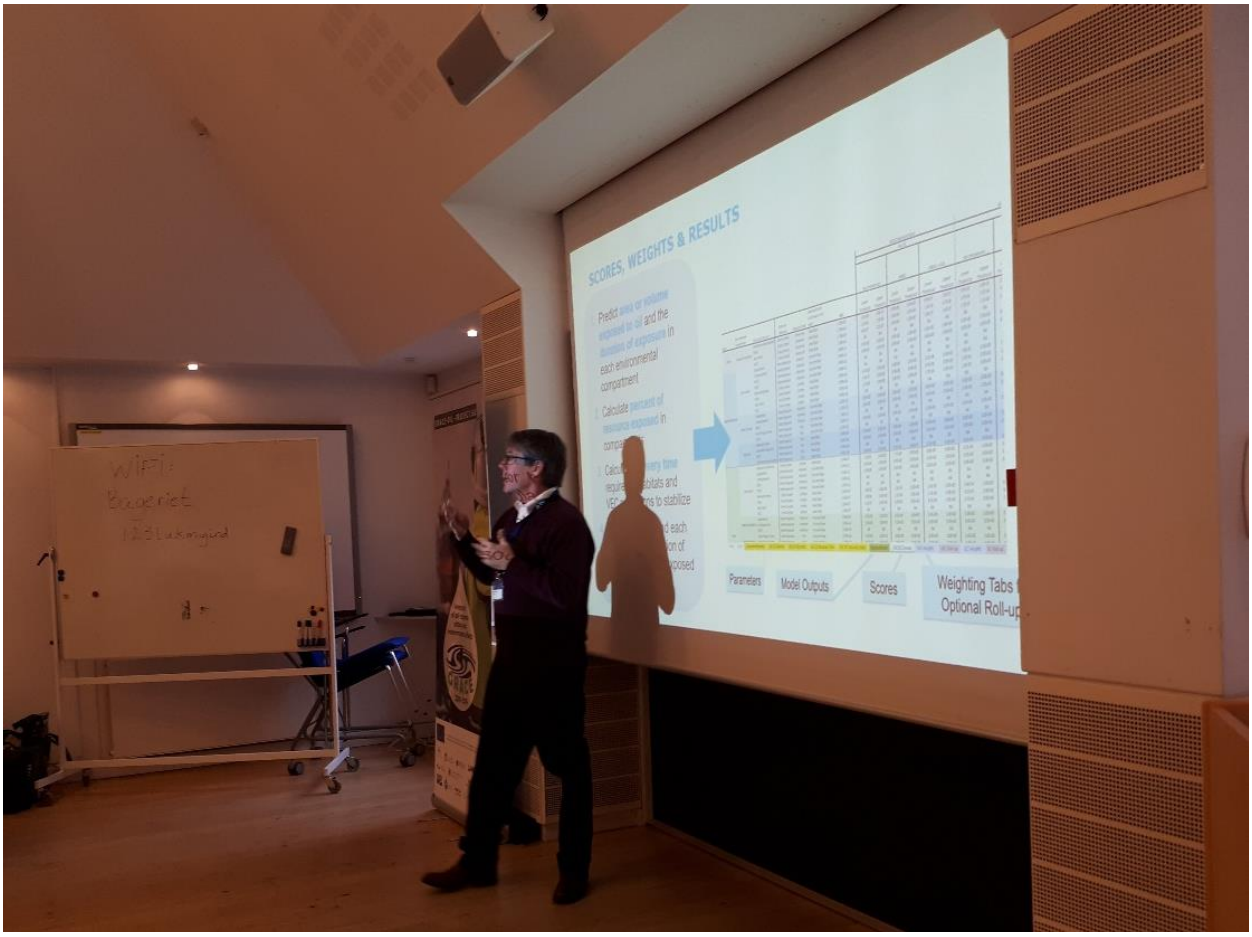
GRACE grant no 679266

Draft SNEBA tool
Workshop report

D5.9

WP5: Strategic Net Environmental Benefit Analysis (SNEBA)



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Lead beneficiary: AU

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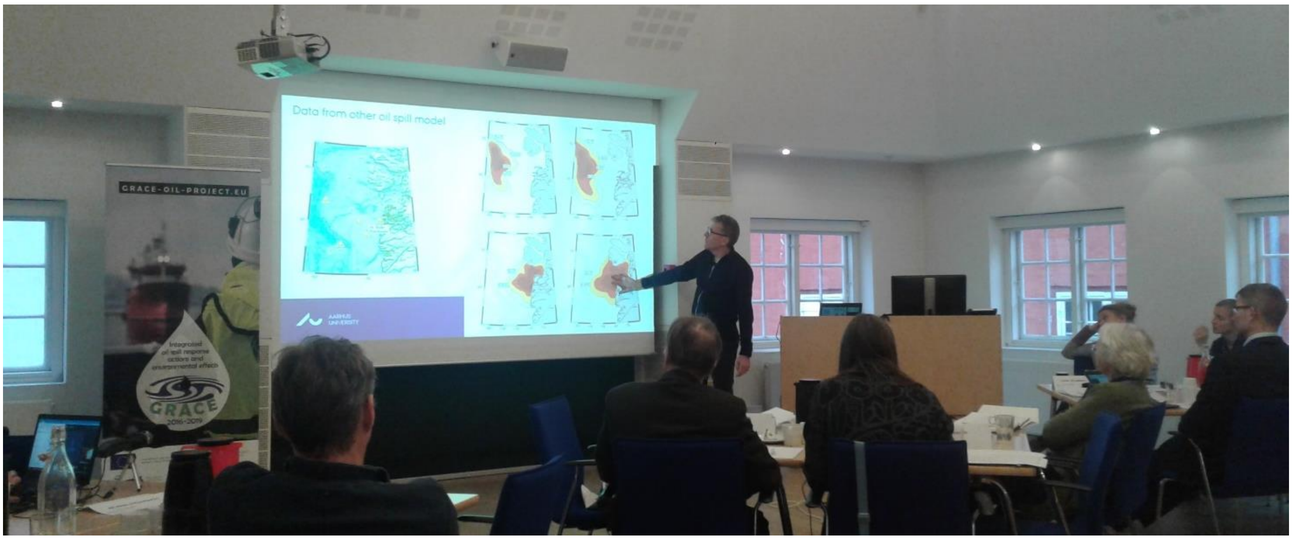
Deliverable status:

Version	Status	Date	Author	Approved by
1.0	draft	30.11.2018	Susse Wegeberg, AU Janne Fritt-Rasmussen, AU Kim Gustavson, AU	
2.0	final	30.11.2018		Steering group 30.11. 2018

Contents


Data from other oil spill model
GRACE-OIL-PROJECT.EU
GRACE
2016-2019

Executive Summary

At the workshop, the beta version of the Strategic Net Environmental Benefit Analysis (SNEBA) tool was launched and presented to relevant stakeholder to optimize feedback and potential improvement of use.

The workshop was held in Copenhagen, November 22, 2018, with 34 participants from 17 different institutions from 10 different countries. Eight persons participated by Skype from Greenland, Ireland and the Basque.

The SNEBA tool is for planning and decision-making. It will be used for designing an appropriate and rapid oil spill response strategy combining the right mix of interventions (e.g., mechanical recovery, in situ burning, chemical dispersants, and/or natural attenuation) based on relevant scenarios.

The SNEBA tool is developed to include and overarching the biological and technical knowledge obtained from the previous WPs, as well as integrated with operational assessments being based on knowledge / expertise on coastal protection and shoreline response provided by SSPA Sweden AB.

The general input and discussion topics were compiled and will be used for adjustment and amendment of the SNEBA tool. Thus, the workshop will be followed up with suggested adjustments internally as well through meetings planned for 2019 with AU, Rambøll and Shell.

The purpose of a Guideline and toolbox for Arctic Marine Risk Assessments

- **The Guideline**
  - Create a common approach for conducting qualitative and quantitative Arctic Marine Risk Assessments, enabling comparable assessments.
  - Better understand and communicate the different risks and risk influencing factors associated with marine activities in the Arctic.
  - Better foundation and decision support for establishing optimized risk management strategies.
- **The toolbox**
  - Include the best practice document(s) and overview of available tools, data sources, incl. their accessibility, quality, completeness/coverage, contact persons, etc.

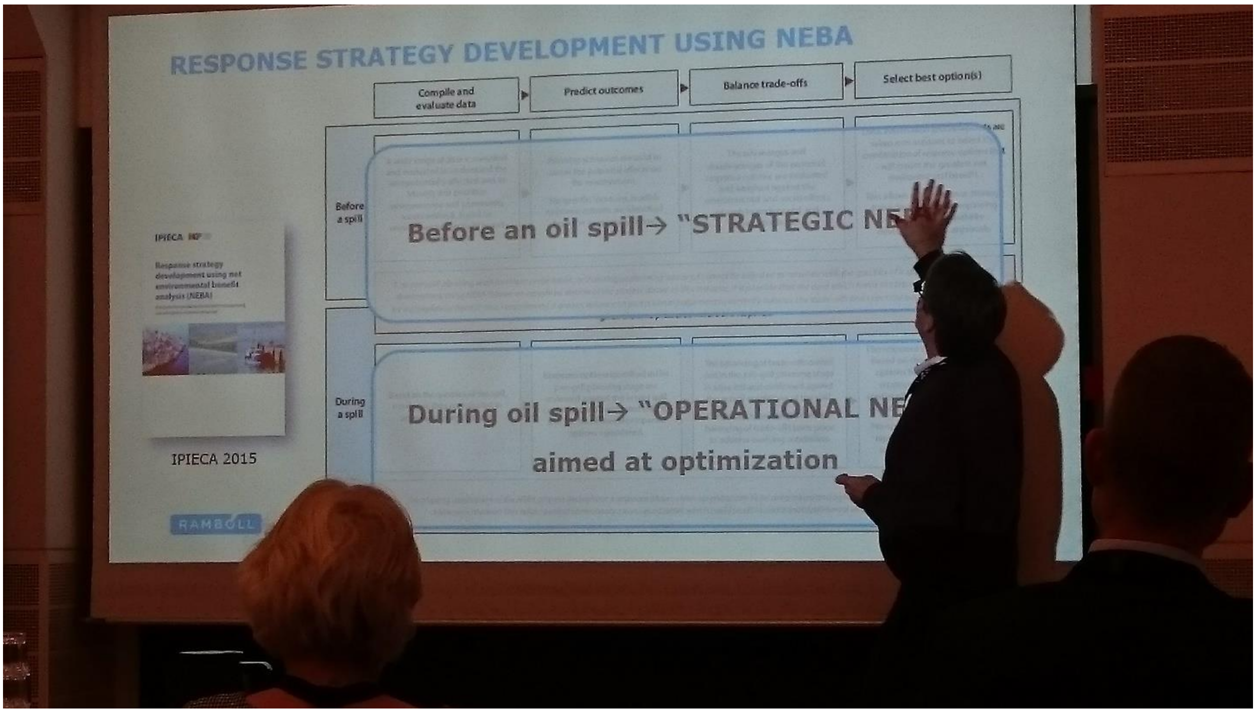
DNV·GL

1 Introduction

The main objective of the WP5 is to develop and launch a Strategic Net Environmental Benefit Analysis (SNEBA) tool for decision-making. It will be used for designing an appropriate and rapid oil spill response strategy combining the right mix of interventions (e.g., mechanical recovery, in situ burning, chemical dispersants, and/or natural attenuation) for closed basins with extreme cold temperatures, based on relevant scenarios. A SNEBA should not be confused with a Net Environmental Benefit Analysis (NEBA) / Spill Impact Mitigating Assessment (SIMA) for acute oil spill situations.

The SNEBA tool is developed to include and overarching the biological and technical knowledge obtained from the previous WPs, as well as integrated with operational assessments being based on knowledge / expertise on coastal protection and shoreline response provided by SSPA Sweden AB.

Present workshop was organized to present the beta version of the SNEBA tool for relevant stakeholder to optimize feedback and potential improvement of use.



2 Venue

The workshop was held at the Citadel (Kastellet) (Figure 3.1) in Copenhagen, Denmark, kindly provided by the Danish Ministry of Defence:

Kastellet 52, DK-2100 Copenhagen Ø, Building 24b, “GL. Varmecentral”

The 22nd November 2018, 10:00-16:00.

Figure 3.1. The Citadel in Copenhagen, Denmark. Venue adress was Kastellet 52, 2100 København Ø, Building 24b, “GL. Varmecentral” (pink arrow).

3 Programme

Time	Presentation title	Content	Output	Presenter / facilitator
10:00	Welcome, goals and introductions	Presentation of project Aim of workshop Presentation of participants	WS goals identified Participants introduced	Susse Wegeberg, AU
10:15	Presentation of SNEBA tool, beta version	Concept and uses of tool based on SNEBA for Store Hellefiskebanke Process and structure of SNEBA	Conceptual understanding Overview of SNEBA process and analysis steps	Susse Wegeberg
10:45		Questions from audience and discussion	Obtain input to potential adjustment of SNEBA tool	Susse Wegeberg
11:00	Key note: Spill Impact Mitigation Analysis (SIMA)	Presentation of the SIMA concept and process	Obtain synergy between SIMA and SNEBA	Rick Wenning, Rambøll, US
11:30		Questions from audience and discussion	Obtain input to potential adjustment of SNEBA tool in relation to SIMA	Rick Wenning Susse Wegeberg
11:45	Key note: EPPR risk assessment	Presentation of EPPR and ongoing risk assessment for the Arctic regarding emergency, prevention, preparedness and response		Jens Peter Holst-Andersen, EPPR Hans Petter Dahlslett, DNV GL
		Questions from audience and discussion	Obtain input on usability of SNEBA tool in relation to other oil spill response analyses/assessments	Jens Peter Holst-Andersen Hans Petter Dahlslett Susse Wegeberg
12:30	Lunch			
13:00	Detailed descriptions of SNEBA tool, beta version, components	1) Step 1 - Basic data 2) Step 2 - Calculation of scores 3) Step 3 - Analysis and flow chart 4) Step 4 – Interpretation of results		Janne Fritt-Rasmussen, AU Kim Gustavson, AU Susse Wegeberg, AU
		Questions from audience and discussion	Obtain input to potential adjustment of sNEBA tool	Janne Fritt-Rasmussen Kim Gustavson Susse Wegeberg
14:30	Coffee			
15:00	Operative add-ons			Nelly Forsman, SSPA Sweden AB Björn Forsman, SSPA Sweden AB
15:30	Wrap up			Susse Wegeberg
16:00	End of workshop			

