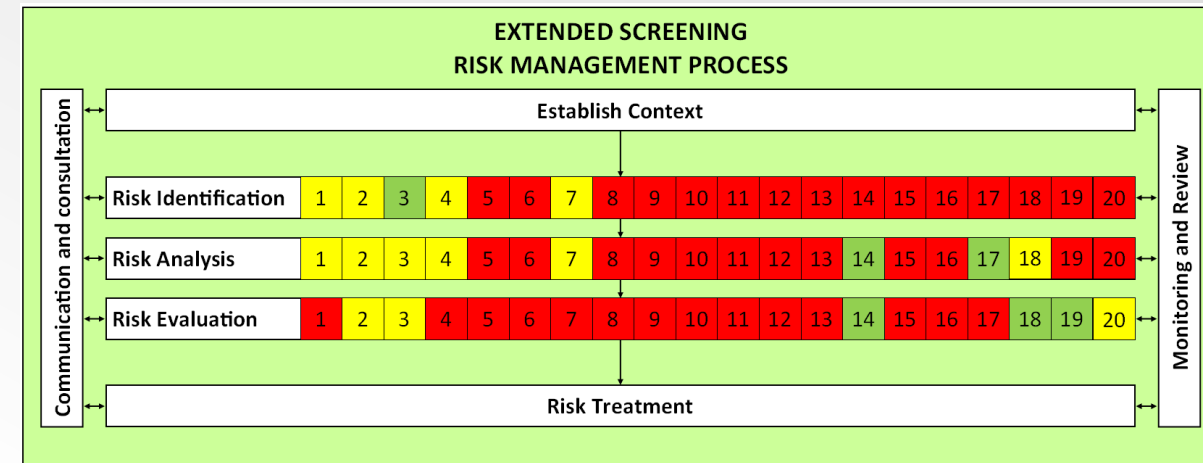
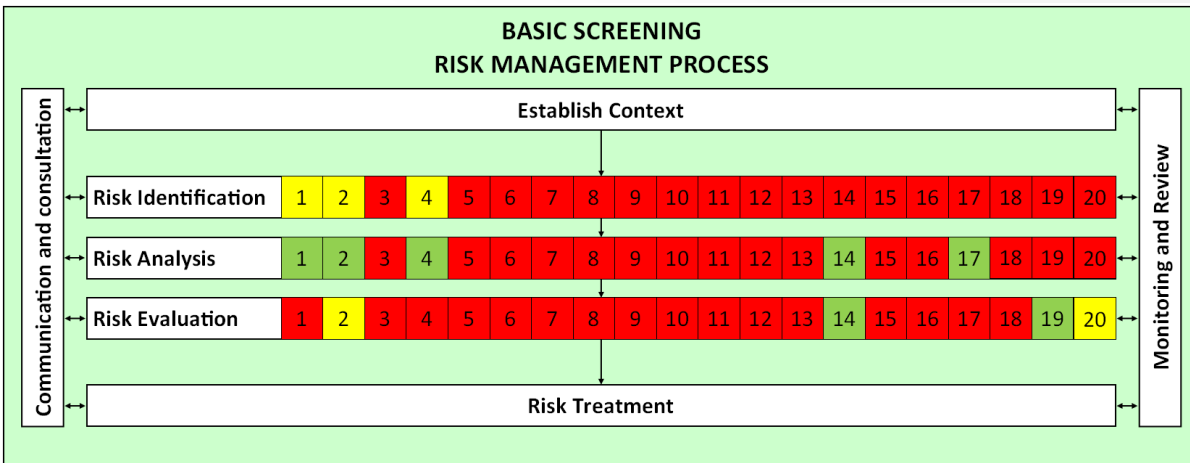
## Risk management questions relevant to PPR

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 Name Risk management questions	KystRisk KystRisk <ul style="list-style-type: none"> <li>• Where are the historic accident risks in the sea area?</li> <li>• How do the risks develop over time?</li> </ul>
2	ID Name Risk management questions	MarinRisk MarinRisk <ul style="list-style-type: none"> <li>• Where are the historic accident risks in the sea area?</li> <li>• How do the risks develop over time?</li> </ul>
3	ID Name Risk management questions	Delphi Delphi Method <ul style="list-style-type: none"> <li>• What kinds of future hazards should be considered?</li> <li>• What are the associated risk levels?</li> </ul>

# OpenRisk Toolbox:

## Specific tools for different risk management questions

ID	Tool
4	<p><b>ID</b> RiskData Hub</p> <p><b>Name</b> RiskData Hub</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"> <li>• Where are the historic accident risks in the sea area?</li> <li>• How do the risks develop over time?</li> </ul>
5	<p><b>ID</b> IWRAP Mk II</p> <p><b>Name</b> IALA Waterway Risk Assessment Programme</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"> <li>• What is the accident likelihood in different sea areas?</li> <li>• What accident scenarios are likely?</li> <li>• What is the effect of different risk control options on the risk level?</li> </ul>
6	<p><b>ID</b> PAWSA</p> <p><b>Name</b> Ports and Waterways Safety Assessment</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"> <li>• How important are different waterway factors as contributors to risk?</li> <li>• What is the effect of risk control options on the risk level?</li> </ul>

# OpenRisk Toolbox:

## Specific tools for different risk management questions

ID	Tool
7	<p><b>ID</b> ERC-M</p> <p><b>Name</b> Maritime Event Risk Classification Method</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"> <li>• What kinds of hazards occur in the sea area?</li> <li>• What is the risk level in different sea areas?</li> <li>• What accident scenarios are likely?</li> <li>• Which issues are contributing factors to the event occurrence?</li> </ul>
8	<p><b>ID</b> ADSAM-C/G</p> <p><b>Name</b> Accidental Damage and Spill Assessment Model for Collision &amp; Accidental Damage and Spill Assessment Model for Grounding</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"> <li>• What size of oil spills can occur in a collision or grounding accident?</li> </ul>
9	<p><b>ID</b> SeaTrack Web</p> <p><b>Name</b> SeaTrack Web</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"> <li>• Where does the oil drift to in the sea area?</li> </ul>

# OpenRisk Toolbox:

## Specific tools for different risk management questions

ID	Tool
10	<p><b>ID</b> NG-SRW</p> <p><b>Name</b> Next Generation SmartResponse Web</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"> <li>• What size of oil spills can occur in a collision or grounding accident?</li> <li>• Where does the oil drift to in the sea area?</li> <li>• What are the consequences to the ecosystem and human use of marine space?</li> </ul>
11	<p><b>ID</b> ERSP Calculator, EBSP Calculator, and EDSP Calculator</p> <p><b>Name</b> Response System Planning Calculators</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"> <li>• What is the potential of the response system to recover, burn, or disperse the spilled oil?</li> </ul>
12	<p><b>ID</b> BowTie</p> <p><b>Name</b> BowTie Method</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"> <li>• Which factors contribute to the event occurrence and/or its consequences?</li> <li>• What is the effectiveness of different controls to mitigate risks?</li> </ul>

# OpenRisk Toolbox:

## Specific tools for different risk management questions

ID	Tool
13	<p><b>ID</b> FRAM</p> <p><b>Name</b> Functional Resonance Analysis Method</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"> <li>• Which system functions are responsible for the variation in the system performance?</li> </ul>
14	<p><b>ID</b> KPIs</p> <p><b>Name</b> Key Performance Indicators</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"> <li>• How important are different system indicators in regards event occurrence and/or consequences?</li> <li>• What is the performance of different system elements compared to target levels?</li> </ul>
15	<p><b>ID</b> SBOSRT</p> <p><b>Name</b> Spatial Bayesian Oil Spill Risk Tool</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"> <li>• What are the oil spill risks in the sea area?</li> <li>• What is the extent of ecological damage in different oil spill risk scenarios?</li> </ul>



# OpenRisk Toolbox:

## Specific tools for different risk management questions

ID	Tool
16	<p><b>ID</b> ISRAM</p> <p><b>Name</b> Integrated Strategic Risk Analysis Methods</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"> <li>• What are the oil spill risks in the sea area?</li> <li>• What size of spills can occur?</li> <li>• Where does the oil spill drift to in the sea area?</li> <li>• What are the consequences to the ecosystem and human use of marine space?</li> <li>• What is the effect of different risk control options on the risk level?</li> </ul>
17	<p><b>ID</b> SoE</p> <p><b>Name</b> Strength of Evidence Assessment Schemes</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"> <li>• How much can the results of the risk analysis be relied on?</li> <li>• How much evidence is there for the elements in the risk analysis?</li> </ul>

# OpenRisk Toolbox:

## Specific tools for different risk management questions

ID	Tool
18	<p><b>ID</b> RM-PCDS</p> <p><b>Name</b> Risk Matrices and Probability-Consequence Diagrams</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"><li>• How do risks compare to one another in the different dimensions of risk?</li></ul>
19	<p><b>ID</b> ALARP</p> <p><b>Name</b> As Low as Reasonably Practicable Principle</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"><li>• Are the risks acceptable?</li><li>• Should further risk control options be implemented?</li></ul>
20	<p><b>ID</b> CBA</p> <p><b>Name</b> Cost-Benefit Analysis</p> <p><b>Risk management questions</b></p> <ul style="list-style-type: none"><li>• How cost-effective are different risk control options?</li></ul>

# 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



**Applicability for different risk management processes:**

Basic screening  Extended screening   
 Intermittent  Strategic

**Applicability for different risk assessment stages:**

Risk identification

↓

Risk analysis

Consequence	Likelihood	Strength of evidence
Risk		

↓

Risk evaluation

**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.

# 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

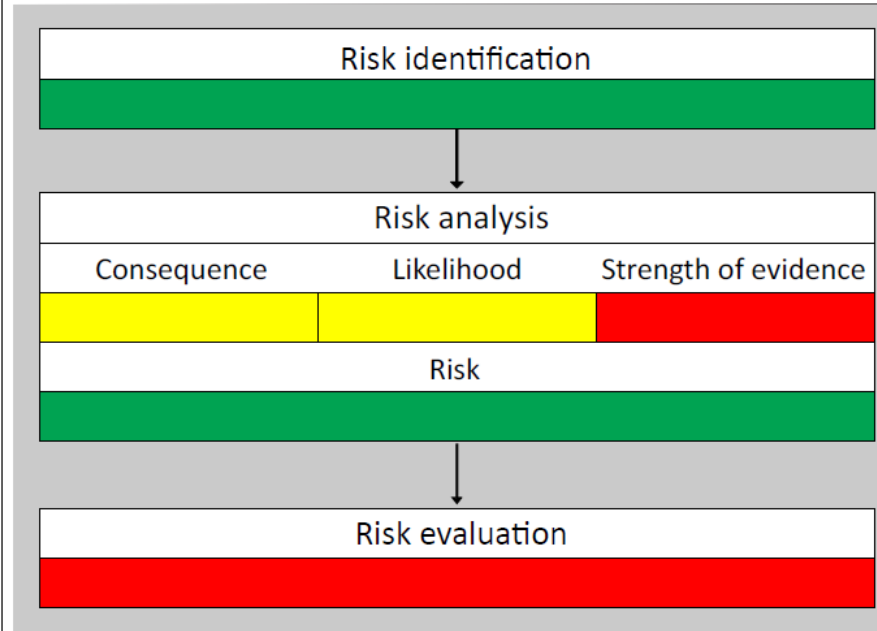
Resources needed  Medium  Skills required  Medium