4 Participants

Anders Mosbech	Aarhus University	amo@bios.au.dk
Björn Forsman	SSPA	bjorn.forsman@sspa.se
Daniel Spelling Clausen	Aarhus University	dsc@bios.au.dk
David Blockley*	Greenland Institute of Natural Resources	dabl@natur.gl
David Boertmann	Aarhus University	dmb@bios.au.dk
Dierk-Steffen Wahrendorf	Federal Institute of Hydrology	Wahrendorf@bafg.de
Hans Petter Dahlslett	DNV GL A/S	hans.petter.dahlslett@dnvgl.com
Hilde Dolva	Norwegian Coastal Administration/ Kystverket	hilde.dolva@kystverket.no
Janne Fritt-Rasmussen	Aarhus University	jfr@bios.au.dk
Jens Peter Holst-Andersen	Arctic Council, EPPR	JPH@fmn.dk
Jorma Rytkönen	Finnish Environment Institute	Jorma.Rytkonen@ymparisto.fi
Josephine Nymand*	Greenland Institute of Natural resources	jony@natur.gl
Julke Brandt	ITOPF Limited	JulkeBrandt@ITOPF.ORG
Kicki Rydskov	Danish Ministry of Defence	vfk-u-kor406@mil.dk
Kim Gustavson	Aarhus University	kig@bios.au.dk
Kirsten Bang	Aarhus University	kib@dce.au.dk
Kirsten Jørgensen	Finnish Environment Institute	kirsten.jorgensen@ymparisto.fi
Lonnie Bogø-Wilms	Greenland Oil Spill Response A/S	lonniewilms@yahoo.dk
Madis-Jaak Lilover	Tallinn University of Technology	Madis.Lilover@ttu.ee
Mathijs Smit	Shell	Mathijs.Smit@shell.com
Michael Strangholt	Aarhus University	mis@dce.au.dk
Mikkel Tamstorf	Aarhus University	mpt@bios.au.dk
Morten Birch Larsen*	Greenland Institute of Natural resources	mola@natur.gl
Morten Thrane Leth*	Ministry of Nature, Environm. and Research, Greenl.	mthl@nanoq.gl
Najaaraq Dement-Poort *	The Environm. Agency for Mineral Resource Activities	nasd@nanoq.gl
Nelly Forsman	SSPA	nelly.forsman@sspa.se
Ole Geertz-Hansen*	Greenland Institute of Natural Resources	olge@natur.gl
Rasmus Kolind*	The Environm. Agency for Mineral Resource Activities	rako@nanoq.gl
Rick Wenning	Rambøll, US	rjwenning@ramboll.com
Sarah Johann*	Aachen University	sarah.johann@rwth-aachen.de
Siim Pärt	Tallinn University of Technology	siim.part@taltech.ee
Susse Wegeberg	Aarhus University	sw@bios.au.dk
Tom Christensen	Aarhus University	toch@bios.au.dk
Yu Jia*	Greenland Institute of Natural resources	yuji@natur.gl

** Via Skype*

5 Outcome

5.1 Input to adjustment and amendment of SNEBA tool, beta version

In Table 2.1 below, we have compiled the comments and general input to the SNEBA tool, beta version, at the workshop to be taken home for adjustment and amendment of the SNEBA tool.

There were comments and discussions also associated to the keynote speaker's presentations, and where relevant for the adjustment of the SNEBA tool, they have been included in Table 2.1.

We also encouraged the participants to send their comments and input by e-mail within a period of 14 days, if any after digesting the SNEBA tool presentation.

Table 2.1. Compilation of comments / input from workshop participants for adjustment and amendment of the SNEBA tool, beta version.

Comment / input / discussion
More different methods exists within a response option category, how have you looked into this in the SNEBA?
Could SNEBA potentially look into a mix of methods?
Complexicty should be balanced so that it is the same in all your level of calculations
To handle habitat recovery is it considered that the calculations associated to injury and recovery for the habitat are more robust than the biological data?
EPPR Circumpolar oil spill response viability analyses – could be followed by a SNEBA
Regarding different levels of toxicity to organisms, you have the same toxicity level at all oil types as default, however, is there a flexibility in the model for input of more specific data?There should also be options to change it over time.
To define the oil spill scenarios, other tools may be used (e.g., risk assessments), and data input is flexible
Net Environmental Benefit (NEB) - criteria for scores; explain when impact is on individual, population, global population, cascade effect level.
Consider if cascade effects may be positive if top predators are diminished as result of oil spill impacts.
Soot Pollution (SP) – consider residues and soot deposition to sea.
Damage Reduction (DaR) – consider table to link with weather conditions to optimize efficiency
Reconsider Plume depth > water depth in Chemical Dispersants (CD) decision tree – there may be a conflict when Σsb is >0. Negative effects on the seabed should be made an option in the CD decision tree, also in relation to marine snow.
Regarding CD decision tree: fSWP 0-2 could be green, red and yellow – might be the solution on above issue.
Decision tress more easy readable, avoid acronyms
Regarding In Situ Burning (ISB) decision tree; check spill size reference: - Consider that it might not be the volume, but rather the area that you want to burn - Consider using the Tier system for oil spill volumes sizes

5.2 Future work

The workshop will be followed up with suggested adjustments and amendments internally as well through meetings organized for 2019. Two meetings are planned for furhter input and discussions with

AU: 17th January 2019

Rambøll US and Shell: 25th January 2019

The final SNEBA tool will be launched in Deliverable 5.10 by March 2019.

6 Presentations

1) From conceptual framework to tool / Susse Wegeberg / AU
2) Optimization of oil spill response planning and preparedness using Spill Mitigation Impact Assessment (SIMA) / Richard Wenning / Rambøll
3) EPPR / Jens Peter Holst-Andersen / Danish Ministry of Defence
4) EPPR Guideline and Tools for Arctic Marine Risk Assessments / Hans Petter Dahlslett / DNV GL
5) SNEBA tool; Steps 1. Basic data and information, and 2. Assessment / Kim Gustavson / AU
6) Scores for the SNEBA / Janne Fritt-Rasmussen / AU
7) SNEBA decision trees / Susse Wegeberg / AU
8) SNEBA – Operative add-ons / Björn Forsmann / SSPA Sweden

SNEBA WORKSHOP

Kastellet, Copenhagen 22nd November 2018

Integrated
oil spill response
actions and
environmental effects

GRACE
2016-2019

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STRATEGIC NET ENVIRONMENTAL BENEFIT ANALYSIS (SNEBA) –

FROM CONCEPTUAL FRAMEWORK TO TOOL

Susse Wegeberg, Janne Fritt-Rasmussen, Kim Gustavson

AARHUS
UNIVERSITY

GRACE

WP6: Management, dissemination and communication
- SYKE

WP1: Oil spill dectection, monitoring, fate and distribution – TUT

WP2: Oil biodegradation and bioremediation – UTARTU

WP3: Determination of oil and dispersant impacts on biota using effect-based tools and ecological risk assessment - RWTH AACHEN

WP4: Combat of oil spill in coastal Arctic water – effectiveness and environmental effects - AU

WP5: Strategic Net Environmental Benefit Analysis (SNEBA) - AU

GRACE - NEW INFORMATION FOR SNEBA AND OPERATIONAL ADD-ONS

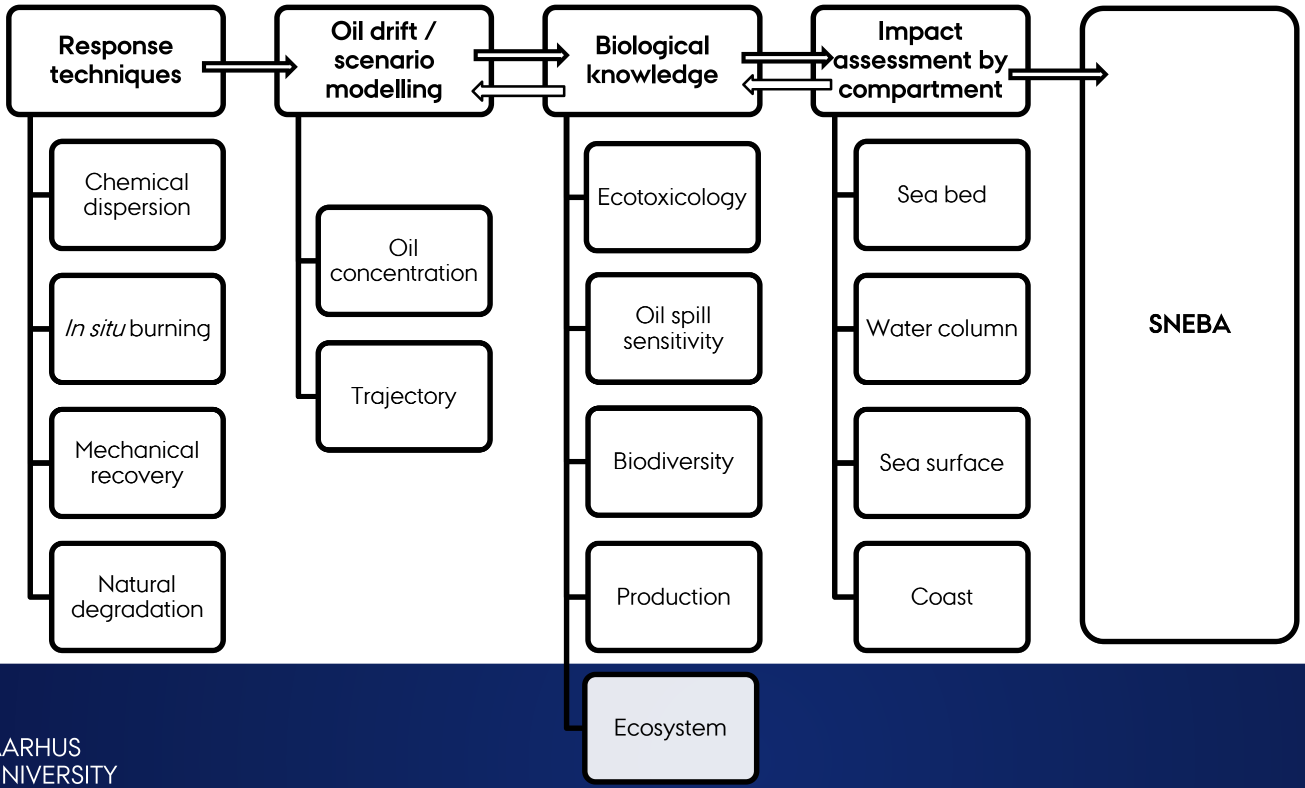
Ecotoxicological data:

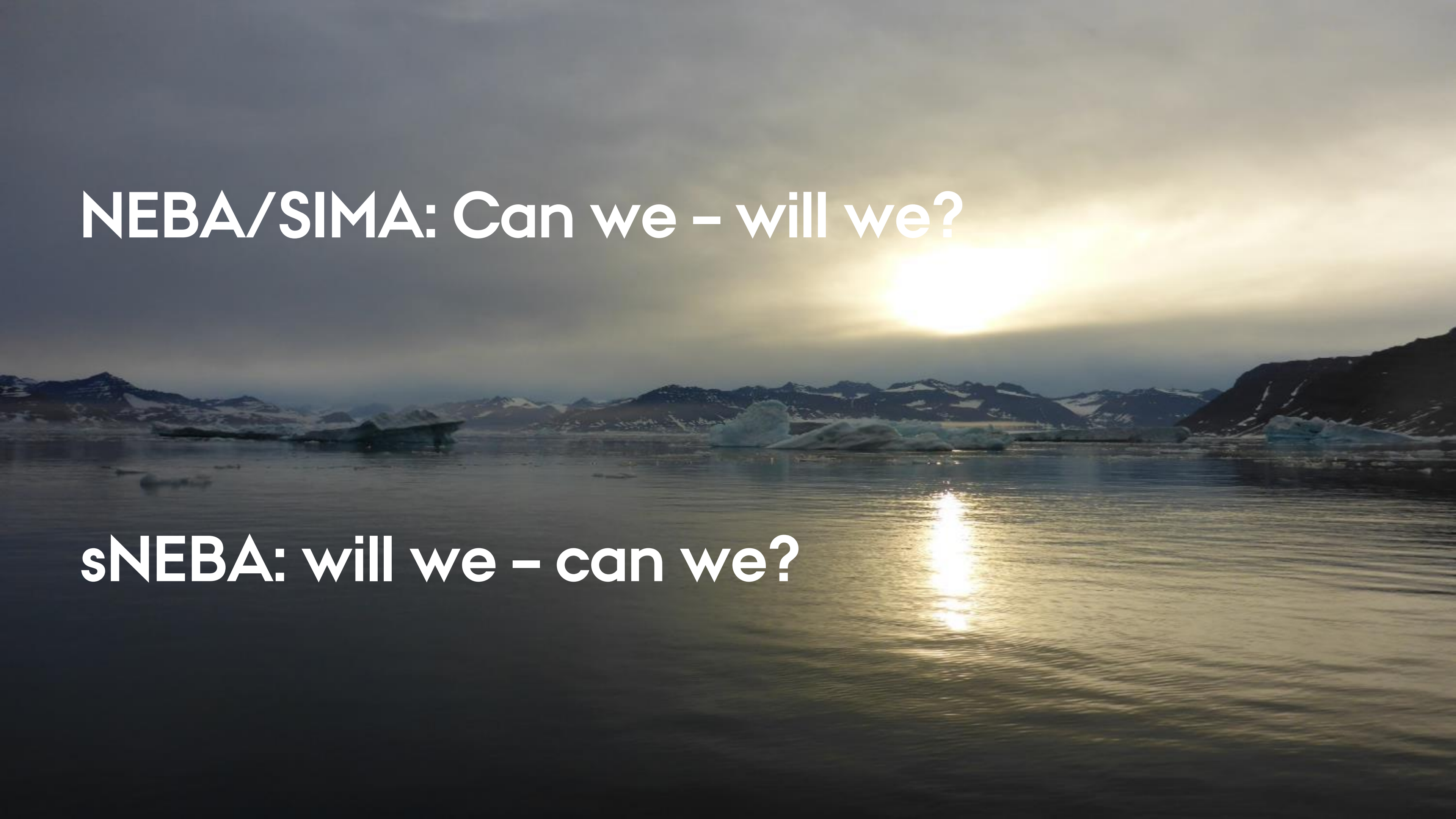
Organims (s)	Treatment	Results	Environmental implications	Publication/ authors/credit

Oil spill support tools:

Tool	Application	Results	Environmental implications	Publication/ authors/credit

SNEBA – CONCEPTUAL FRAMEWORK





NEBA/SIMA: Can we – will we?

sNEBA: will we – can we?

STORE HELLEFISKE BANKE AS EXAMPLE

Wegeberg, S., Rigét, F., Gustavson, K. & Mosbech, A. 2016

- Distribution of oil spill in the water column
- Modeling of oil concentrations in the water column and oil spill trajectories
- Environmental side effects of in situ burning and chemical dispersion
- Effects on ecosystem key components in relation to oil volume, dispersed oil volume and sea surface area of toxic oil concentrations
- Restitution
- SNEBA; synthesis and analysis
- Conclusion and recommendations regarding use of dispersants and in situ burning
- Uncertainties and knowledge gaps for cold waters


STORE HELLEFISKEBANKE, GRØNLAND

Miljøvurdering af oliespild samt potentialet for oliespildsbekæmpelse

Videnskabelig rapport fra DCE – Nationalt Center for Miljø og Energi nr. 216 2016

AARHUS UNIVERSITET
DCE – NATIONALT CENTER FOR MILJØ OG ENERGI

Funded by the Greenland Government

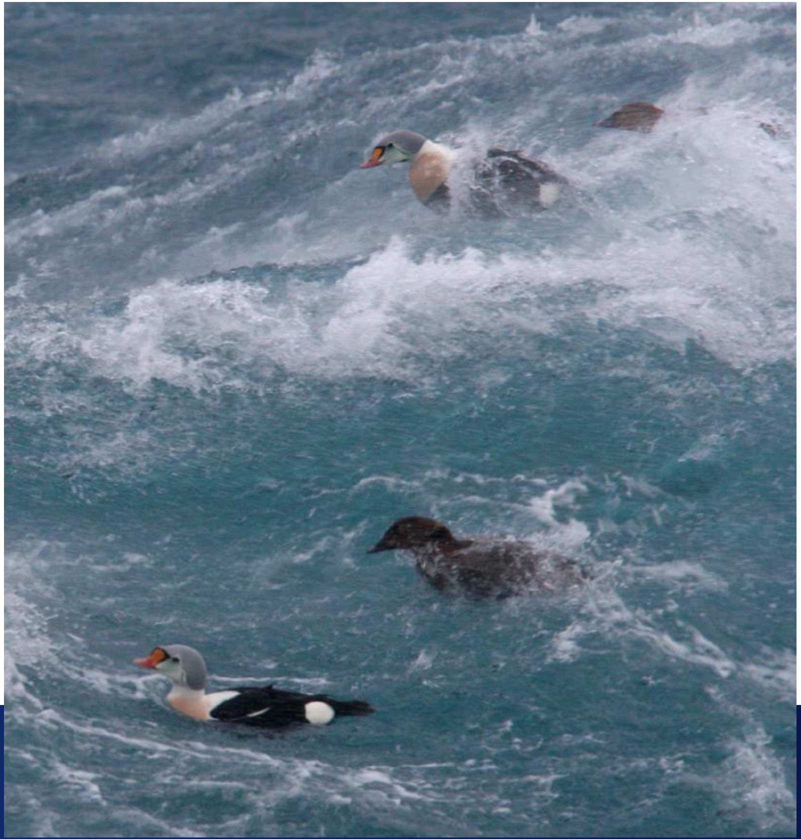
EFFECTS ON ECOSYSTEM KEY COMPONENTS

Oil volume, dispersed oil volume and sea surface area of toxic oil concentrations

- Phytoplankton and zooplankton
- Fish
- Benthos
- Birds (Risk assessment of king eider populations)
- Coastal ecosystems and beaching oil
  - Tidal seaweed communties
  - Kelp forest

SNEBA; SYNTHESIS AND ANALYSIS

- Oil spill response technique
  - Surface dispersants
  - In situ burning
- Season
- Spatial compartments
  - Sea surface
  - Seawater
  - Seabed
  - Shoreline



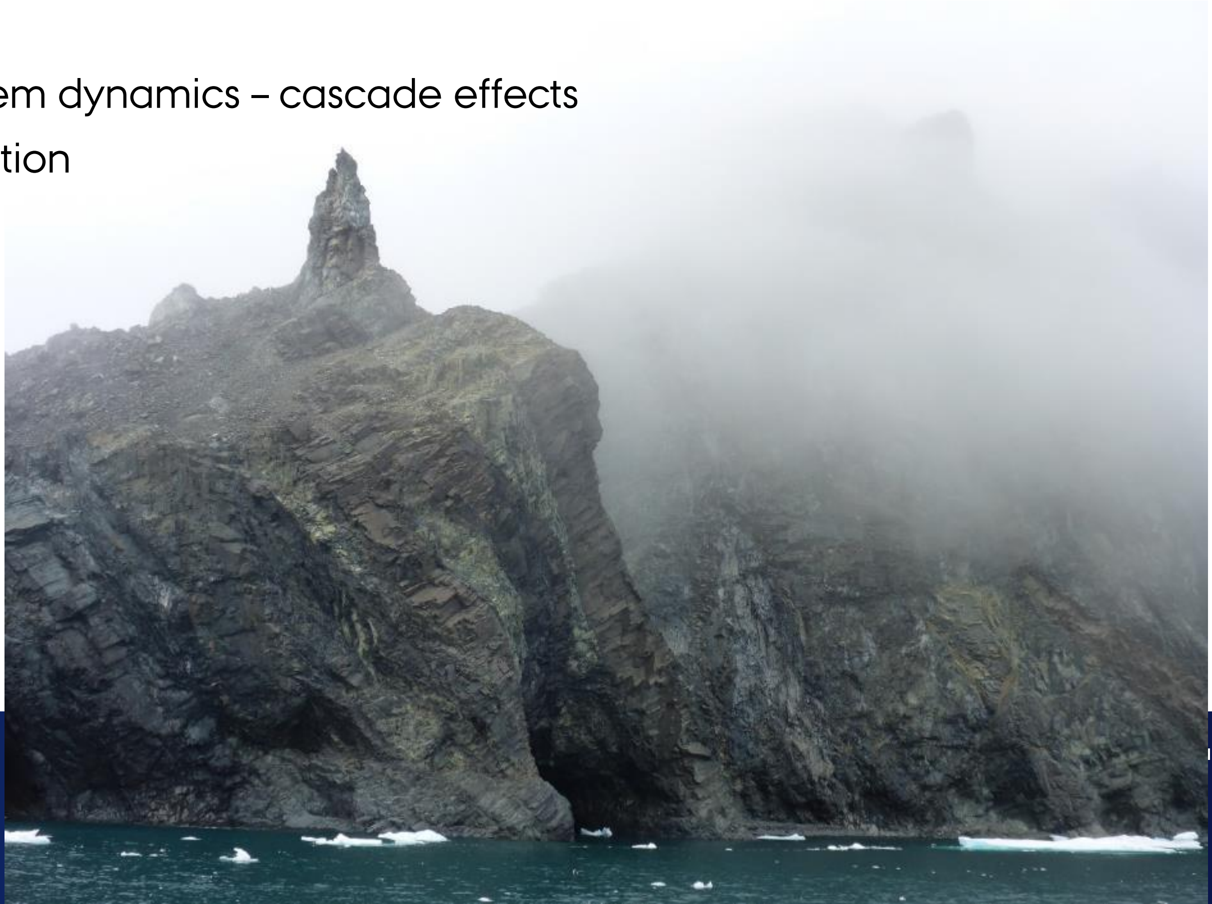
Method	Season	Sea surface		Water column (0-50m)		Sea bed (0-50m)		Coast		Total assessment
Dispersion	Spring	Seabirds Walrus	+	Spring bloom of plankton, including fish larvae Bowhead whale, other whales	÷	Benthos, in particular bivalves	÷	Intertidal zone Kelp forest	+	÷ Despite the benefit for organisms on sea surface and the coastal ecosystems, it is assessed that the effect in the water column, and hence on the food web and risk of cascade effects, exceeds the potential positive environmental effect during most of the year
	Summer	Seabirds	+	Plankton Fish, sandeel	÷					
	Autumn	Seabirds	+	Plankton Fish, sandeel	÷					
	winter	Seabirds Walrus	+	Plankton Fish, sandeel	+					
ISB	Spring	Seabirds Walrus	±	Spring bloom of plankton, including fish larvae Bowhead whale, other whales	±	Benthos, in particular bivalves	±	Intertidal zone Kelp forest	+	± It is predominantly assessed that the method will give an overall positive environmental effect, however, with reservations on still unknown environmental side effects of burning residues and soot
	Summer	Seabirds	±	Plankton Fish, sandeel	±					
	Autumn	Seabirds	±	Plankton Fish, sandeel	±					
	Winter	Seabirds Walrus	±	Fish, sandeel	±					
Natural degradation	Spring	Seabirds Walrus	÷	Spring bloom of plankton, including fish larvae Bowhead whale, other whales	±	Benthos, in particular bivalves	+	Intertidal zone Kelp forest	÷	÷ As natural dispersion of oil in the water column and hence potential effects on organisms on the sea surceace and in the water column as well as the risk of the oil beaching, it is assessed that the risk of not being able to repond to an oil spill may result in negative environmental effects
	Summer	Seabirds	÷	Plankton Fish, sandeel	±					
	Autumn	Seabirds	÷	Plankton Fish, sandeel	±					
	Winter	Seabirds Walrus	÷	Fish, sandeel	±					

UNCERTAINTIES AND KNOWLEDGE GAPS

- Understanding of ecosystem dynamics – cascade effects
- Natural removal/degradation
- Ecotoxicological effects

↓

New information from GRACE



SNEBA TOOL AND OPERATIVE ADD-ONS

Contributing partners:

- SSPA
- TUT

SNEBA tool

Matrix for operational requirements

Oil-in-ice Code

Assessment of risk for oil spill

SNEBA (NOT SIMA)

- SNEBA is a planning tool
- Desktop analysis for environmentally assessing and preparing of oil spill combating
  - Potential
  - Strategy
  - Capacity building
- SNEBA results form base for a faster and more robust response in case of oil spill
- Decision-making tool on a scientific basis for, e.g.:
  - Activity oil spill contingency plan
  - National oil spill strategy
  - Cross-border and trans-boundary co-operation and agreements.

QUESTIONS?

SNEBA steps:

1
- Basic data and information

2
- Assessment

3
- Scores for the SNEBA

4
- Analysis through decision trees

5
- Interpretation and dissemination of SNEBA results

1) Basic information

Oil in m³	Sea surface	Seawater	Seabed	Shoreline	Total Volume
Marine Diesel	5	526	30	0	810
HFO (IFO-180)	1240	65	175	2020	3500
Crude oil (Statfjord)	350	14	126	504	1400

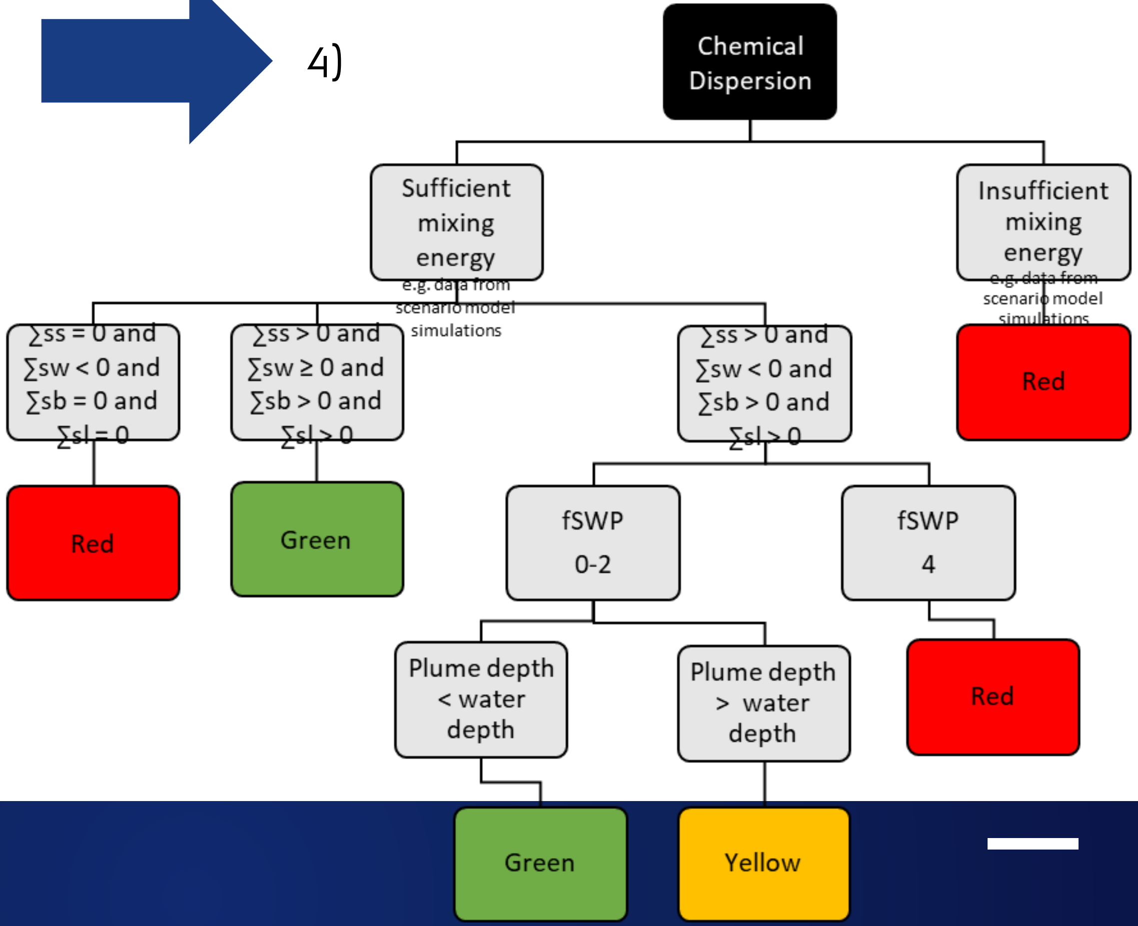
2) Assessments

	Dissolved or natural dispersed oil in seawater (m³)	Lowest EC_{50} or NEC for aquatic organisms (mg/l)	Seawater volume potentially polluted at a toxic level (m³) from natural dispersion	Sea area with potential oil concentration above levels for toxic effects to 15 m's depth from natural dispersion
Marine Diesel	526	0,7	750986	25033
HFO (IFO-180)	65	0,7	92857	3095
Crude oil (Statfjord)	14	0,7	20000	667

3) Scores

	Km/direction/%	Score			
		0	**2**	**4**	
Distance to inhabitation or sensitive organisms on land (km)[1]	*Insert value*	> 6	6-3	< 3	0
Prevailing wind direction towards inhabitation or animal congregations[1]	*Insert value*	No		Yes	4
Ice; red. albedo effect (% cover)[3]	*Insert value*	0-30	30-70	>70	4
				SP	8

4)



1) BASIC DATA

Step	Box
1) Basic data and information	
Definition of assessment area / waterbody	1.1
Definition of spill scenarios	1.2
Selection criteria for identification of species and organism groups of concern in the assessment area	1.3
Characterization of the assessment area's surroundings	1.4
Physical and chemical characterization of the water body in the assessment area	1.5
Characterization of the oil type(s) selected for the oil spill scenarios	1.6
Ecotoxicological data	1.7
Definitions of oil dispersion	1.8
Models for oil spill simulations	1.9

2) ASSESSMENT

Step	Box
2) Assessment	
Assumptions and criteria behind calculations of polluted areas / volumes	2.1
Calculation of sea surface, seawater, seabed and shoreline pollution	2.2
Evaluation of oxygen conditions	2.3
Evaluation of natural biodegradation potential	2.4
Description and assessment of oil spill response method efficiencies	2.5
Assessment of environmental pros and cons of oil spill response methods	2.6