### Applicability for different risk management processes:

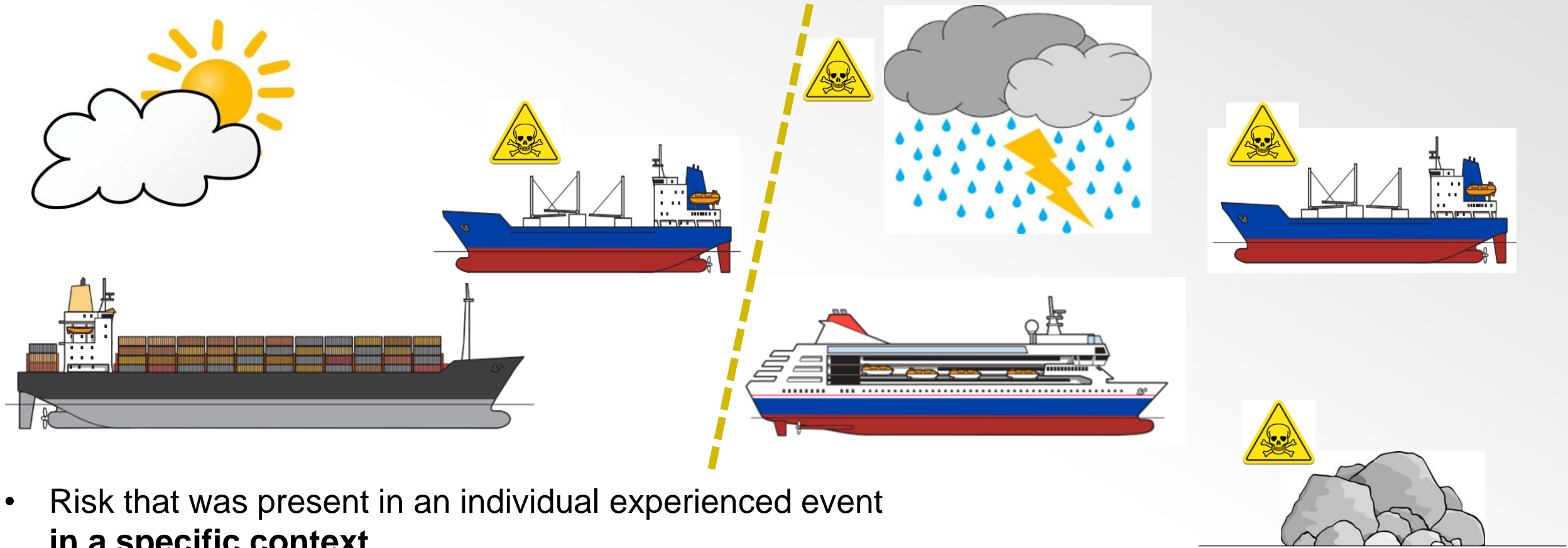
Basic screening  Extended screening   
 Intermittent  Strategic

### Applicability for different risk assessment stages:



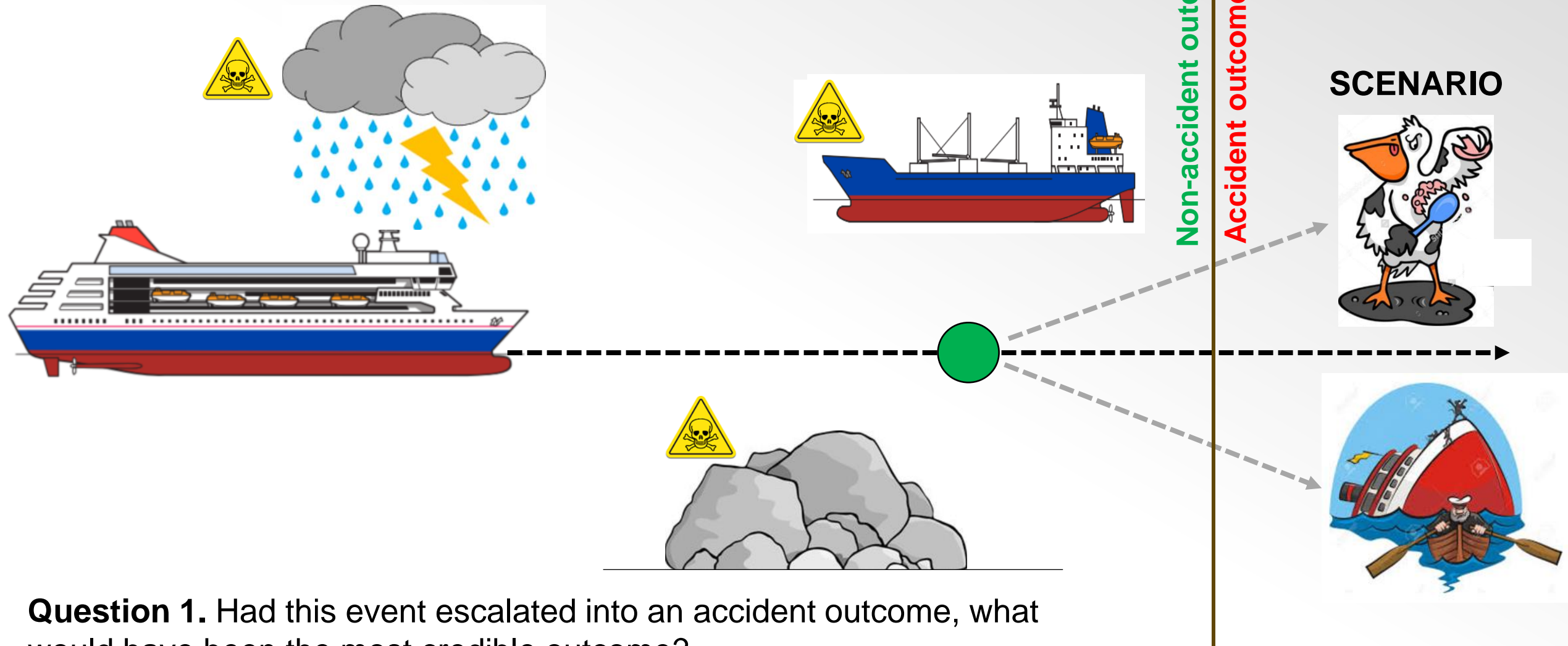
**Notes:** Strongly applicable =  Applicable =  Not applicable =

# 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

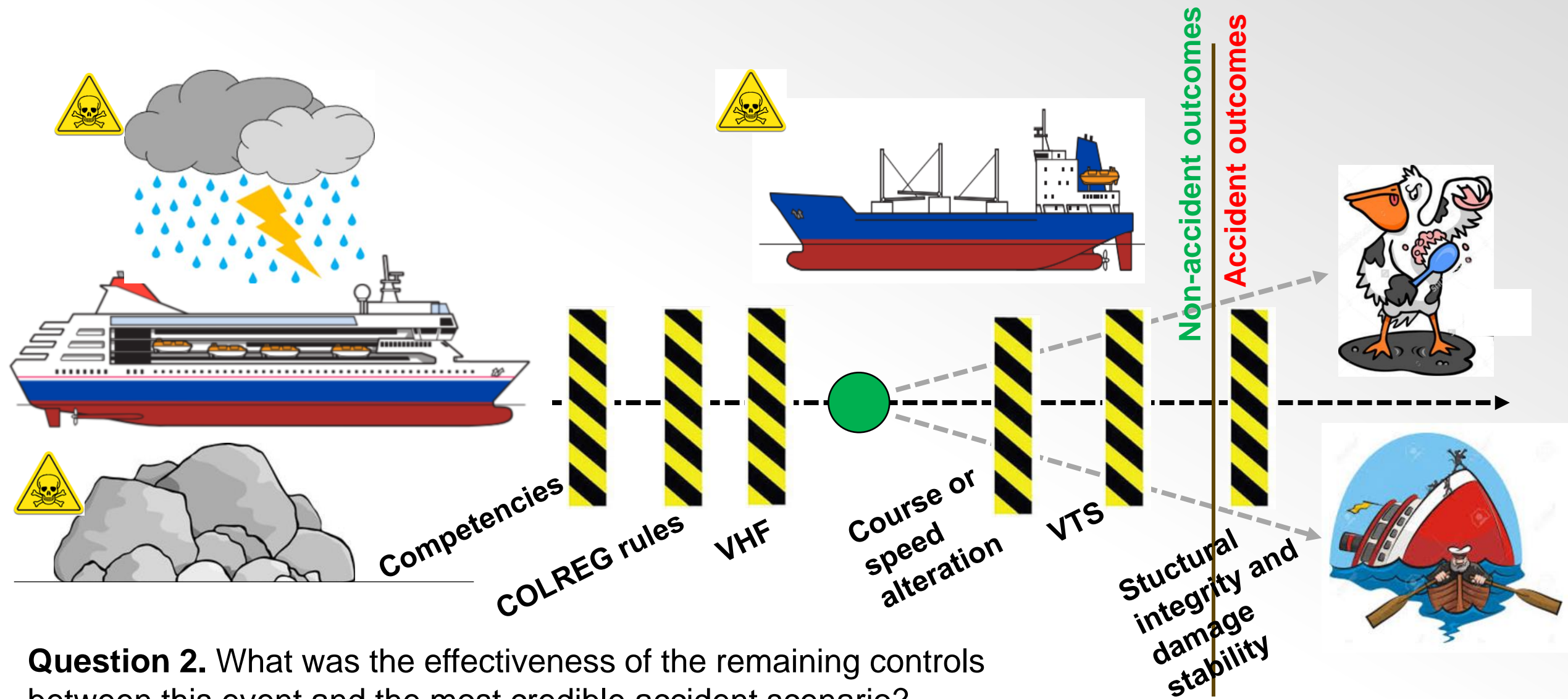
# Maritime Application of the ERC



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



# Maritime Application of the ERC



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

# 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 Category	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	Sevvere 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 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.

# 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 occurred to passenger or cargo ships with several casualties.
10	21	101	500	1 - 4	Accidents that have occurred small cargo ships, fishing 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 occurred during a grounding, 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 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.

# ERC-M Event Risk Classification Matrix

## Economic losses

Effective	Limited	Minimal	Not effective	Category of consequences	Typical insurance claims and examples
250	503	2 503	12 500	Catastrophic	Hull & Machinery up to 750 000 000 € or P&I up to 100 000 000 € Examples: Costa Concordia, Prestige and Erika
50	102	502	2 500	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
10	21	101	500	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 environmental damages
2	4	20	100	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.
1				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 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.