3) SCORES

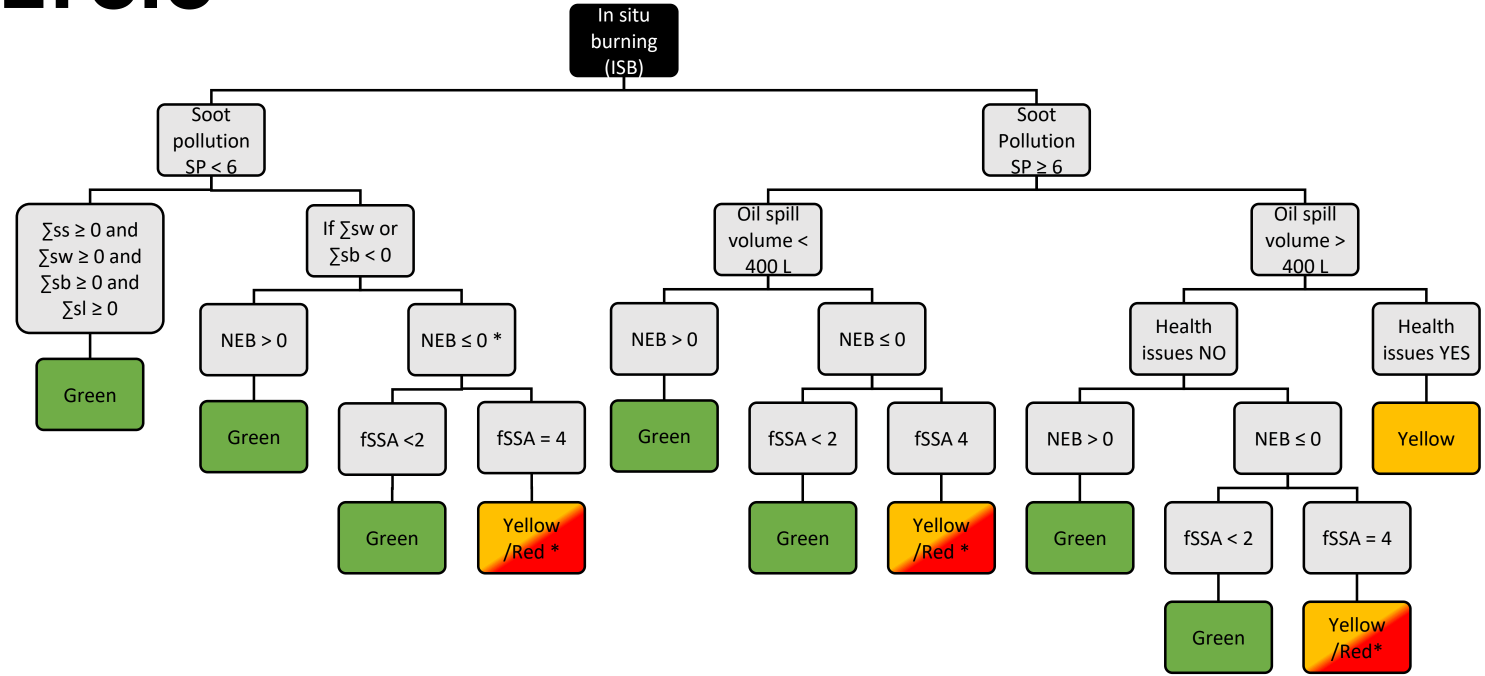
Step	Box
3) Scores for the SNEBA	
Score for NEB for identified species and organism of concern on sea surface, water column, sea bed and coast	3.1
Score for Soot Polution (SP) with respect to in situ burning (ISB) as oil spill response method	3.2
Score system for Damage Reduction (DaR) with respect to mechanical recovery as oil spill response method	3.3
Score system for pollution of sea surface, seawater, seabed and shoreline	3.4

4) ANALYSIS

Step	Decision tree
4) Analysis	
Mechanical recovery	MR
Chemical dispersion	CD
In situ burning (ISB)	ISB
Do nothing	DN

- for each of the four seasons (spring, summer, autumn and winter)

4) ANALYSIS



- In situ burning (ISB)
  - Soot pollution $SP < 6$
    - $\sum ss \geq 0$ and $\sum sw \geq 0$ and $\sum sb \geq 0$ and $\sum sl \geq 0$
      - Green
    - If $\sum sw$ or $\sum sb < 0$
      - $NEB > 0$
        - Green
      - $NEB \leq 0$ *
        - $fSSA <2$
          - Green
        - $fSSA = 4$
          - Yellow /Red *
  - Soot Pollution $SP \geq 6$
    - Oil spill volume < 400 L
      - $NEB > 0$
        - Green
      - $NEB \leq 0$
        - $fSSA < 2$
          - Green
        - fSSA 4
          - Yellow /Red *
    - Oil spill volume > 400 L
      - Health issues NO
        - $NEB > 0$
          - Green
        - $NEB \leq 0$
          - $fSSA < 2$
            - Green
          - $fSSA = 4$
            - Yellow /Red*
      - Health issues YES
        - Yellow

In situ burning
ISB_{spring}
ISB_{summer}
ISB_{autumn}
ISB_{winter}

5) INTERPRETATION AND DISSEMINATION

Step	Box
5) Interpretation and dissemination of the analysis	
SNEBA for mechanical recovery, chemical dispersion, in situ burning (ISB) and do nothing for the four seasons (spring, summer, autumn and winter)	5.1

SNEBA RESULTS

Green

The oil spill response method can be considered an option foroil spill combat in the assessment area for the specific season in order to obtain an overall environmental benefit from the oil spill response method operation.

Yellow

The oil spill response method man be considered an option for oil spill combat in the assessment area for the specific season, however, expert judgement is needed in the specific oil spill situation and season in order to obtain an overall environmental benefit from the oil spill response method operation

Red

The oil spill response method cannot be considered an option for oil spill combat in the assessment area for the specific season in order to obtain an overall environmental benefit from the oil spill response method operation.

SNEBA

- Oil spill response methods that may be **beneficial** for the environment in the assessment area in the different seasons.
- SNEBA results **do not compare** the oil spill response methods in order to select the best option.
- Several tools in the toolbox

Please note that the SNEBA must be followed by a Spill Impact Mitigation Analysis (SIMA) in the acute oil spill situation.

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GRACE

OPTIMIZATION OF OIL SPILL RESPONSE PLANNING AND PREPAREDNESS USING SPILL MITIGATION IMPACT ASSESSMENT (SIMA)

RICHARD J WENNING
PORTLAND, MAINE US

GRACE WORKSHOP
COPENHAGEN, 22 NOVEMBER 2018

RAMBOLL

Integrated
oil spill response
actions and
environmental effects
GRACE
2016-2019

DISCUSSION

sNEBA, NEBA and SIMA

NEBA Approaches in the Arctic & Elsewhere

Applying SIMA

Concluding Thoughts

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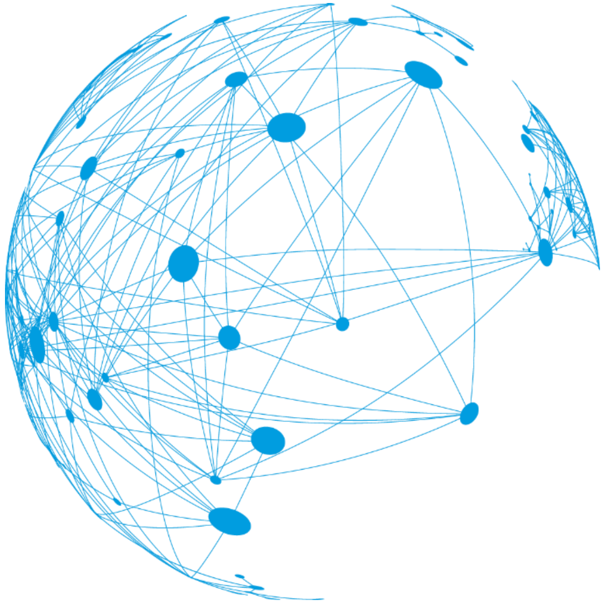
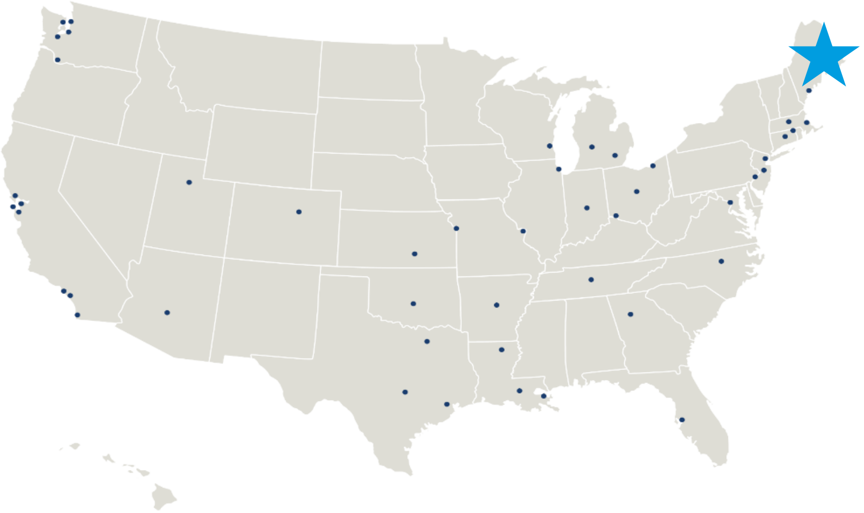
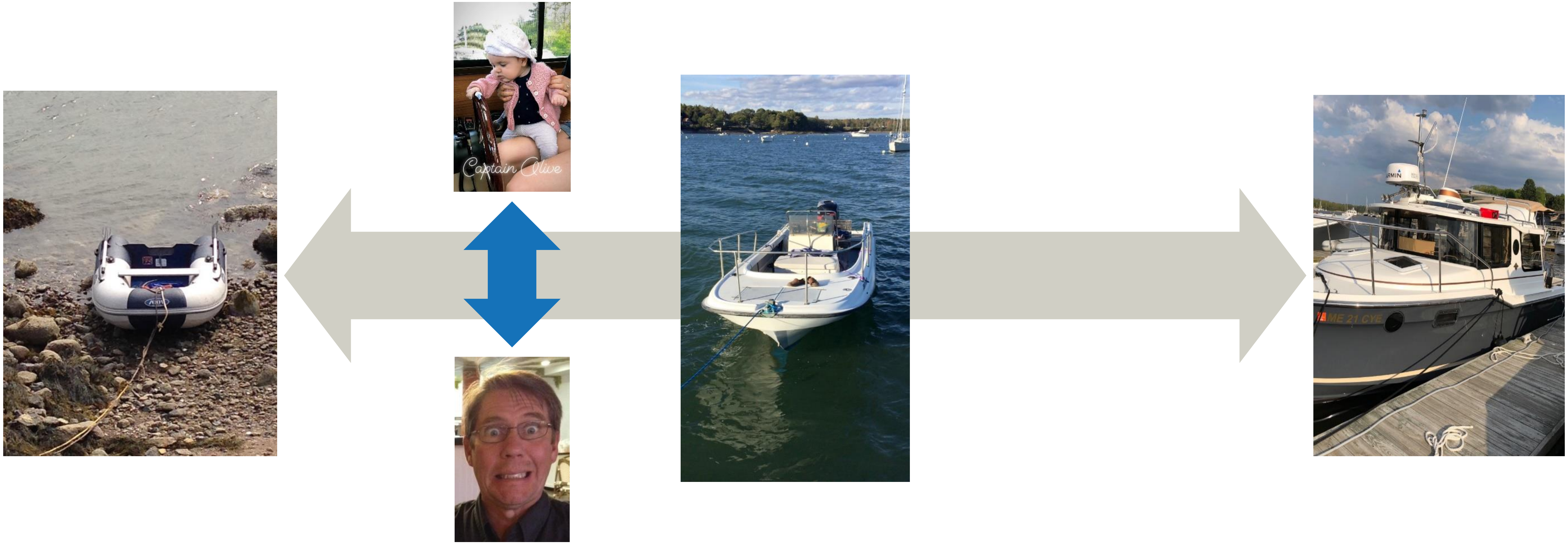
RICHARD J WENNING
Principal, Ecology Practice Leader

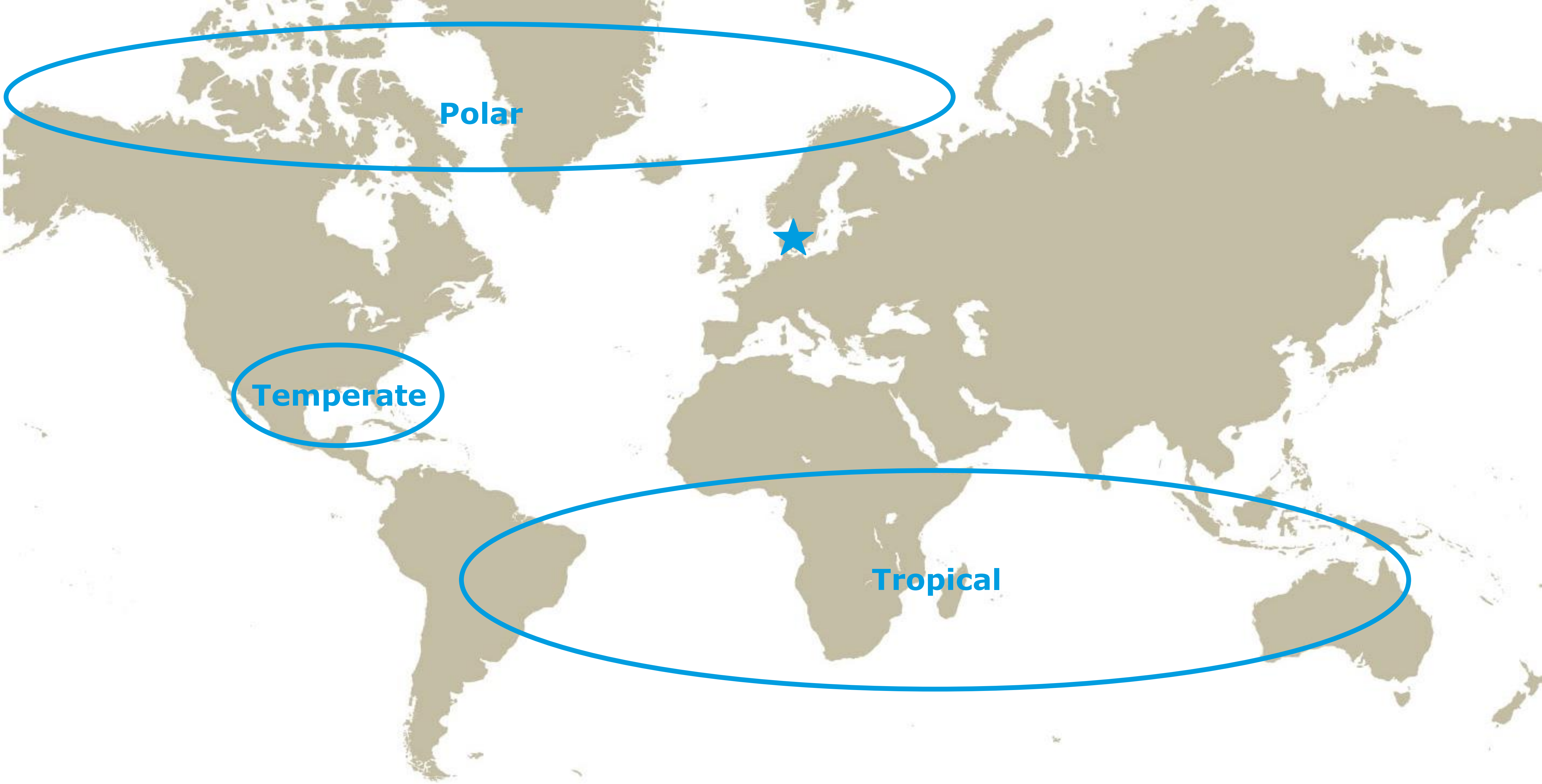
- POPs Ecotoxicology
- Health & Ecological Risk Assessment
- Sediment Quality & Clean-up Levels
- Oil Spill Assessment & Mitigation
- SETAC Editor-in-Chief, IEAM





COMPLEXITY




Polar
Temperate
Tropical

sNEBA, NEBA and SIMA

NEBA Approaches in the Arctic & Elsewhere

Applying SIMA

Concluding Thoughts

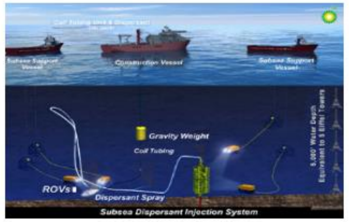
NET ENVIRONMENTAL BENEFIT ANALYSIS (NEBA)

- A risk-based, science-informed tool useful to support decisions to:
  - **Prepare a strategy** in-advance for an accident
  - **Minimize consequences** of an oil spill on people and the environment
  - **Optimize performance** of oil spill response activities
- Reveal **trade-offs** between oil spill responses (OSR)

✓ Contingency planning and preparedness

✓ Emergency response

In Situ Burning



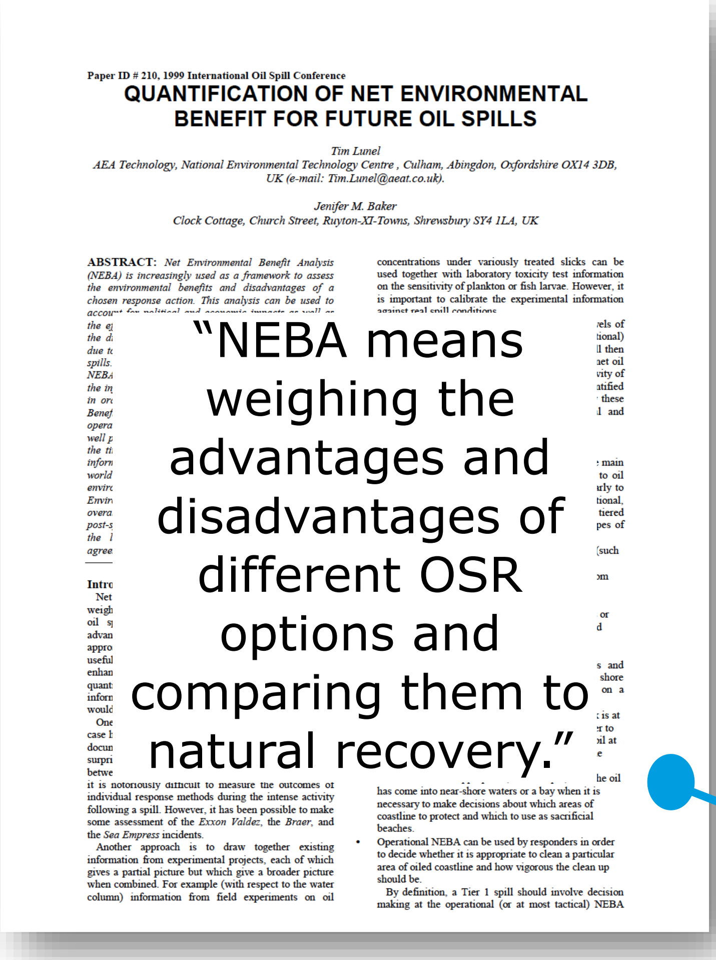
SSDI; Subsea Dispersant Injection

Surface Dispersant

Mechanical Recovery

Natural Recovery

NEBA 20 YEARS AGO



Paper ID # 210, 1999 International Oil Spill Conference

QUANTIFICATION OF NET ENVIRONMENTAL BENEFIT FOR FUTURE OIL SPILLS

Tim Lunel
AEA Technology, National Environmental Technology Centre , Culham, Abingdon, Oxfordshire OX14 3DB, UK (e-mail: Tim.Lunel@aeat.co.uk).

Jenifer M. Baker
Clock Cottage, Church Street, Ruyton-XI-Towns, Shrewsbury SY4 1LA, UK

ABSTRACT: *Net Environmental Benefit Analysis (NEBA) is increasingly used as a framework to assess the environmental benefits and disadvantages of a chosen response action. This analysis can be used to*

it is notoriously difficult to measure the outcomes of individual response methods during the intense activity following a spill. However, it has been possible to make some assessment of the *Exxon Valdez*, the *Braer*, and the *Sea Empress* incidents.

Another approach is to draw together existing information from experimental projects, each of which gives a partial picture but which give a broader picture when combined. For example (with respect to the water column) information from field experiments on oil

concentrations under variously treated slicks can be used together with laboratory toxicity test information on the sensitivity of plankton or fish larvae. However, it is important to calibrate the experimental information

has come into near-shore waters or a bay when it is necessary to make decisions about which areas of coastline to protect and which to use as sacrificial beaches.

- Operational NEBA can be used by responders in order to decide whether it is appropriate to clean a particular area of oiled coastline and how vigorous the clean up should be.

By definition, a Tier 1 spill should involve decision making at the operational (or at most tactical) NEBA

"NEBA means weighing the advantages and disadvantages of different OSR options and comparing them to natural recovery."

Lunel and Baker (1999)

3 NEBA Levels

Strategic... spill is out to sea

Tactical... spill is approaching the near-shore

Operational... spill cleanup is needed on shoreline

Exxon Valdez, US 1989

Braer, Shetlands Isl. 1993

Sea Empress, US 1996

3 Questions

1. Will the oil re-mobilize and affect other resources?
2. Is the oiling intensity sufficiently extreme to justify cleanup for ecological reasons?
3. Are there socio-economic reasons that over-ride ecological reasons?

THE EARLY YEARS…

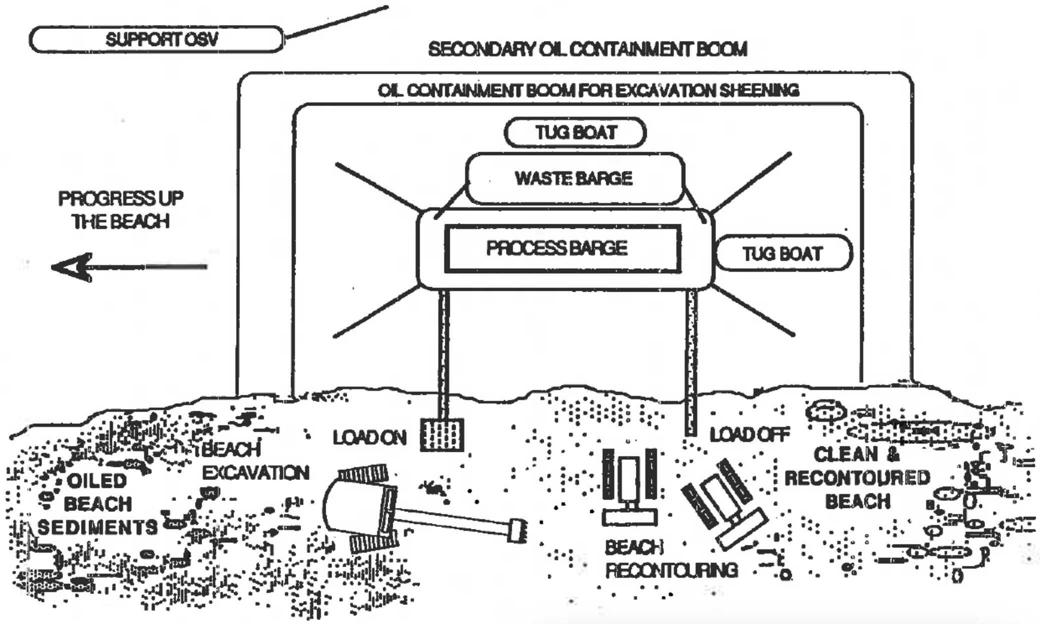
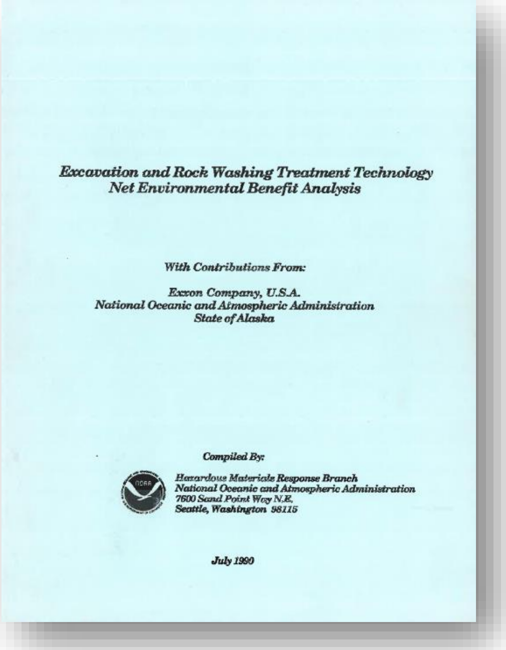


Figure I-2. Beach excavation rock washing project.

1990



Excavation and Rock Washing Treatment Technology
Net Environmental Benefit Analysis

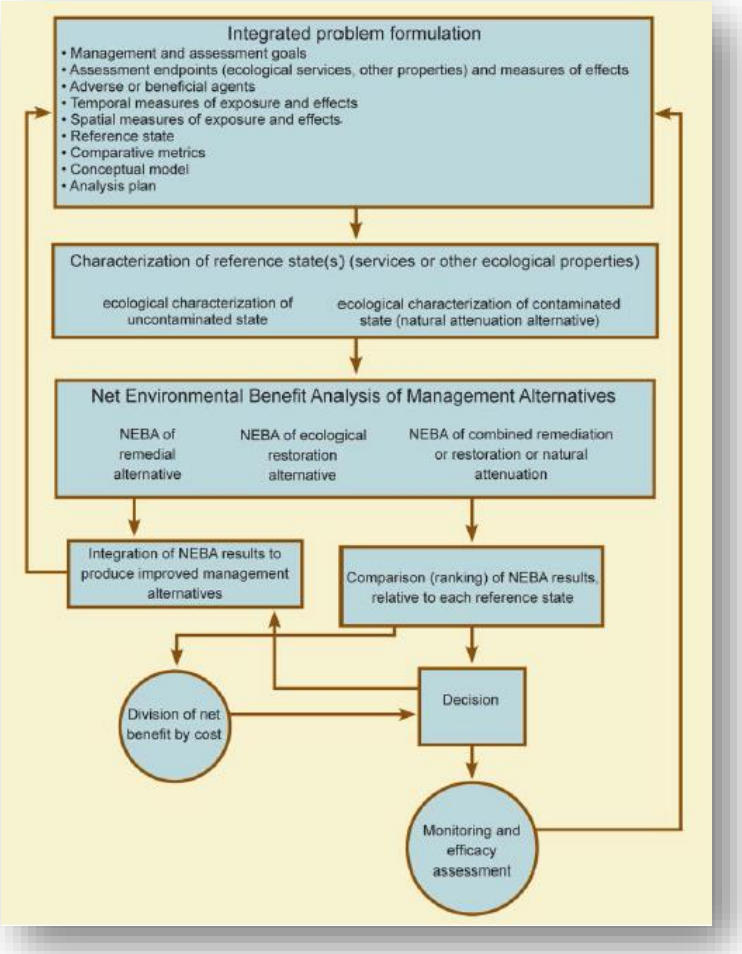
With Contributions From:

Exxon Company, U.S.A.
National Oceanic and Atmospheric Administration
State of Alaska

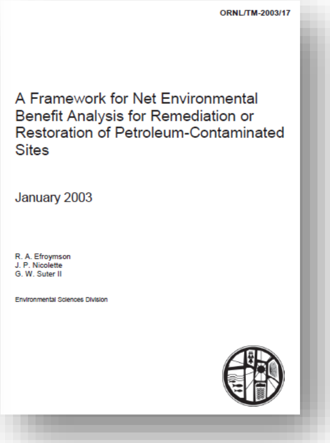
Compiled By:

Hazardous Materials Response Branch
National Oceanic and Atmospheric Administration
7600 Sand Point Way N.E.
Seattle, Washington 98115

July 1990



2003



ORNL/TM-2003/17

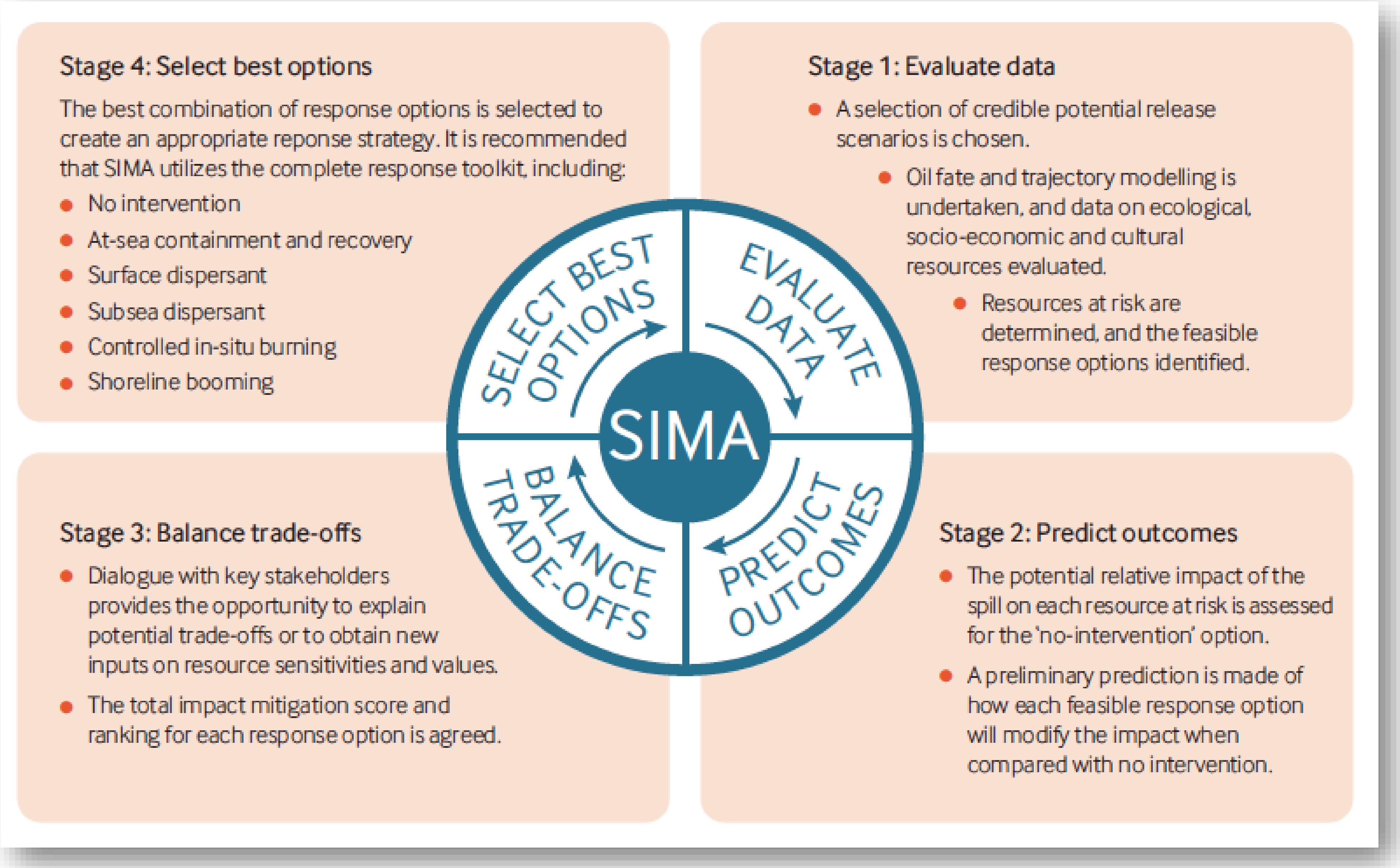
A Framework for Net Environmental Benefit Analysis for Remediation or Restoration of Petroleum-Contaminated Sites

January 2003

R. A. Efroymson
J. P. Nicolette
G. W. Suter II

Environmental Sciences Division

CURRENT 4-STEP FRAMEWORK



Stage 4: Select best options

The best combination of response options is selected to create an appropriate reponse strategy. It is recommended that SIMA utilizes the complete response toolkit, including:

- No intervention
- At-sea containment and recovery
- Surface dispersant
- Subsea dispersant
- Controlled in-situ burning
- Shoreline booming

Stage 1: Evaluate data

- A selection of credible potential release scenarios is chosen.
  - Oil fate and trajectory modelling is undertaken, and data on ecological, socio-economic and cultural resources evaluated.
    - Resources at risk are determined, and the feasible response options identified.