# 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			

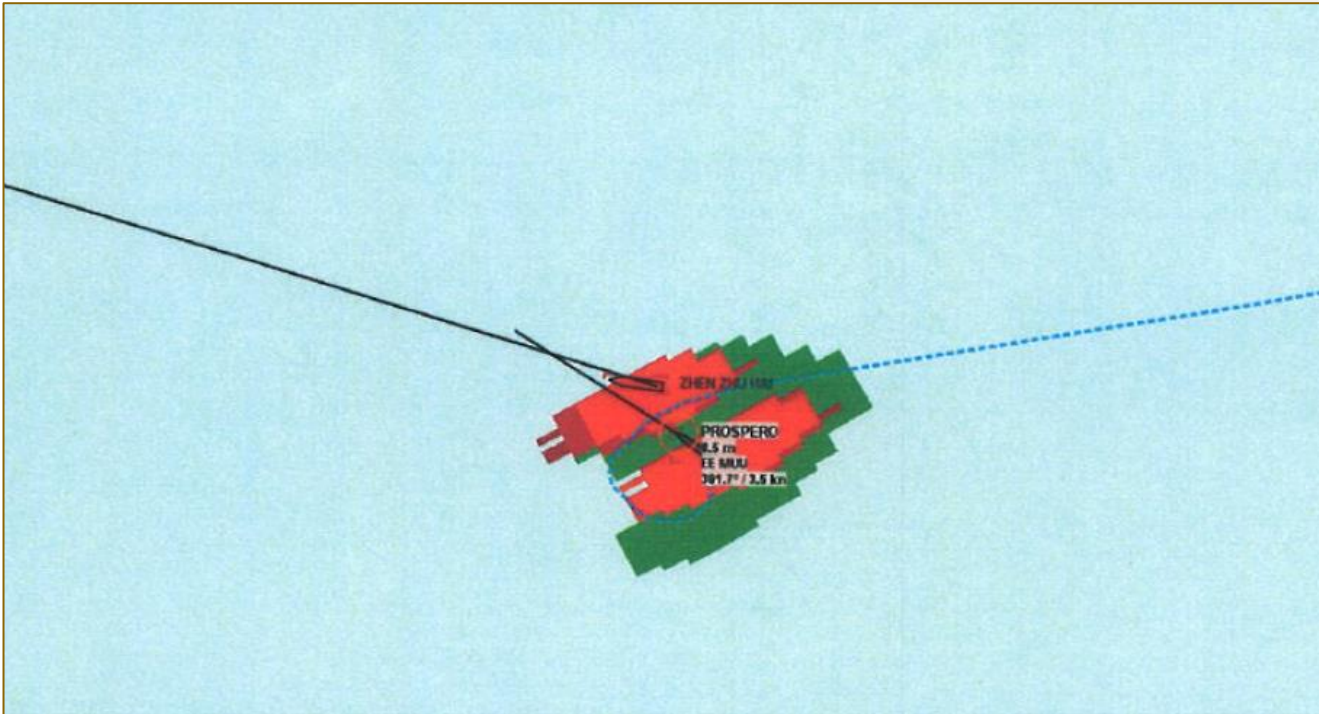
## Economical Losses

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			

## 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			

# 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			

## Economical 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			

## 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			

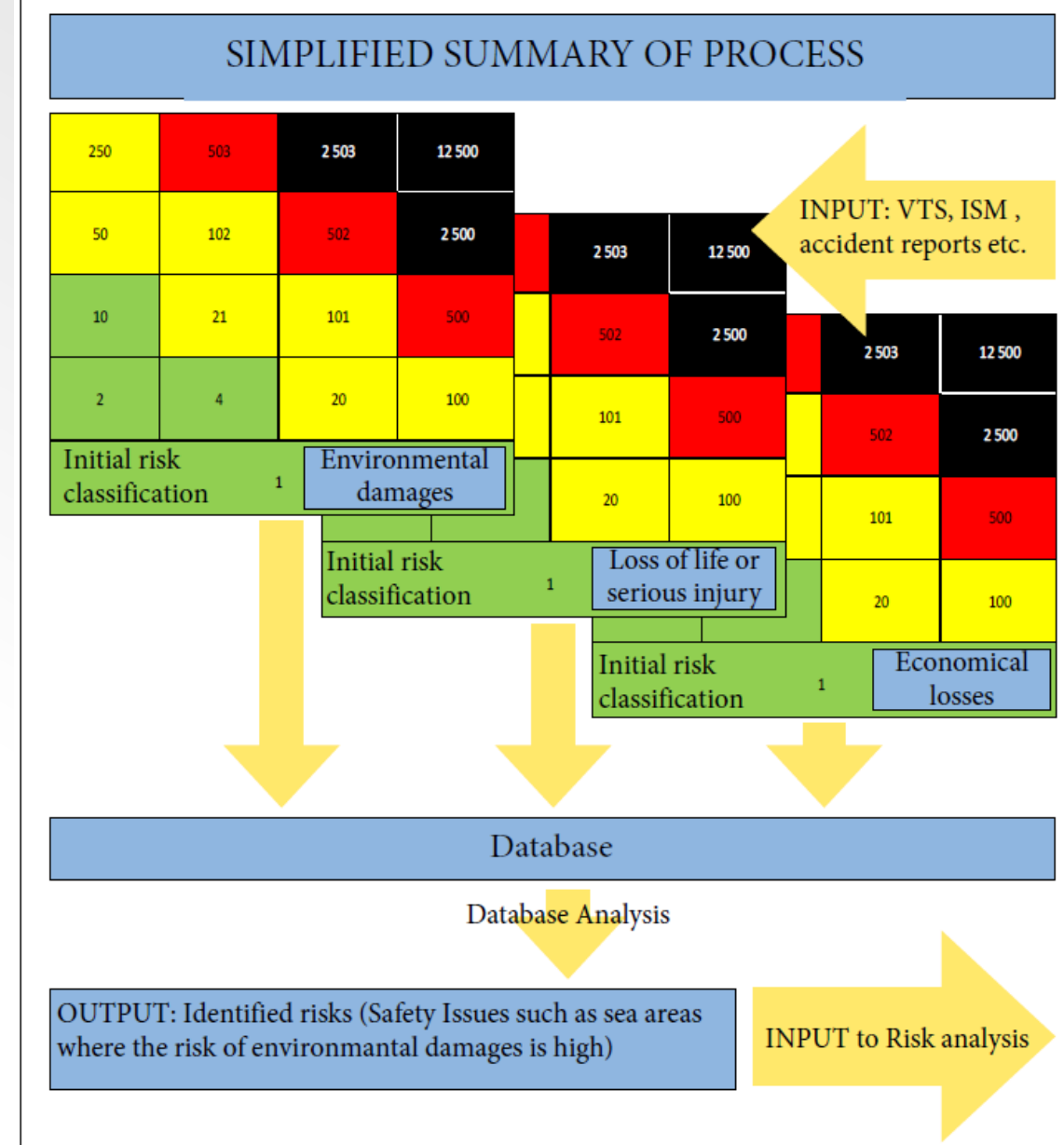
# Process

## Data Collection

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

## Structured Database

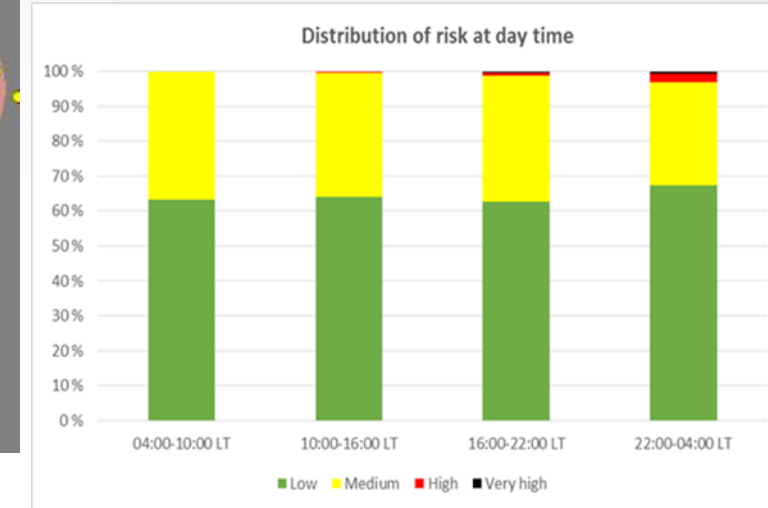
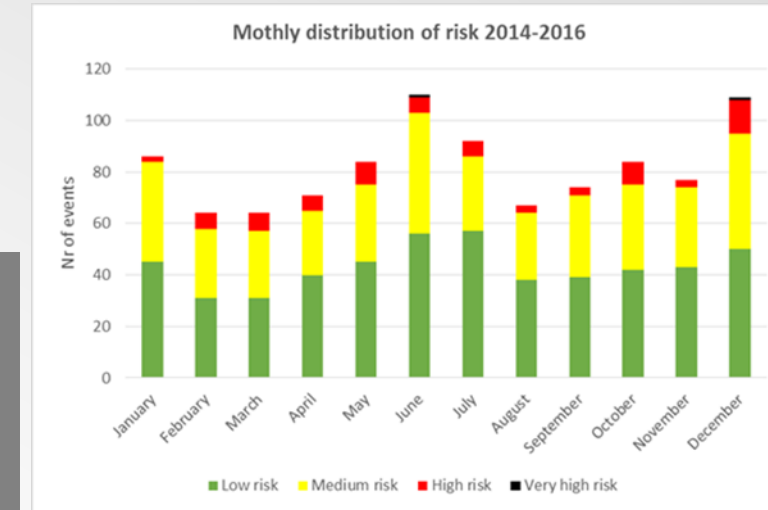
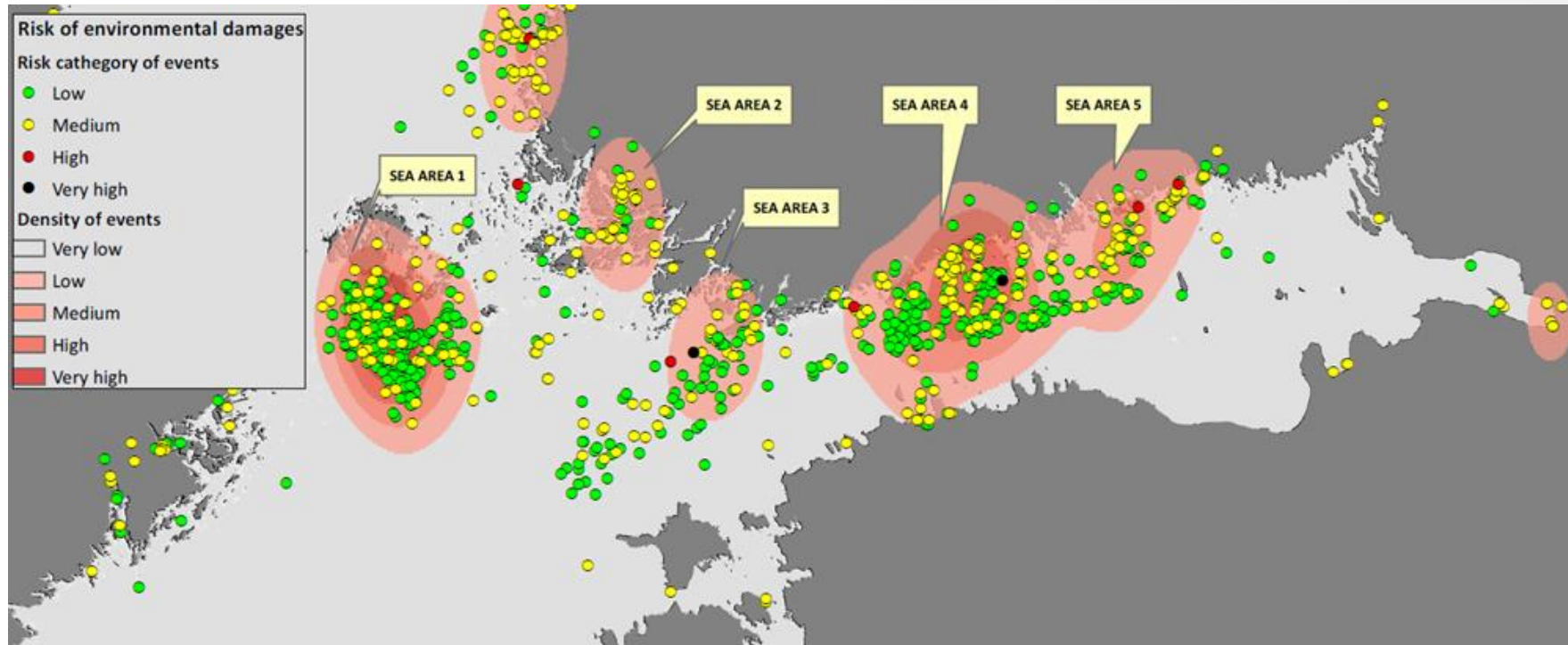
- Date
- Location
- Weather conditions
- IMO number
- Accident type  
(grounding/collision/contact/fire/...)