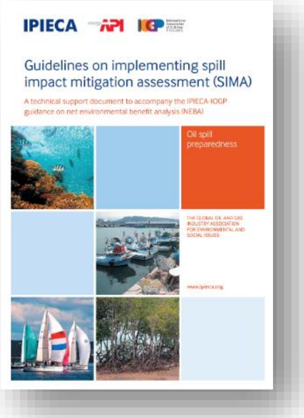
Stage 3: Balance trade-offs

- Dialogue with key stakeholders provides the opportunity to explain potential trade-offs or to obtain new inputs on resource sensitivities and values.
- The total impact mitigation score and ranking for each response option is agreed.

Stage 2: Predict outcomes

- The potential relative impact of the spill on each resource at risk is assessed for the 'no-intervention' option.
- A preliminary prediction is made of how each feasible response option will modify the impact when compared with no intervention.

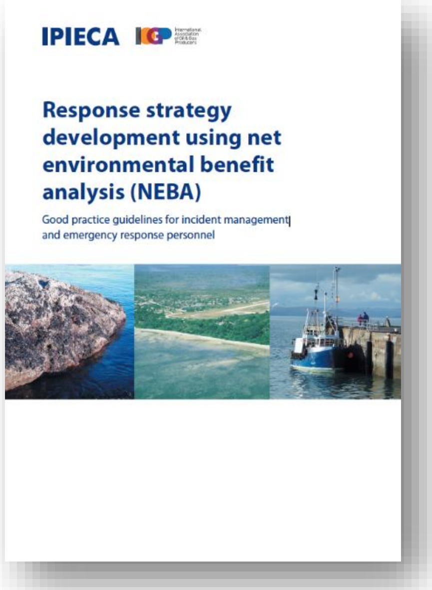
2017



Guidelines on implementing spill impact mitigation assessment (SIMA)

A technical support document to accompany the IPIECA-IOGP guidance on net environmental benefit analysis (NEBA)

RESPONSE STRATEGY DEVELOPMENT USING NEBA

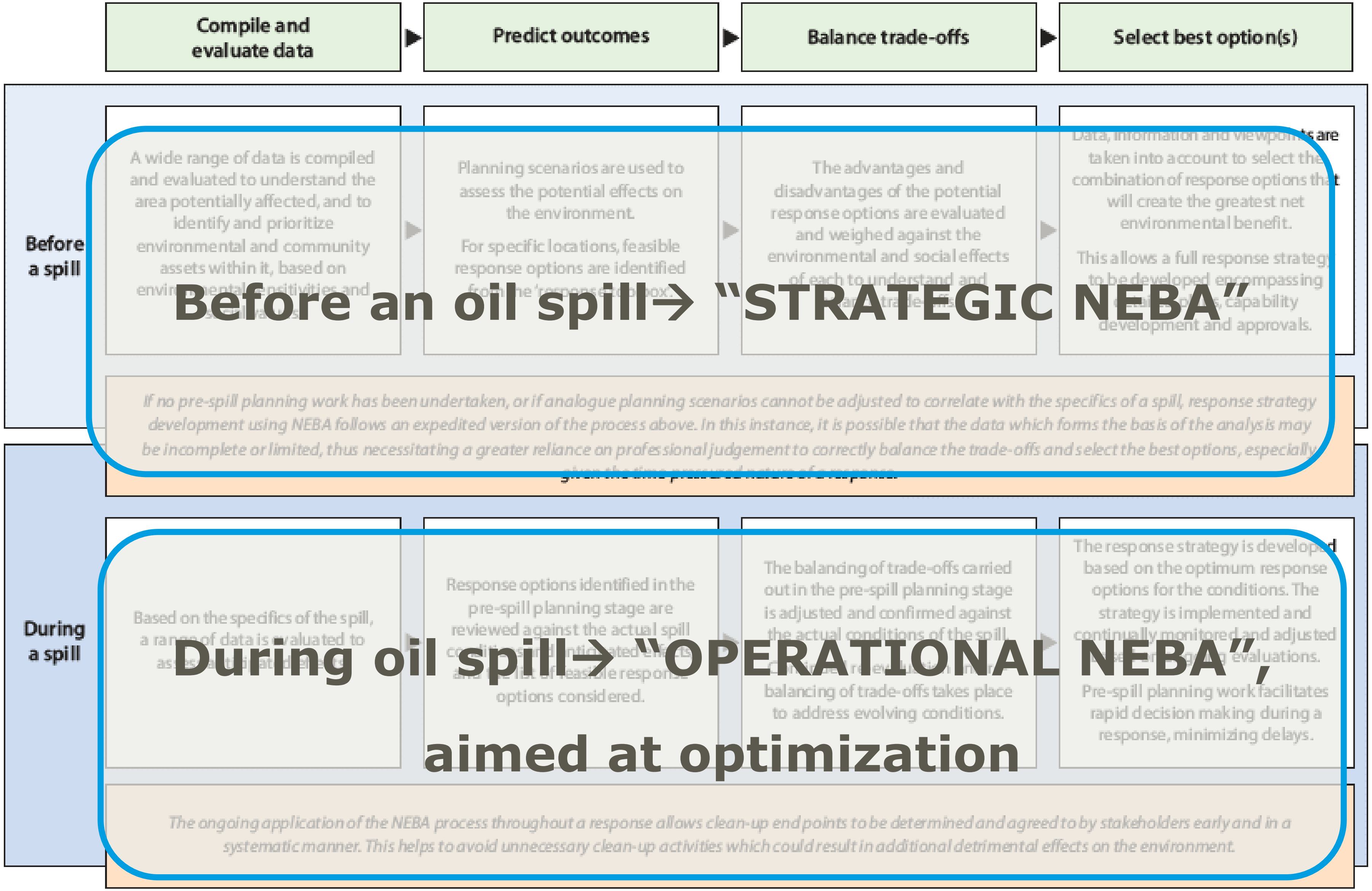


IPIECA IOGP

Response strategy development using net environmental benefit analysis (NEBA)

Good practice guidelines for incident management and emergency response personnel

IPIECA 2015



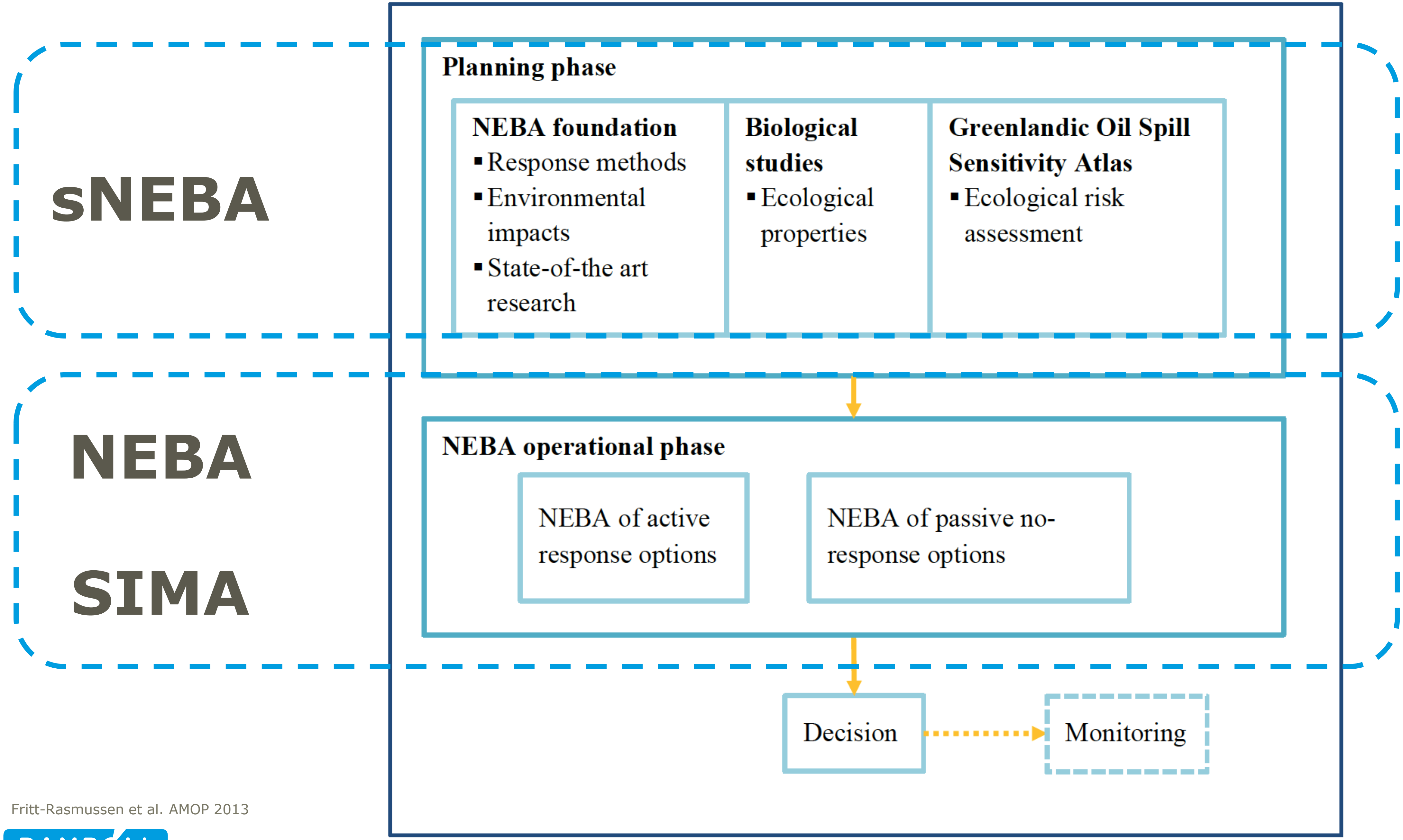
	Compile and evaluate data	Predict outcomes	Balance trade-offs	Select best option(s)
Before a spill	A wide range of data is compiled and evaluated to understand the area potentially affected, and to identify and prioritize environmental and community assets within it, based on environmental sensitivities and social values.	Planning scenarios are used to assess the potential effects on the environment. For specific locations, feasible response options are identified from the 'response toolbox'.	The advantages and disadvantages of the potential response options are evaluated and weighed against the environmental and social effects of each to understand and balance trade-offs.	Data, information and viewpoints are taken into account to select the combination of response options that will create the greatest net environmental benefit. This allows a full response strategy to be developed encompassing detailed plans, capability development and approvals.
During a spill	Based on the specifics of the spill, a range of data is evaluated to assess anticipated effects.	Response options identified in the pre-spill planning stage are reviewed against the actual spill conditions and anticipated effects and the list of feasible response options considered.	The balancing of trade-offs carried out in the pre-spill planning stage is adjusted and confirmed against the actual conditions of the spill. Continued re-evaluation and re-balancing of trade-offs takes place to address evolving conditions.	The response strategy is developed based on the optimum response options for the conditions. The strategy is implemented and continually monitored and adjusted based on ongoing evaluations. Pre-spill planning work facilitates rapid decision making during a response, minimizing delays.

If no pre-spill planning work has been undertaken, or if analogue planning scenarios cannot be adjusted to correlate with the specifics of a spill, response strategy development using NEBA follows an expedited version of the process above. In this instance, it is possible that the data which forms the basis of the analysis may be incomplete or limited, thus necessitating a greater reliance on professional judgement to correctly balance the trade-offs and select the best options, especially given the time-pressured nature of a response.

The ongoing application of the NEBA process throughout a response allows clean-up end points to be determined and agreed to by stakeholders early and in a systematic manner. This helps to avoid unnecessary clean-up activities which could result in additional detrimental effects on the environment.

Before an oil spill→ "STRATEGIC NEBA"

During oil spill→ "OPERATIONAL NEBA", aimed at optimization



sNEBA

NEBA

SIMA

Planning phase

NEBA foundation
- Response methods
- Environmental impacts
- State-of-the art research

Biological studies
- Ecological properties

Greenlandic Oil Spill Sensitivity Atlas
- Ecological risk assessment

NEBA operational phase

NEBA of active response options

NEBA of passive no-response options

Decision

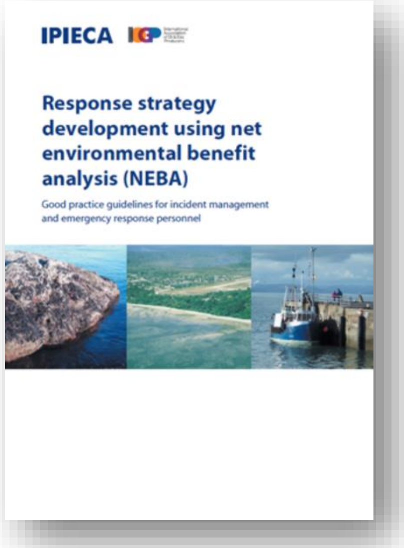
Monitoring

Figure 4 **Conceptual outline of the structure for the NEBA: the planning phase and the operational phase.**

Fritt-Rasmussen et al. AMOP 2013

NEBA

… environmental benefits of an oil spill ?



IPIECA

Response strategy development using net environmental benefit analysis (NEBA)

Good practice guidelines for incident management and emergency response personnel

SIMA

… mitigate the environmental consequences of an oil spill

IPIECA

Guidelines on implementing spill impact mitigation assessment (SIMA)

A technical support document to accompany the IPIECA-IOGP guidance on net environmental benefit analysis (NEBA)

Oil spill preparedness

THE GLOBAL OIL AND GAS INDUSTRY ASSOCIATION FOR ENVIRONMENTAL AND SOCIAL ISSUES

www.ipieca.org

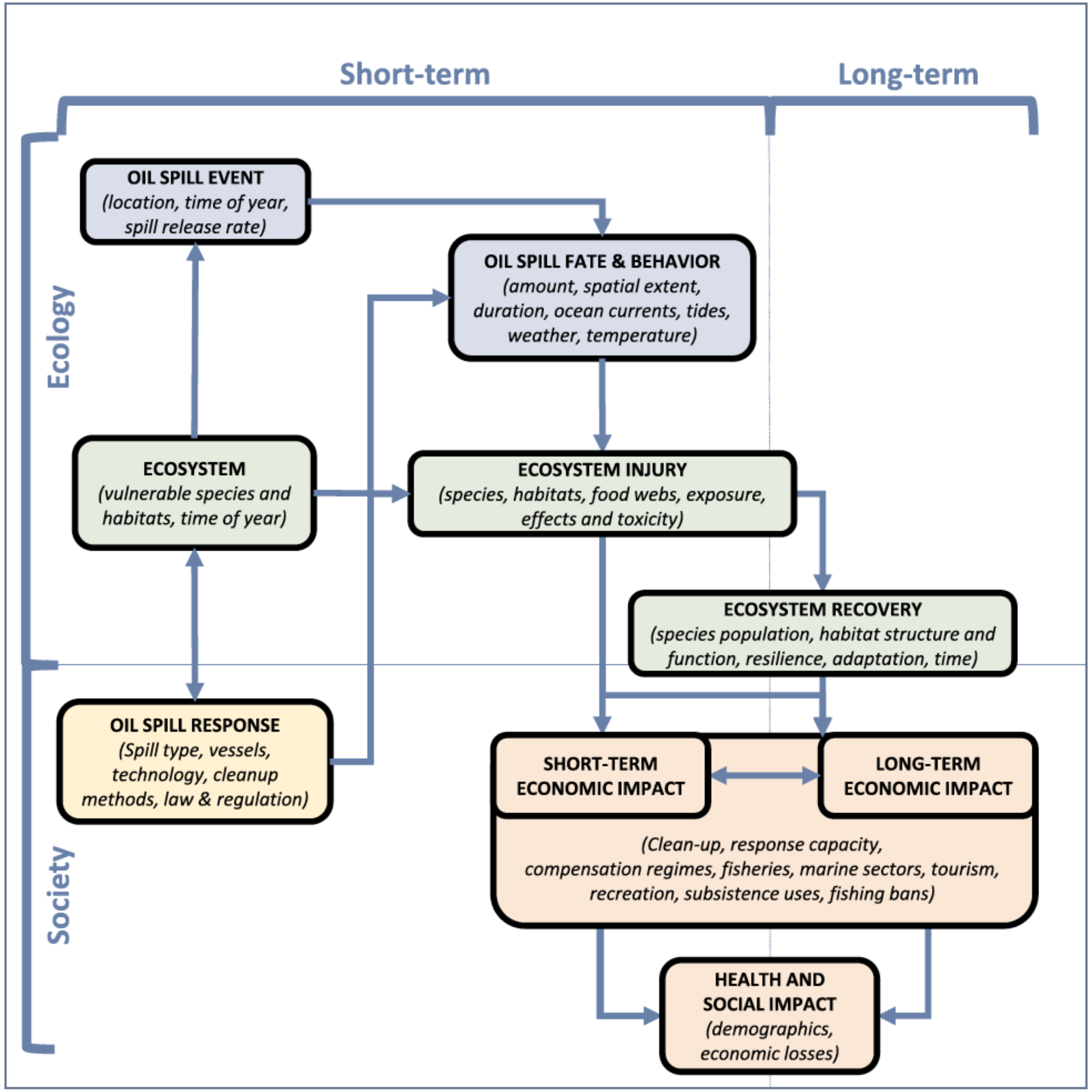
INTEGRATING ENVIRONMENTAL SCIENCE, ASSESSMENT, AND RESPONSE ACTIONS

Link the spill event to oil behavior (**blue**)

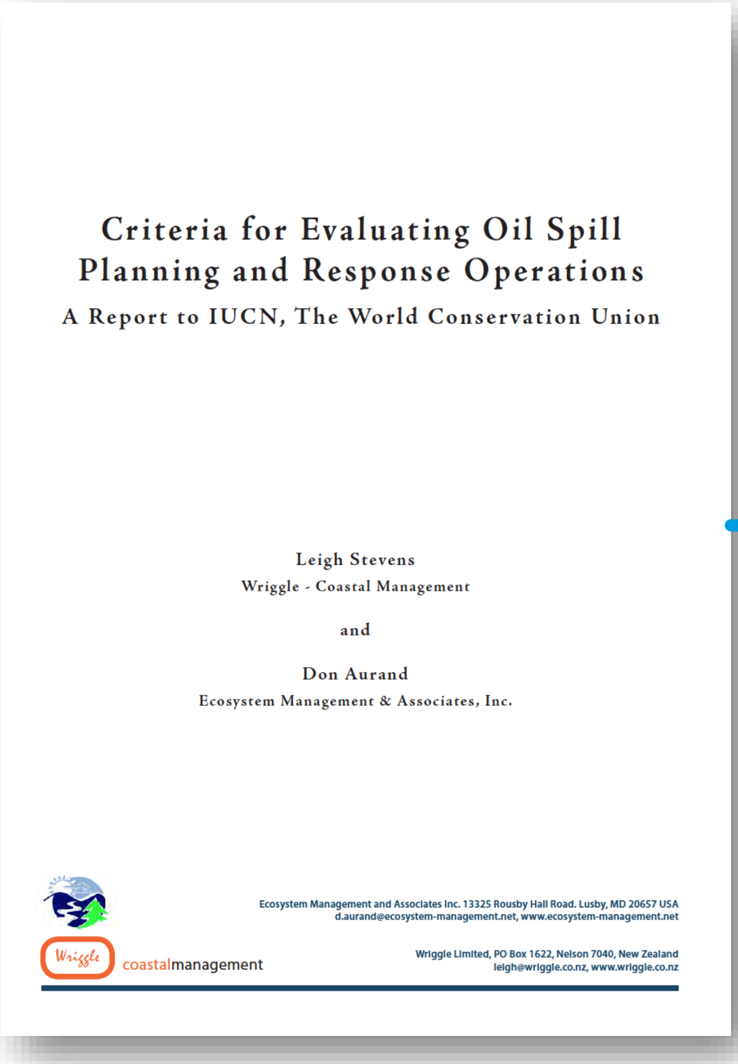
Connect the ecosystem with potential for injury and recovery (**green**)

Consider short- and long-term consequences (**orange**)

Chang et al. *Ecol. Soc.* 19(2):26. 2014.



COMPLEXITY (AGAIN)



Criteria for Evaluating Oil Spill Planning and Response Operations

A Report to IUCN, The World Conservation Union

Leigh Stevens
Wriggle - Coastal Management

and

Don Aurand
Ecosystem Management & Associates, Inc.

Ecosystem Management and Associates Inc. 13325 Rousby Hall Road. Lusby, MD 20657 USA
d.aurand@ecosystem-management.net, www.ecosystem-management.net

Wriggle coastalmanagement

Wriggle Limited, PO Box 1622, Nelson 7040, New Zealand
leigh@wriggle.co.nz, www.wriggle.co.nz

2008

"…this type of assessment is ***often very difficult, if not impossible, to achieve*** *due to:*

- *Limitations in the available scientific information*
- *Variability in conditions, which may occur at the time of the spill*

… ***there is a point at which a decision (often subjective and contested by stakeholders) will still need to be made regarding how much scientific information is enough, and how much variability can and should be accounted for*** *in the planning process."*

(Section 2.6, p. 9)

sNEBA, NEBA and SIMA

NEBA Approaches in the Arctic & Elsewhere

Applying SIMA

Concluding Thoughts

THERE ARE SEVERAL NEBA APPROACHES

- Net Environmental Benefits Analysis (NEBA), (IPIECA 2015)
- Guidelines on implementing spill impact mitigation assessment (SIMA), (IPIECA 2018)
- Consensus Ecological Risk Assessment (CERA), (Aurand *et al*. 2000, 2012; BREA 2011)
- Net Environmental Damage and Response Assessment (NEDRA), (SINTEF 2012)
- Marginal Ice Risk Assessment (MIRA), (DNV-GL 2014)
- ERA Acute, (Stephansen *et al.* 2017)
- Baysian Model for Arctic Risk Assessment, (Nevalainen *et al.* 2017)
- Comparative Risk Assessment (CRA), (French McKay, Bock, Walker *et al.* 2018)

Marine Environmental Research 141 (2018) 289–304

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ELSEVIER

Current practices and knowledge supporting oil spill risk assessment in the Arctic

Richard J. Wenning[a,*], Hilary Robinson[b], Michael Bock[a], Mary Ann Rempel-Hester[c], William Gardiner[d]

[a] Ramboll US, 136 Commercial Street, Suite 402, Portland, ME, 04101, United States
[b] Ramboll US, 4350 N Fairfax Drive, Suite 300, Arlington, VA, 22203, United States
[c] EcoAnalysts, 4729 NE View Drive, Port Gamble, WA, 98364, United States
[d] Technical Services Branch, Seattle District, U.S. Army Corps of Engineers, 4735 East Marginal Way South, Seattle, WA, 98134, United States

ARTICLE INFO

Keywords:
Arctic
Comparative risk assessment (CRA)
Oil spill response
Net environmental benefits analysis (NEBA)
Spill impact mitigation assessment (SIMA)

ABSTRACT

Oil spill response (OSR) in the Arctic marine environment conducted as part of operational planning and preparedness supporting exploration and development is most successful when knowledge of the ecosystem is readily available and applicable in an oil spill risk assessment framework. OSR strategies supporting decision-making during the critical period after a spill event should be explicit about the environmental resources potentially at risk and the efficacy of OSR countermeasures that best protect sensitive and valued resources. At present, there are 6 prominent methods for spill impact mitigation assessment (SIMA) in the Arctic aimed at supporting OSR and operational planning and preparedness; each method examines spill scenarios and identifies response strategies best suited to overcome the unique challenges posed by polar ecosystems and to minimize potential long-term environmental consequences. The different methods are grounded in classical environmental risk assessment and the net environmental benefit analysis (NEBA) approach that emerged in the 1990s after the Exxon Valdez oil spill. The different approaches share 5 primary assessment elements (oil physical and chemical properties, fate and transport, exposure, effects and consequence analysis). This paper highlights how the different Arctic methods reflect this common risk assessment framework and share a common need for oil spill science relevant to Arctic ecosystems. An online literature navigation portal, developed as part of the 5-year Arctic Oil Spill Response Technologies Joint Industry Programme, complements the different approaches currently used in the Arctic by capturing the rapidly expanding body of scientific knowledge useful to evaluating exposure, vulnerability and recovery of the Arctic ecosystem after an oil spill.

1. Introduction

The changing Arctic environment is creating new opportunities for energy, shipping, and other resource and economic development activities, at the same time generating heretofore unanticipated environmental, economic and social concerns (Pettersen and Song, 2017; DNV-GL, 2016; NPC, 2015; NRC, 2014; CFR, 2014; Lloyds, 2012; Arctic Council, 2009). Oil and gas exploration and production, in particular, is rapidly expanding and further increases in shipping and development are virtually certain in the coming decades (Knol and Arbo, 2014). The protection of the Arctic environment has become of paramount concern.

Accordingly, governments, international organizations and several multi-national energy and resource development companies are working to formulate strategies that minimize their impacts on Arctic communities and the environment. The International Maritime Organization (IMO) has adopted the International Code for Ships Operating in Polar Waters (Polar Code), which includes mandatory measures covering safety and pollution prevention for a broad range of commercial shipping activities (IMO, 2014). Similarly, the Arctic Council has issued international oversight and operating guidelines for transportation and for both mining and oil and gas exploration and development (Arctic Council, 2015; Tucci, 2008). Regulatory and international authorities are requiring accident preparedness and response plans for oil pipelines, transportation, exploration and production activities (IMO, 2014; Tuler et al., 2007; Ornitz and Champ, 2002). Frequent engagements between governments, stakeholders and other organizations are increasingly included as part of oil spill response

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[*] Corresponding author.
E-mail address: rjwenning@ramboll.com (R.J. Wenning).

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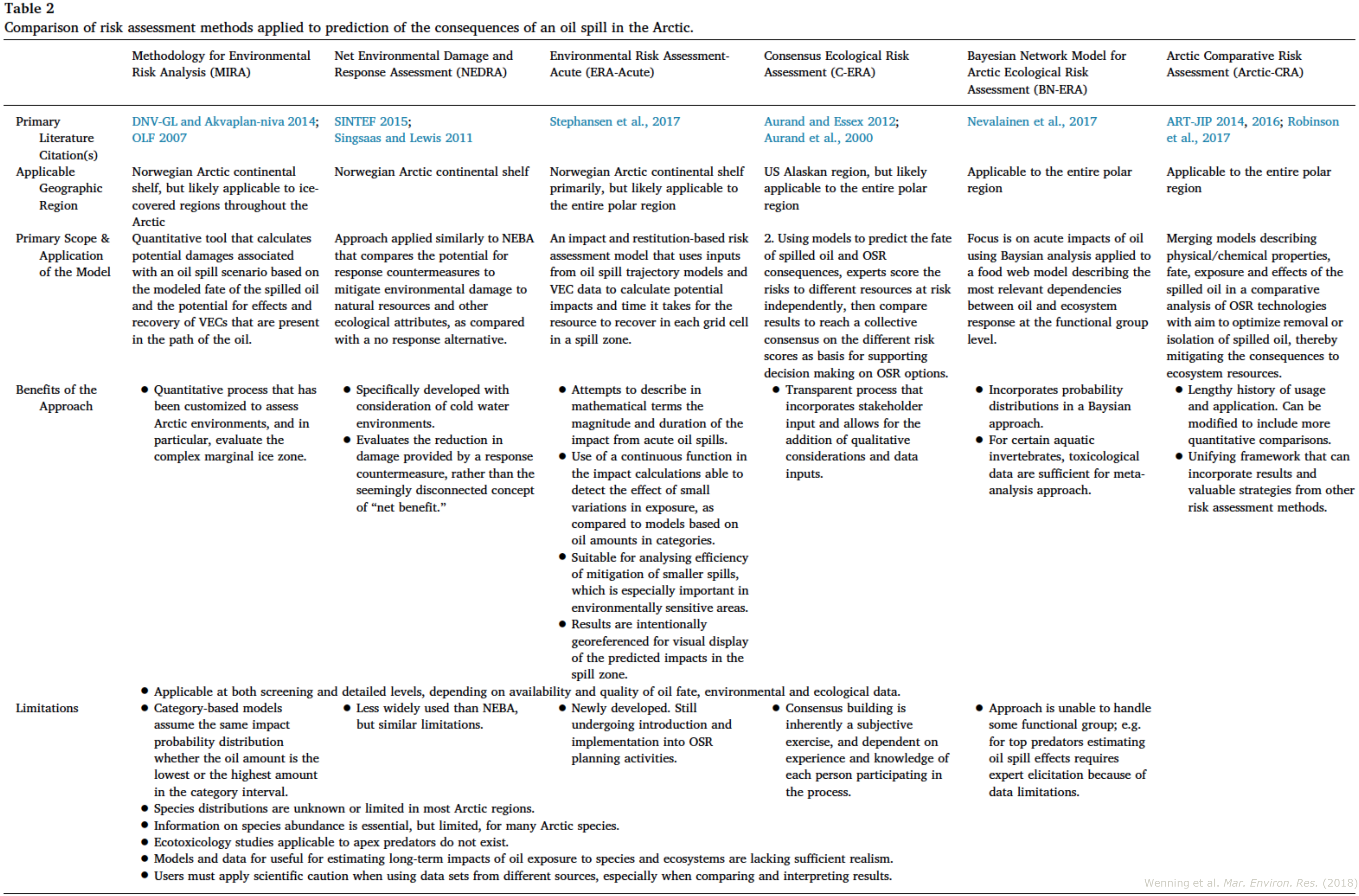


Table 2

Comparison of risk assessment methods applied to prediction of the consequences of an oil spill in the Arctic.