# Examples

## Finnish Gulf of Finland and Archipelago Sea

**Questions:** Where are accidents likely to occur? When?



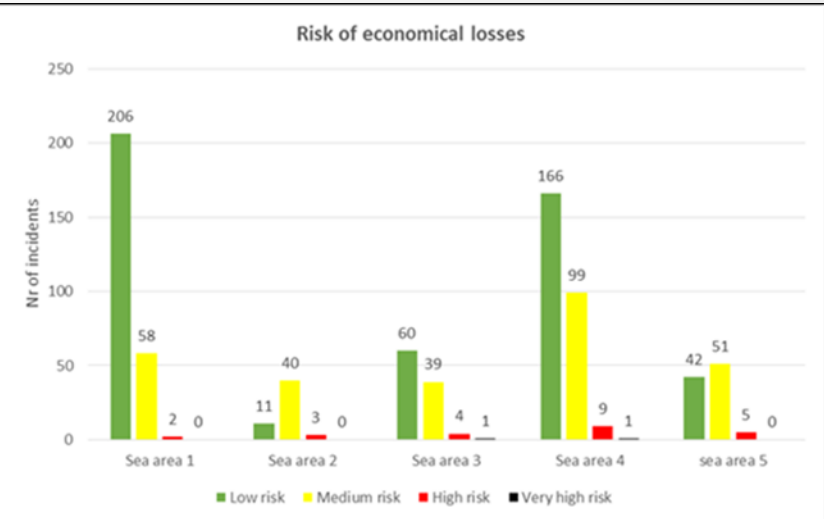
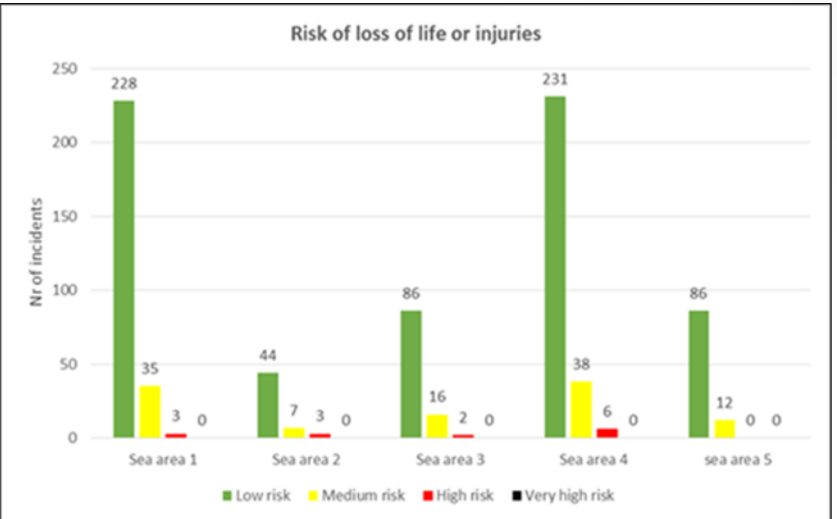
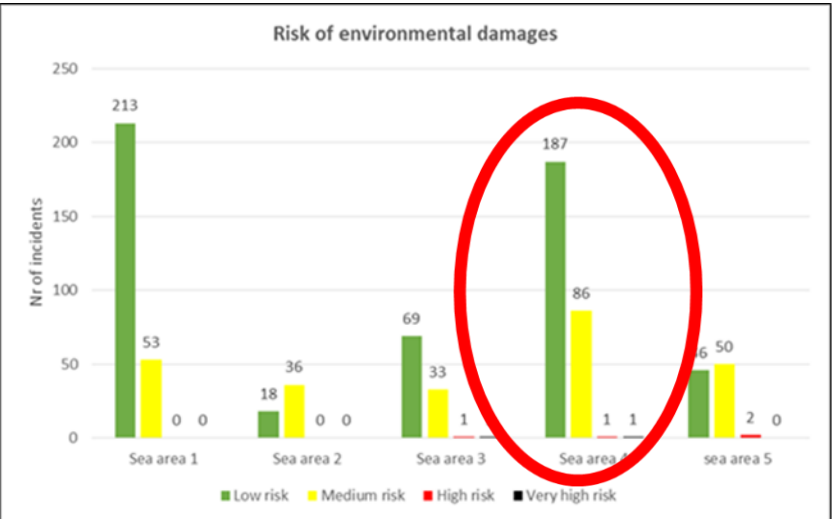
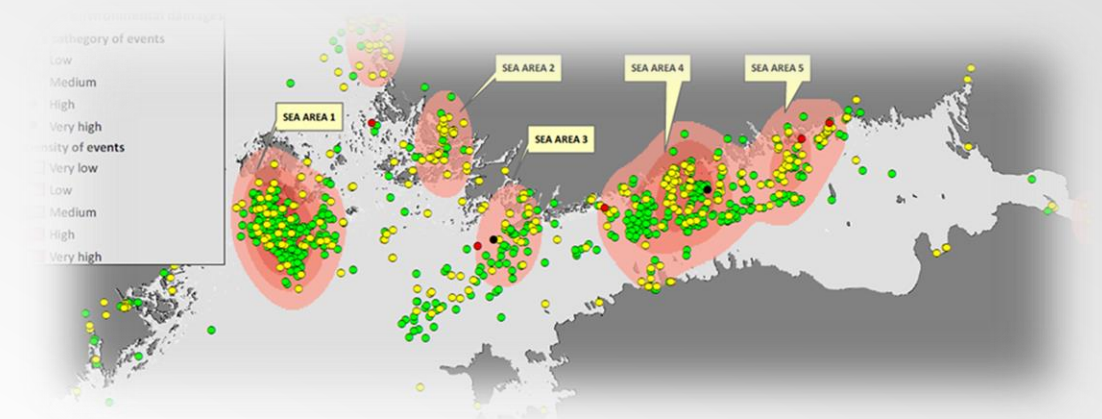
The events in the Gulf of Finland from 2014 to 2016 (N=983).



# Examples

## Finnish Gulf of Finland and Archipelago Sea

Question: What are the priority areas?



# Examples

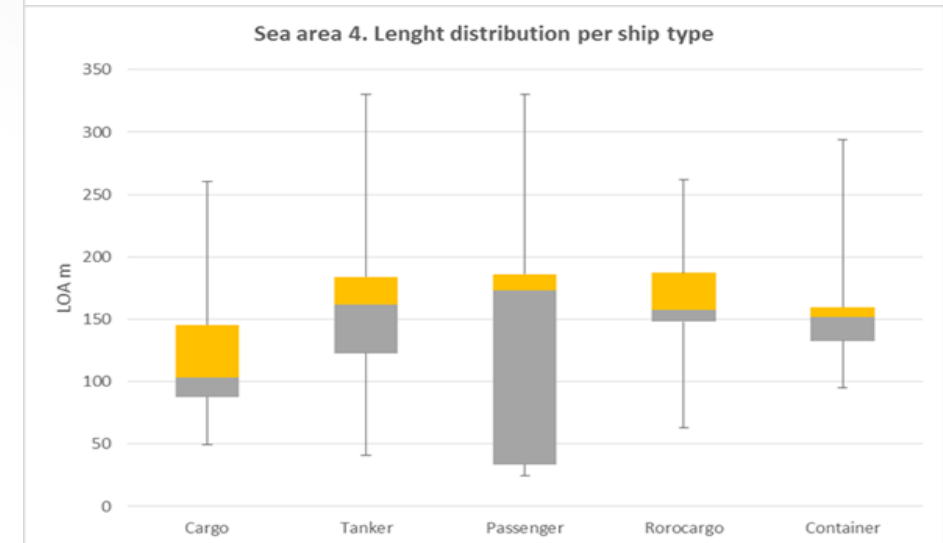
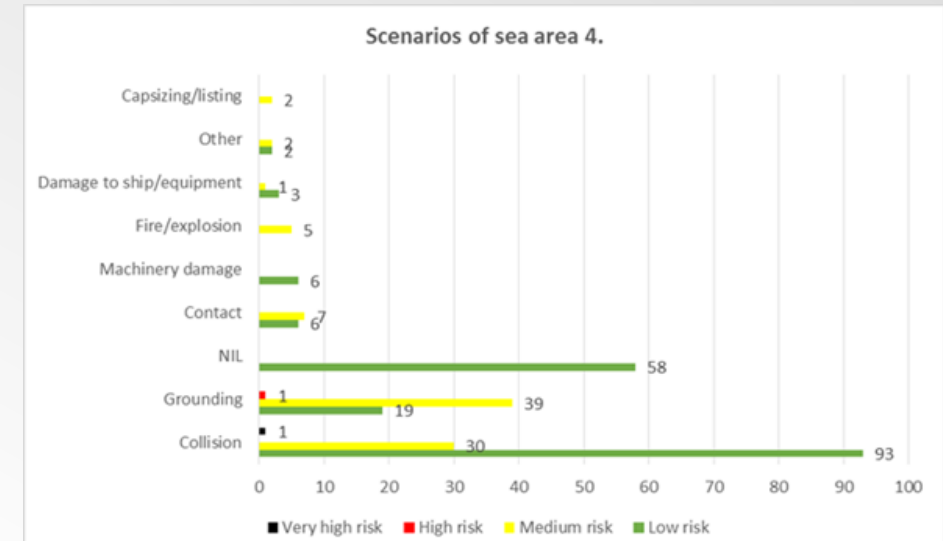
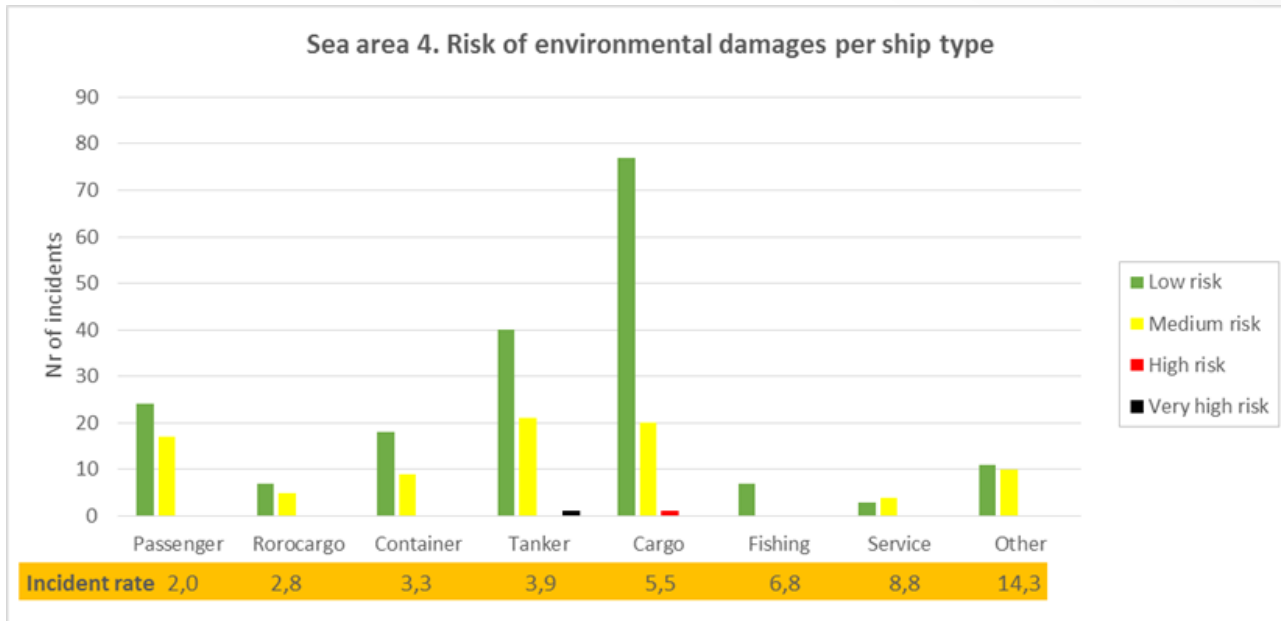
## Finnish Gulf of Finland and Archipelago Sea

### Questions:

What are dominant ship types for ecological impacts?

What are dominant accident / incident types?

What ship sizes are involved?





# OpenRisk

**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

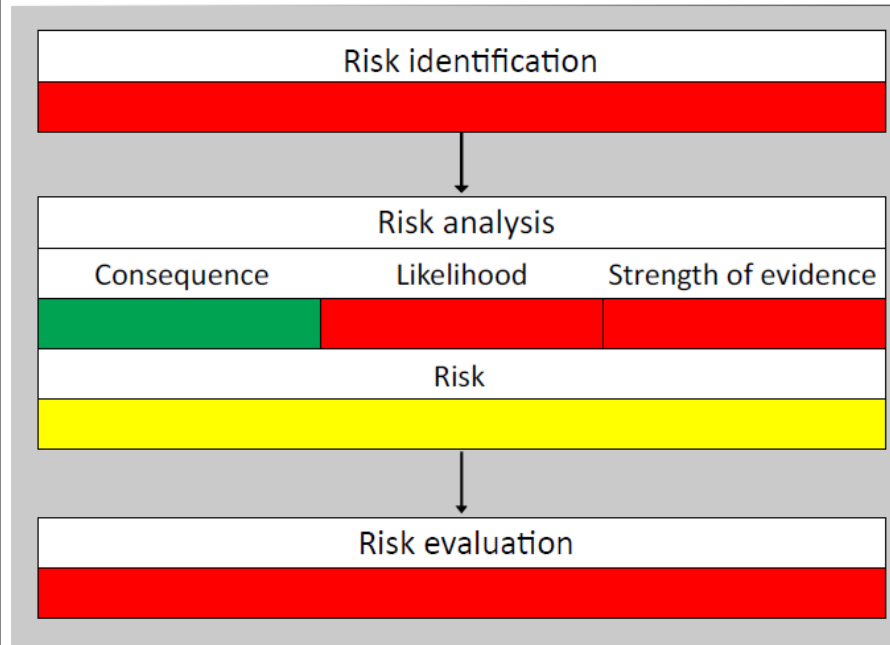
Resources needed  Low  Skills required  Medium



### 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

IMPACT  
SCENARIO

HULL  
DAMAGE

OIL  
OUTFLOW

SHIP  
LAYOUT

LOADING  
CONDITION

## A. Accident scenario definition

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

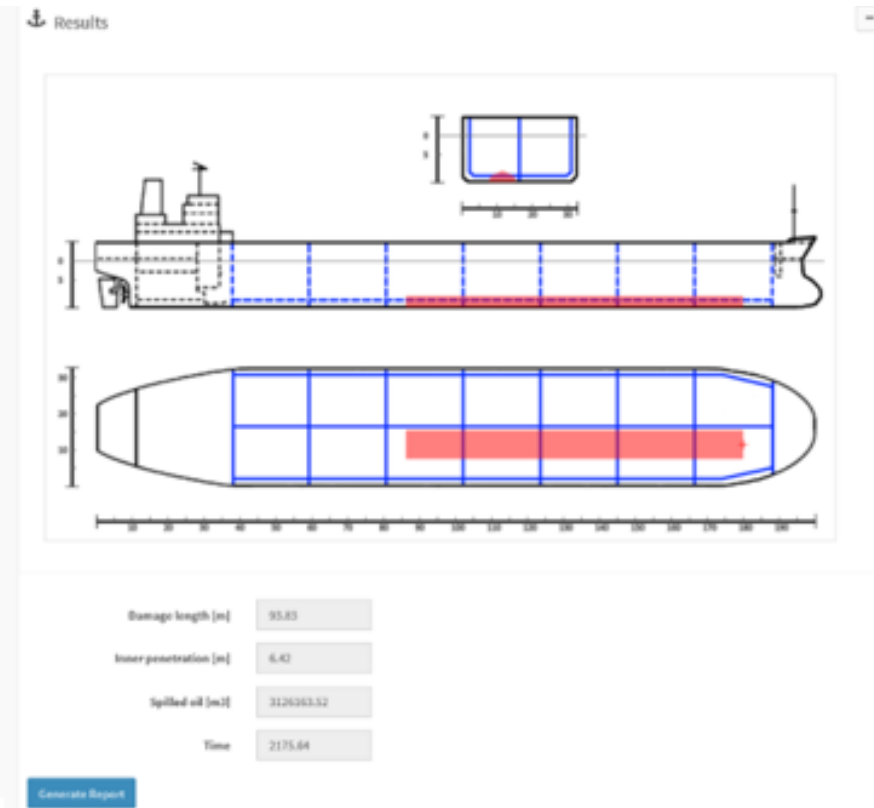
Ship type: Oil Tanker

Service speed [m/s]: 8

Service speed [knots]: 15.55

Level 2 parameters

## B. Visual representation of grounding damage extent



# Accidental Damage and Spill Assessment Model

IMPACT  
SCENARIO

HULL  
DAMAGE

OIL  
OUTFLOW

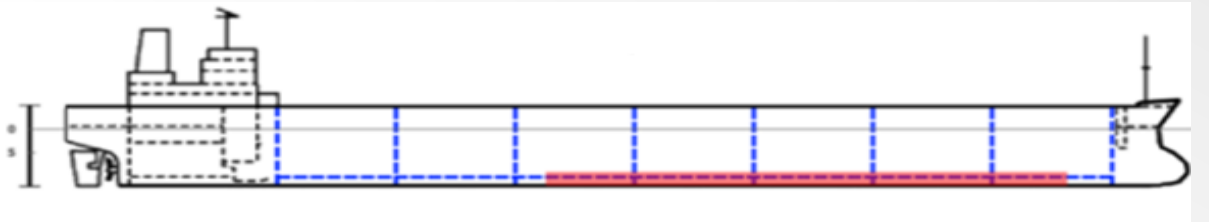
SHIP  
LAYOUT

LOADING  
CONDITION

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

## a) Input parameters

<b>Single scenario</b>	<b>Struck Ship</b>
Type of accident Grounding	Ships T200
Rock size [m] 3	Ship name T200
Penetration [m] 5	Length [m] 200
c_t_scale -1	Ship type Oil Tanker
Rock location in longitudinal -1	Service speed [m/s] 8
Rock location in transverse -1	Service speed [knots] 15.55
<b>Run Model</b>	Level 2 parameters



# Accidental Damage and Spill Assessment Model

IMPACT  
SCENARIO

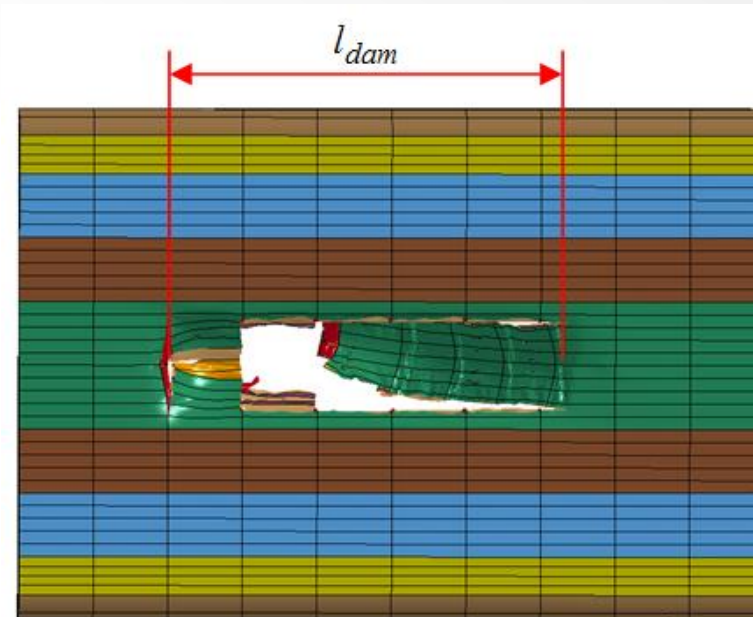
HULL  
DAMAGE

OIL  
OUTFLOW

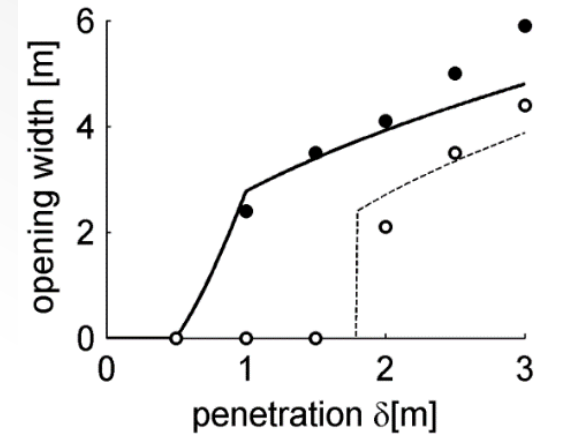
SHIP  
LAYOUT

LOADING  
CONDITION

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



Simple criterion  
for damage extent



Finite Element calculations

# Accidental Damage and Spill Assessment Model

IMPACT SCENARIO

HULL DAMAGE

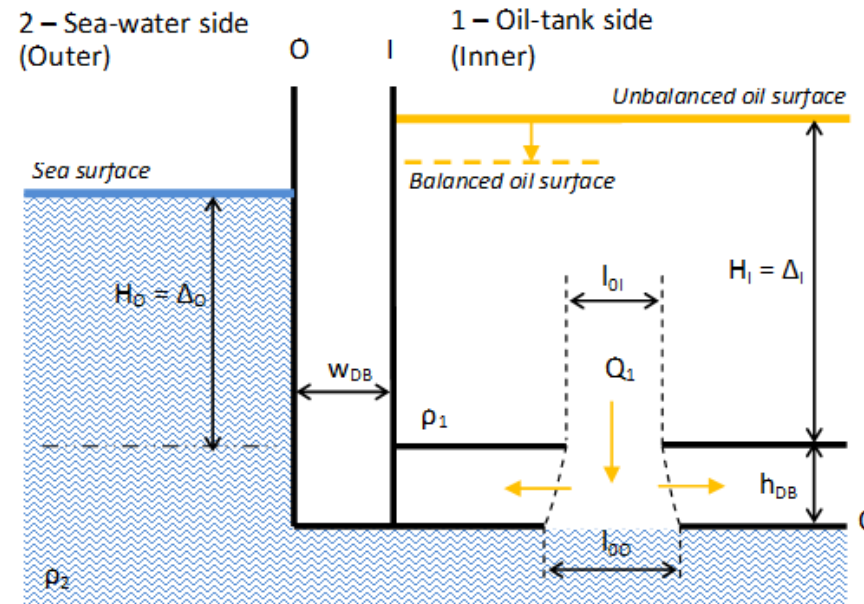
OIL OUTFLOW

SHIP LAYOUT

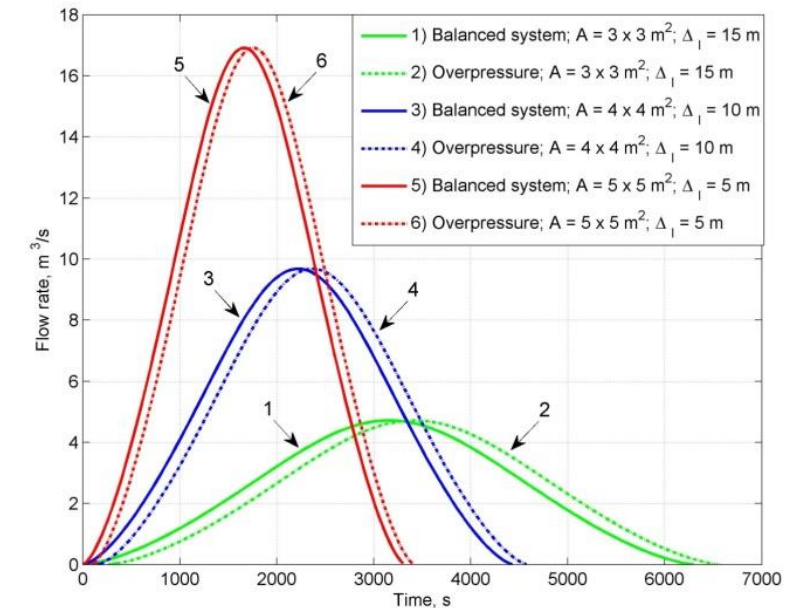
LOADING CONDITION

Calculation of oil outflow resulting from accidental damage size

## Scenario definition

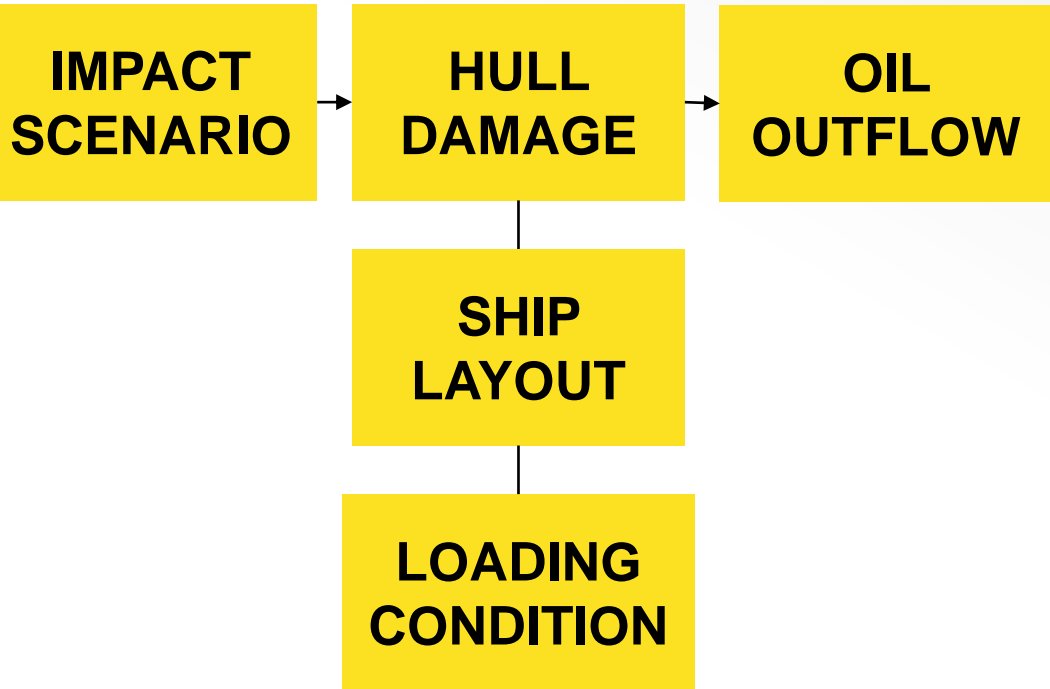


## Oil outflow as function of time based on hydrostatic balance





# Accidental Damage and Spill Assessment Model



## A. Accident      B. Grounding damage extent

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

## 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		Oil spill	
Length [m]	93,83	Volume (m <sup>3</sup> )	3126163,52
Inner width [m]	6,42	Duration	2175,64
Outer width [m]	8,02		

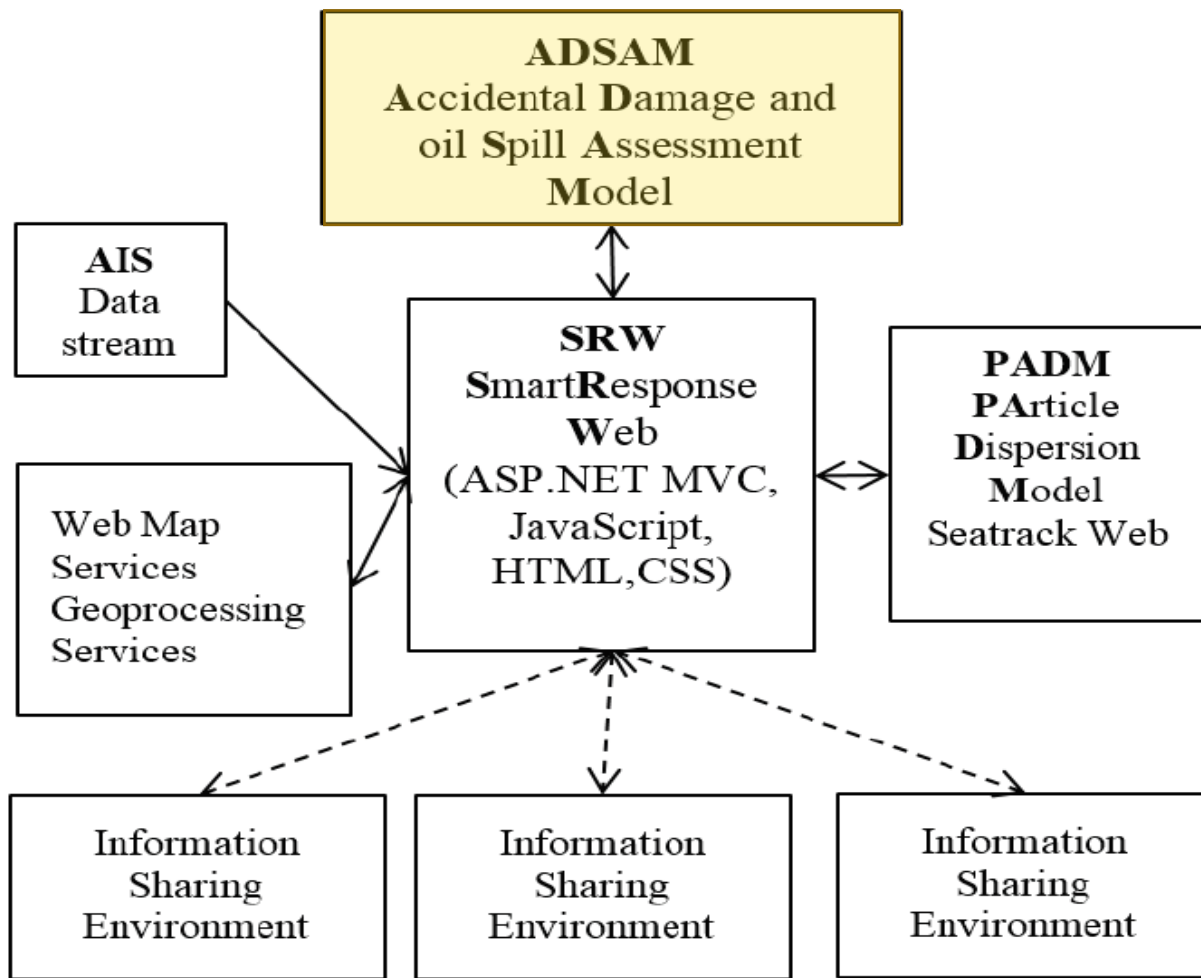


# OpenRisk

**EXAMPLE TOOL**

**NG-SRW  
NEXT-GENERATION SMART  
RESPONSE WEB**

# Accidental Damage and Spill Assessment Model



## ADSAM Calculation of accidental oil outflow (volume, time)

**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

**b) Visual representation of bottom damage**

Results

Damage length [m]: 93.83

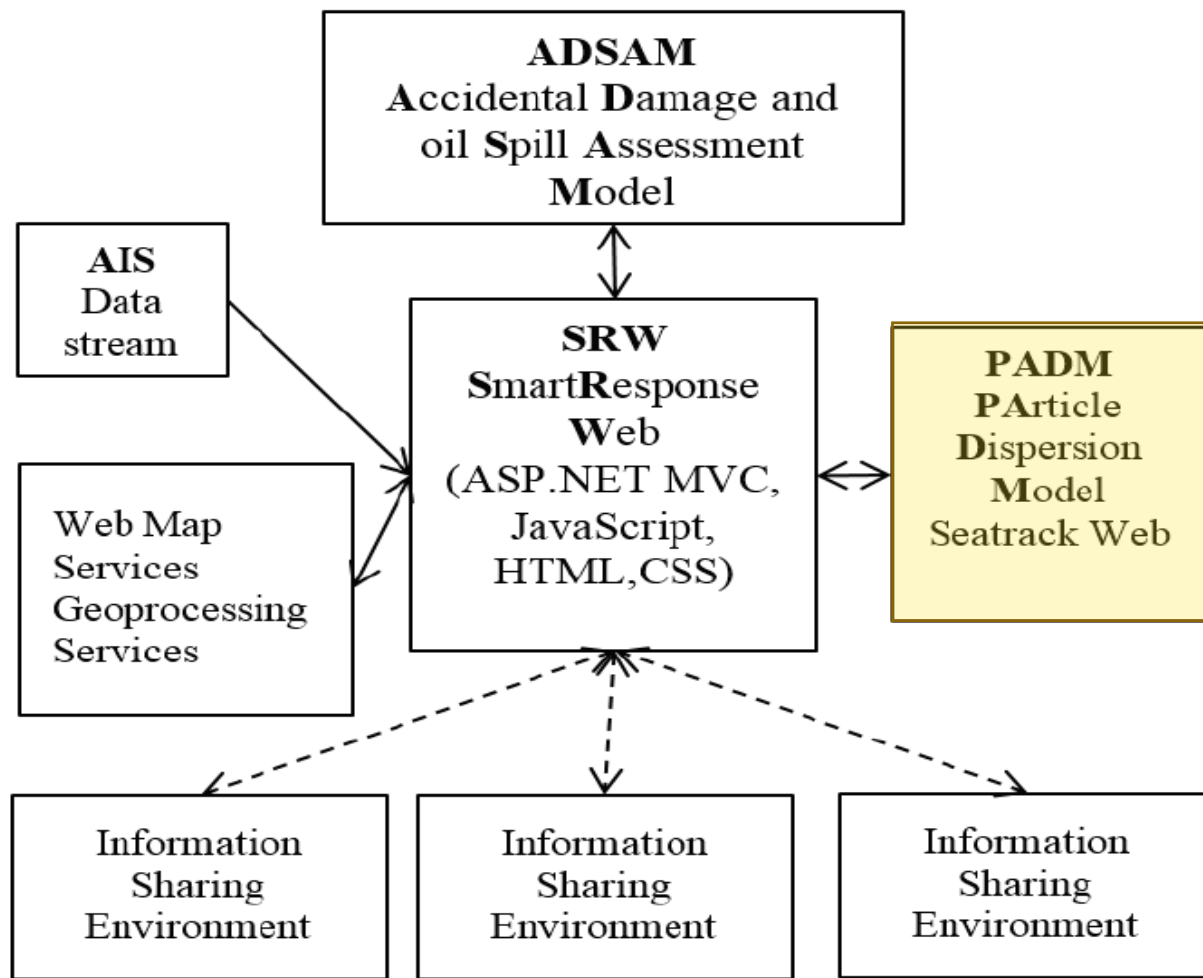
Inner penetration [m]: 6.42

Spilled oil [m<sup>3</sup>]: 212633.32

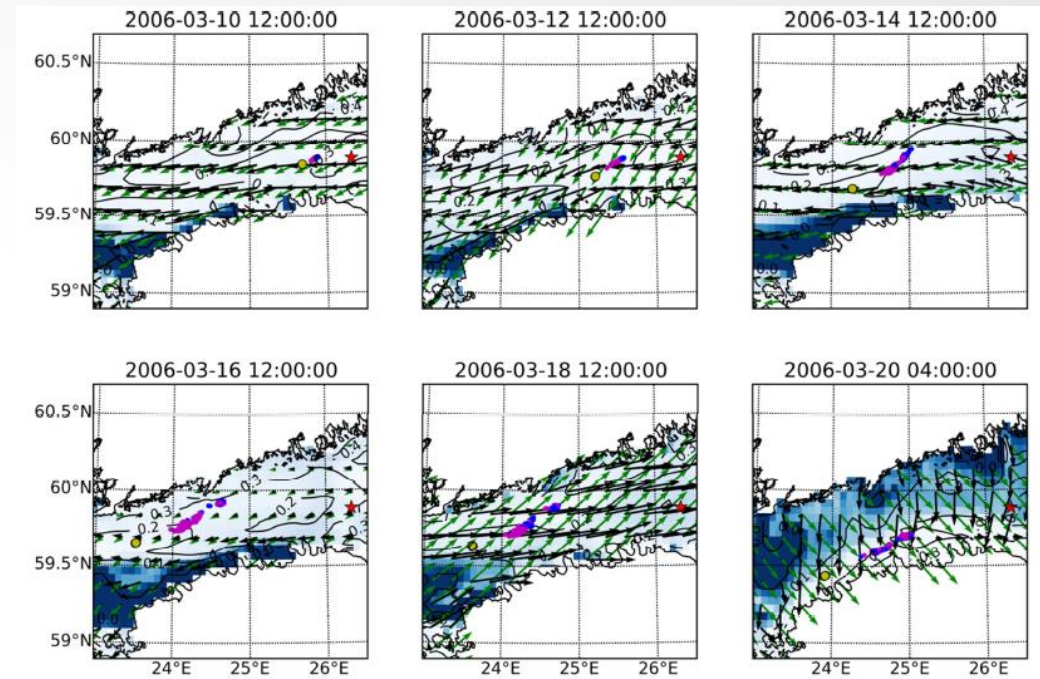
Time: 2175.84

Generate Report

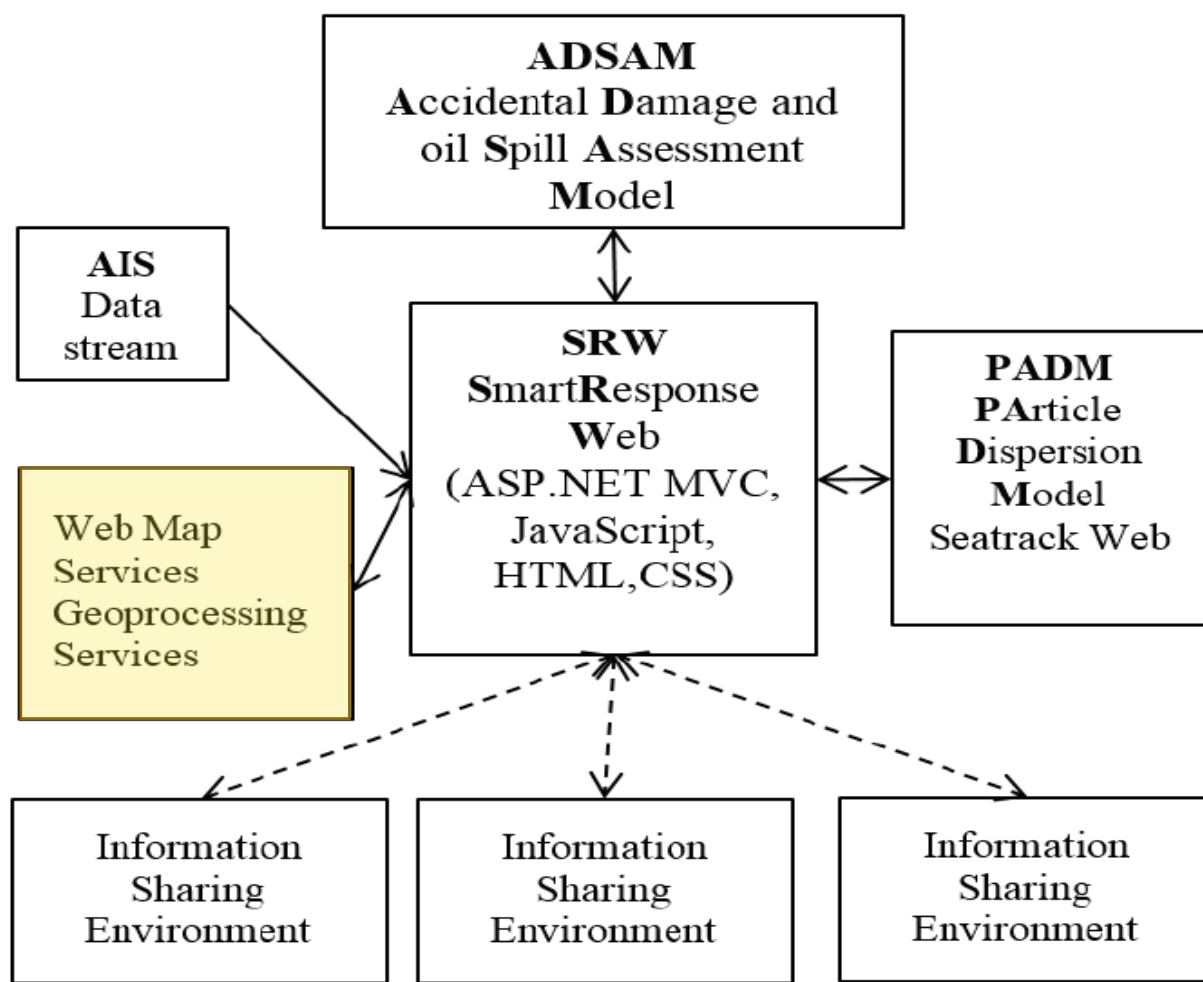
# Accidental Damage and Spill Assessment Model



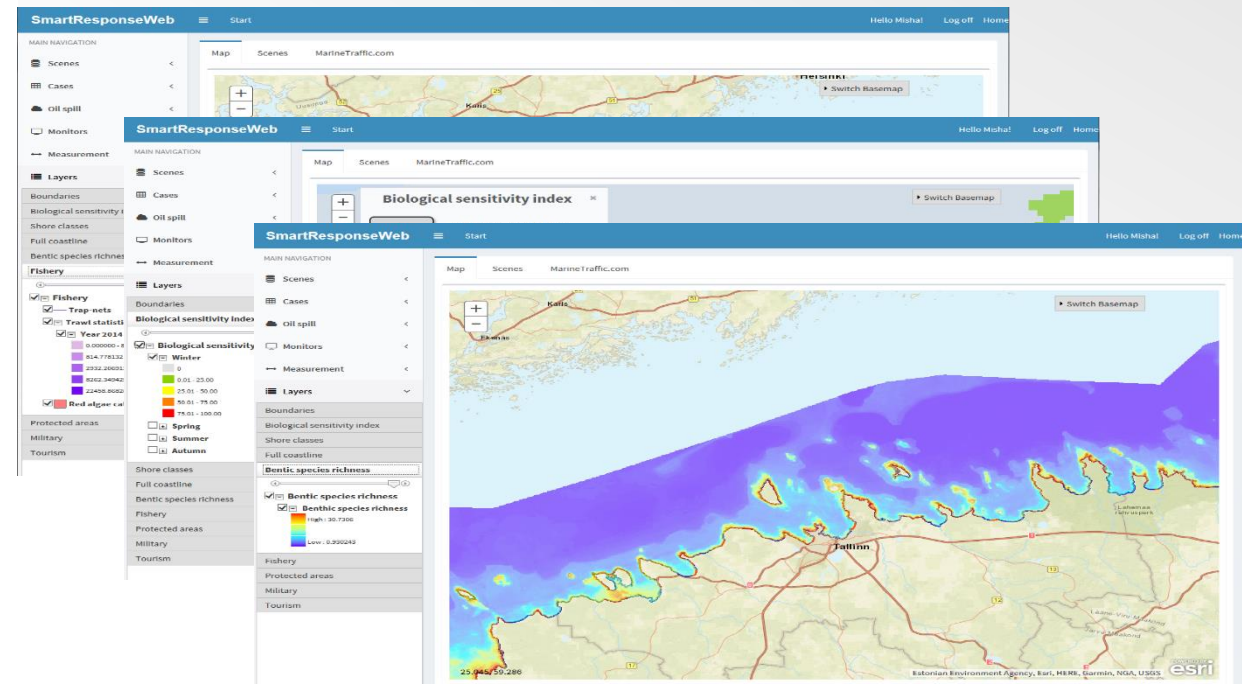
**PADM (Particle Dispersion Model)  
Calculation of oil drift in the sea  
(implemented in SeaTrack Web)**



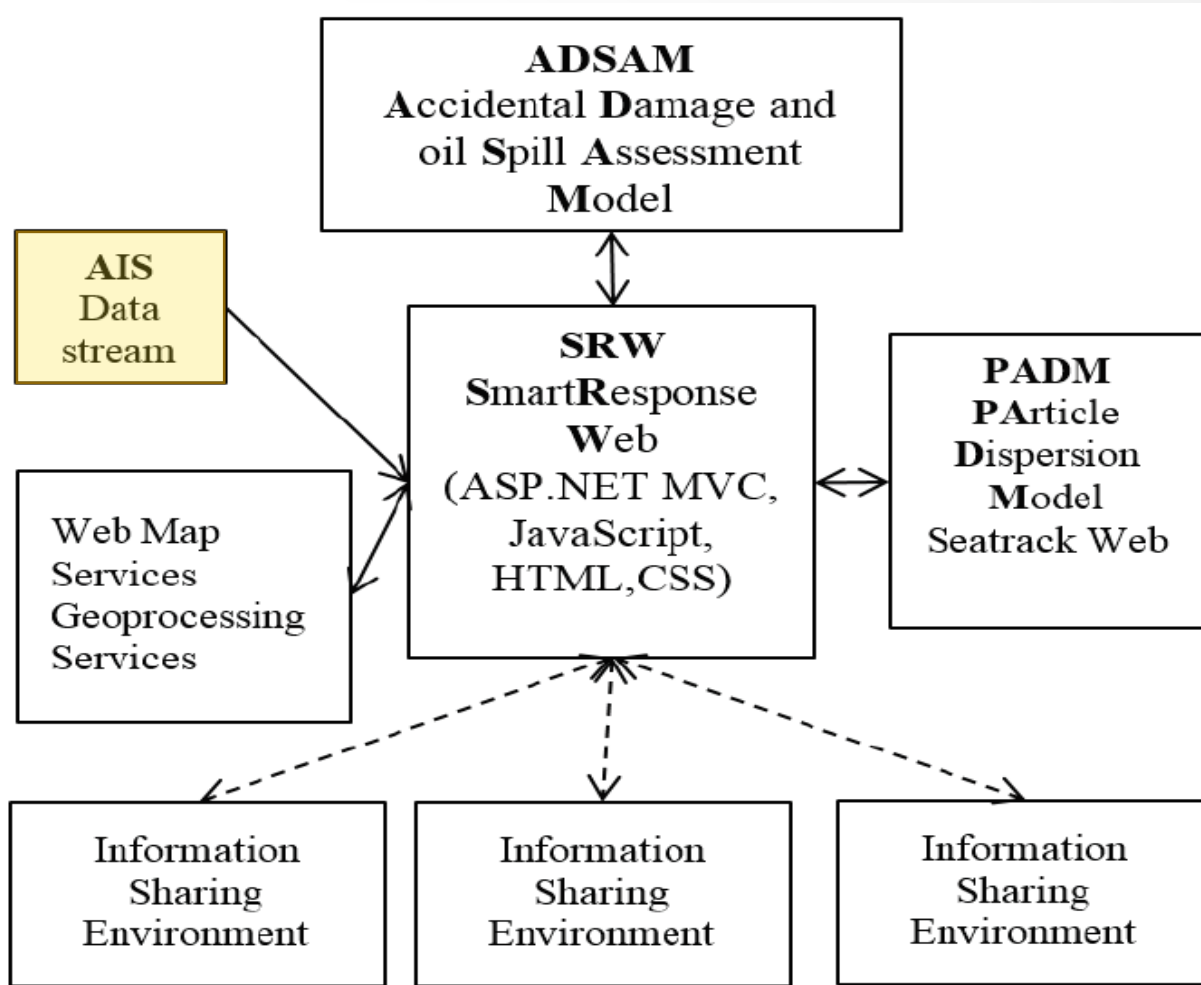
# Accidental Damage and Spill Assessment Model



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



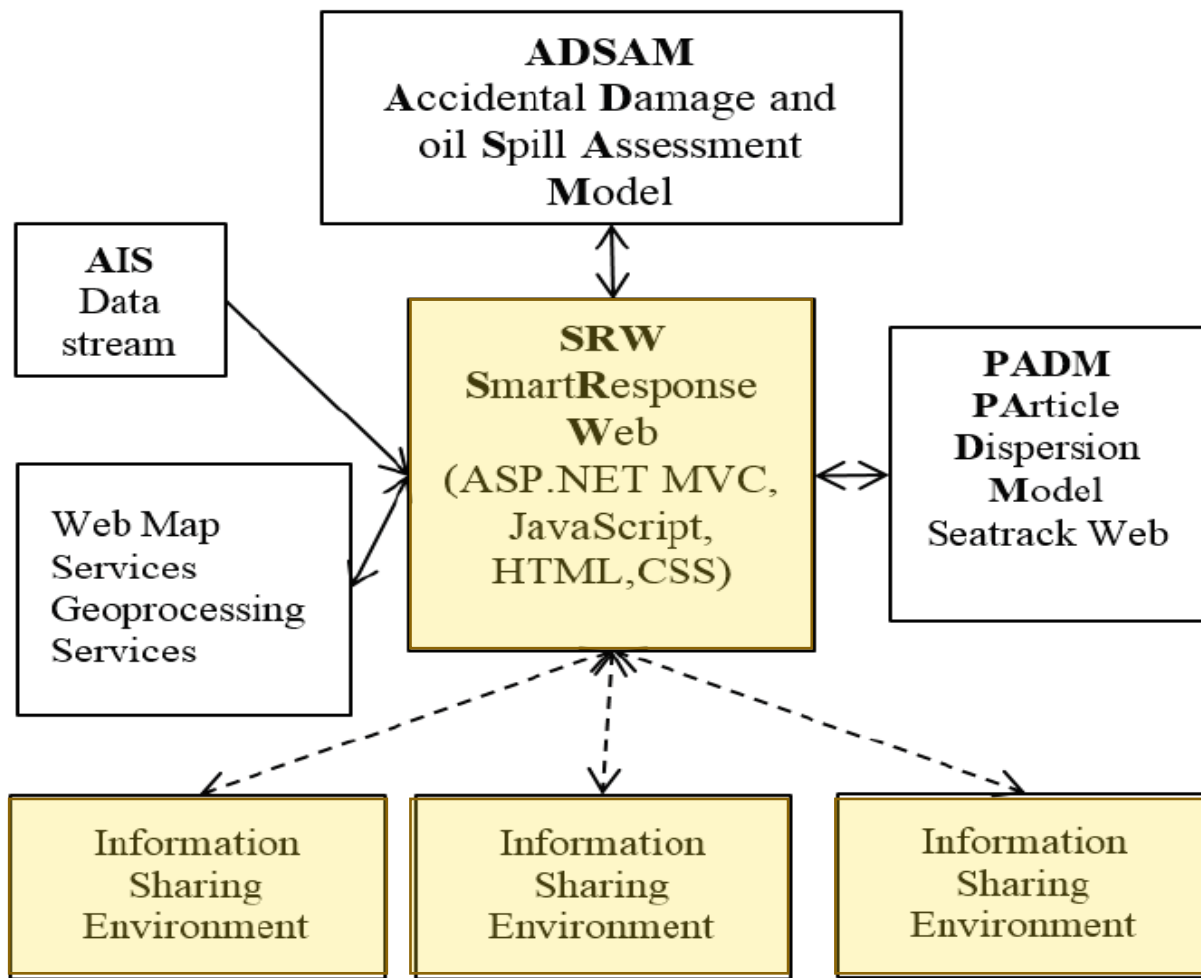
# Accidental Damage and Spill Assessment Model



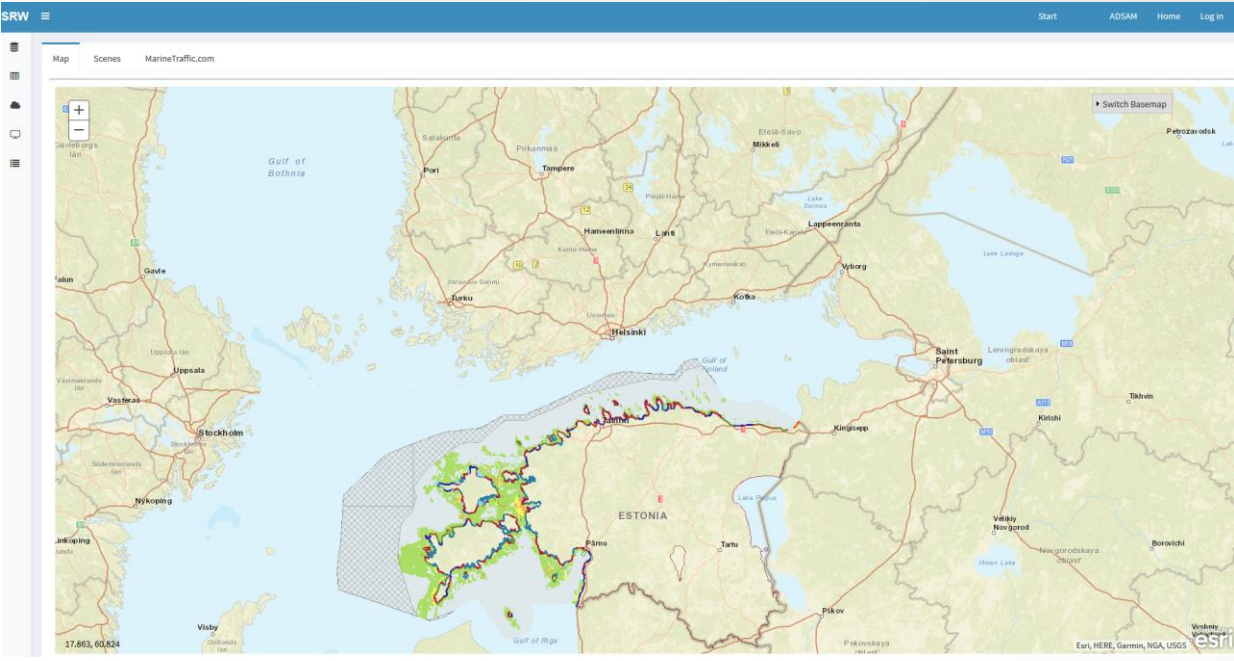
**AIS data stream**  
**Display information from Automatic Identification System (ship traffic)**

**For operational response planning**

# Accidental Damage and Spill Assessment Model



**Next Generation-SmartResponse Web Information integration and summary**



# Questions?

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