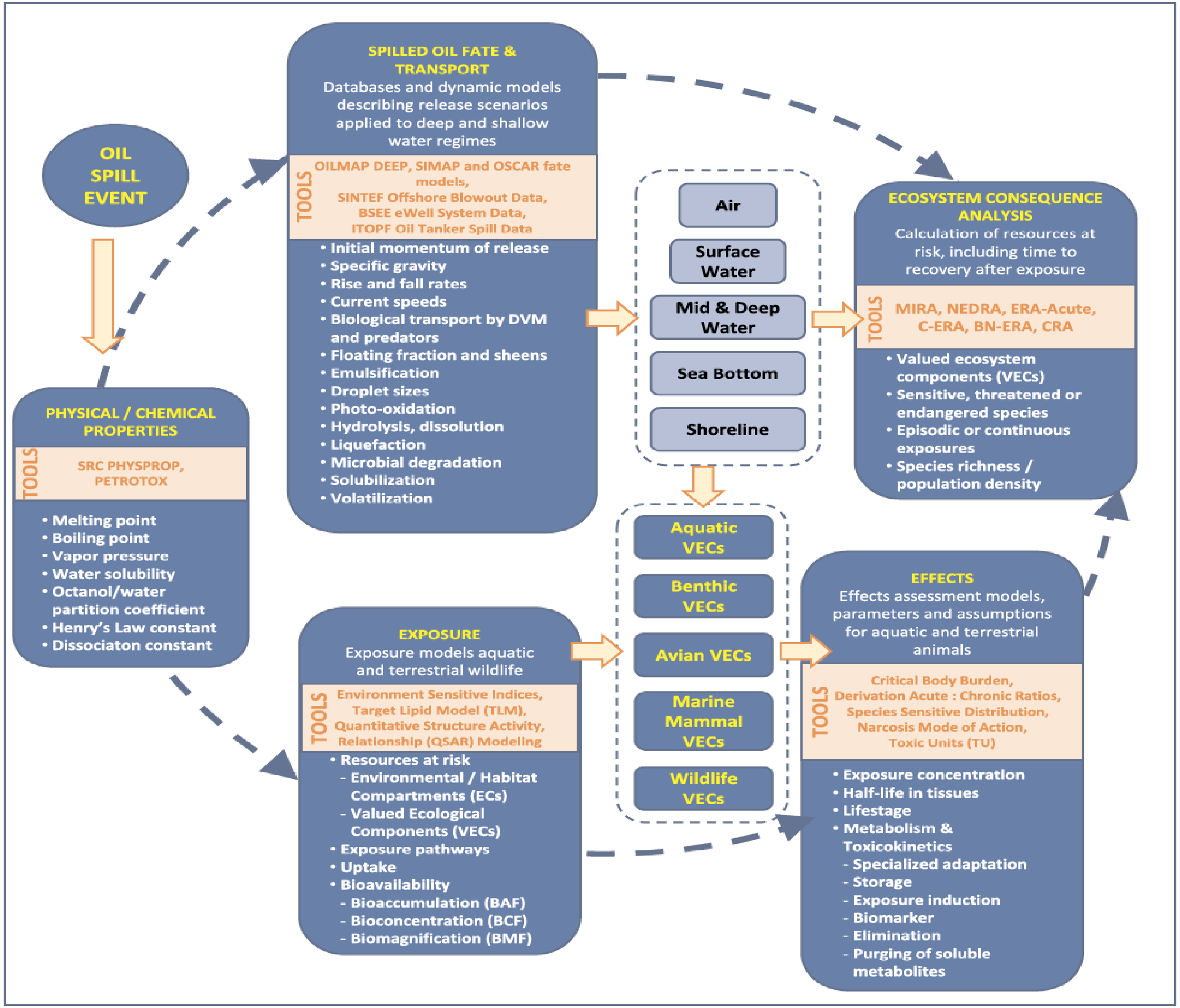
	Methodology for Environmental Risk Analysis (MIRA)	Net Environmental Damage and Response Assessment (NEDRA)	Environmental Risk Assessment-Acute (ERA-Acute)	Consensus Ecological Risk Assessment (C-ERA)	Bayesian Network Model for Arctic Ecological Risk Assessment (BN-ERA)	Arctic Comparative Risk Assessment (Arctic-CRA)
Primary Literature Citation(s)	DNV-GL and Akvaplan-niva 2014; OLF 2007	SINTEF 2015; Singsaas and Lewis 2011	Stephansen et al., 2017	Aurand and Essex 2012; Aurand et al., 2000	Nevalainen et al., 2017	ART-JIP 2014, 2016; Robinson et al., 2017
Applicable Geographic Region	Norwegian Arctic continental shelf, but likely applicable to ice-covered regions throughout the Arctic	Norwegian Arctic continental shelf	Norwegian Arctic continental shelf primarily, but likely applicable to the entire polar region	US Alaskan region, but likely applicable to the entire polar region	Applicable to the entire polar region	Applicable to the entire polar region
Primary Scope & Application of the Model	Quantitative tool that calculates potential damages associated with an oil spill scenario based on the modeled fate of the spilled oil and the potential for effects and recovery of VECs that are present in the path of the oil.	Approach applied similarly to NEBA that compares the potential for response countermeasures to mitigate environmental damage to natural resources and other ecological attributes, as compared with a no response alternative.	An impact and restitution-based risk assessment model that uses inputs from oil spill trajectory models and VEC data to calculate potential impacts and time it takes for the resource to recover in each grid cell in a spill zone.	2. Using models to predict the fate of spilled oil and OSR consequences, experts score the risks to different resources at risk independently, then compare results to reach a collective consensus on the different risk scores as basis for supporting decision making on OSR options.	Focus is on acute impacts of oil using Baysian analysis applied to a food web model describing the most relevant dependencies between oil and ecosystem response at the functional group level.	Merging models describing physical/chemical properties, fate, exposure and effects of the spilled oil in a comparative analysis of OSR technologies with aim to optimize removal or isolation of spilled oil, thereby mitigating the consequences to ecosystem resources.
Benefits of the Approach	● Quantitative process that has been customized to assess Arctic environments, and in particular, evaluate the complex marginal ice zone.	● Specifically developed with consideration of cold water environments. ● Evaluates the reduction in damage provided by a response countermeasure, rather than the seemingly disconnected concept of "net benefit."	● Attempts to describe in mathematical terms the magnitude and duration of the impact from acute oil spills. ● Use of a continuous function in the impact calculations able to detect the effect of small variations in exposure, as compared to models based on oil amounts in categories. ● Suitable for analysing efficiency of mitigation of smaller spills, which is especially important in environmentally sensitive areas. ● Results are intentionally georeferenced for visual display of the predicted impacts in the spill zone.	● Transparent process that incorporates stakeholder input and allows for the addition of qualitative considerations and data inputs.	● Incorporates probability distributions in a Baysian approach. ● For certain aquatic invertebrates, toxicological data are sufficient for meta-analysis approach.	● Lengthy history of usage and application. Can be modified to include more quantitative comparisons. ● Unifying framework that can incorporate results and valuable strategies from other risk assessment methods.
	● Applicable at both screening and detailed levels, depending on availability and quality of oil fate, environmental and ecological data.					
Limitations	● Category-based models assume the same impact probability distribution whether the oil amount is the lowest or the highest amount in the category interval.	● Less widely used than NEBA, but similar limitations.	● Newly developed. Still undergoing introduction and implementation into OSR planning activities.	● Consensus building is inherently a subjective exercise, and dependent on experience and knowledge of each person participating in the process.	● Approach is unable to handle some functional group; e.g. for top predators estimating oil spill effects requires expert elicitation because of data limitations.	
	● Species distributions are unknown or limited in most Arctic regions. ● Information on species abundance is essential, but limited, for many Arctic species. ● Ecotoxicology studies applicable to apex predators do not exist. ● Models and data for useful for estimating long-term impacts of oil exposure to species and ecosystems are lacking sufficient realism. ● Users must apply scientific caution when using data sets from different sources, especially when comparing and interpreting results.					

Wenning et al. *Mar. Environ. Res.* (2018)

SHARED ASSESSMENT CHALLENGES

- ➢ Identify resources potentially at risk
- ➢ Collect relevant fate and effects data from field and laboratory research
- ➢ Learn from prior spill events in similar environments and time of year

Wenning et al. *Mar. Pollut. Bull.* 141:289. 2018



OIL SPILL EVENT

PHYSICAL / CHEMICAL PROPERTIES

TOOLS: SRC PHYSPROP, PETROTOX

- Melting point
- Boiling point
- Vapor pressure
- Water solubility
- Octanol/water partition coefficient
- Henry's Law constant
- Dissociaton constant

SPILLED OIL FATE & TRANSPORT

Databases and dynamic models describing release scenarios applied to deep and shallow water regimes

TOOLS: OILMAP DEEP, SIMAP and OSCAR fate models, SINTEF Offshore Blowout Data, BSEE eWell System Data, ITOPF Oil Tanker Spill Data

- Initial momentum of release
- Specific gravity
- Rise and fall rates
- Current speeds
- Biological transport by DVM and predators
- Floating fraction and sheens
- Emulsification
- Droplet sizes
- Photo-oxidation
- Hydrolysis, dissolution
- Liquefaction
- Microbial degradation
- Solubilization
- Volatilization

Air

Surface Water

Mid & Deep Water

Sea Bottom

Shoreline

ECOSYSTEM CONSEQUENCE ANALYSIS

Calculation of resources at risk, including time to recovery after exposure

TOOLS: MIRA, NEDRA, ERA-Acute, C-ERA, BN-ERA, CRA

- Valued ecosystem components (VECs)
- Sensitive, threatened or endangered species
- Episodic or continuous exposures
- Species richness / population density

EXPOSURE

Exposure models aquatic and terrestrial wildlife

TOOLS: Environment Sensitive Indices, Target Lipid Model (TLM), Quantitative Structure Activity, Relationship (QSAR) Modeling

- Resources at risk
  - Environmental / Habitat Compartments (ECs)
  - Valued Ecological Components (VECs)
- Exposure pathways
- Uptake
- Bioavailability
  - Bioaccumulation (BAF)
  - Bioconcentration (BCF)
  - Biomagnification (BMF)

Aquatic VECs

Benthic VECs

Avian VECs

Marine Mammal VECs

Wildlife VECs

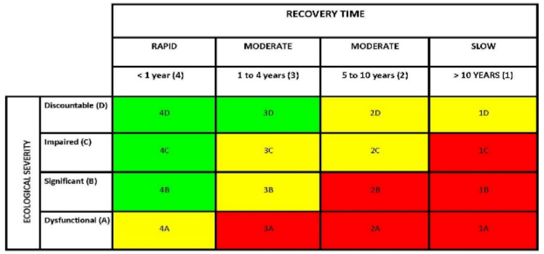
EFFECTS

Effects assessment models, parameters and assumptions for aquatic and terrestrial animals

TOOLS: Critical Body Burden, Derivation Acute : Chronic Ratios, Species Sensitive Distribution, Narcosis Mode of Action, Toxic Units (TU)

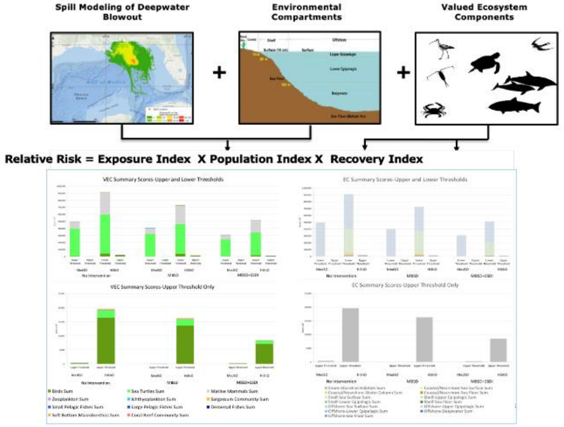
- Exposure concentration
- Half-life in tissues
- Lifestage
- Metabolism & Toxicokinetics
  - Specialized adaptation
  - Storage
  - Exposure induction
  - Biomarker
  - Elimination
  - Purging of soluble metabolites

COMPLEXITY (AGAIN)



		RECOVERY TIME			
		RAPID	MODERATE	MODERATE	SLOW
		< 1 year (4)	1 to 4 years (3)	5 to 10 years (2)	> 10 YEARS (1)
ECOLOGICAL SEVERITY	Discountable (D)	4D	3D	2D	1D
	Impaired (C)	4C	3C	2C	1C
	Significant (B)	4B	3B	2B	1B
	Dysfunctional (A)	4A	3A	2A	1A

C-ERA Decision Framework
(Walker et al. 2016)



CRA-SIMA
(French McKay, Bock et al. 2018)

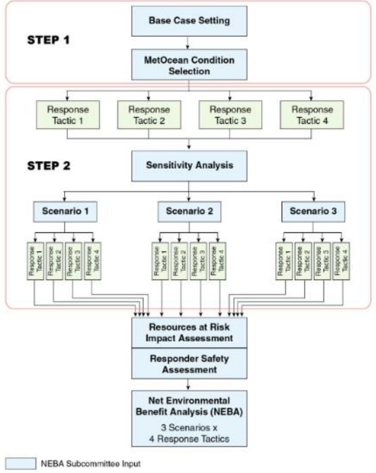
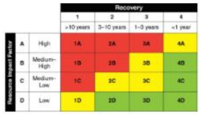


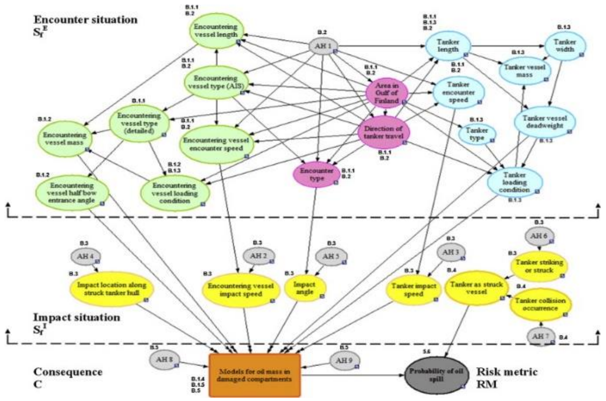
Figure 1. Proposed technical approach using a deterministic identification of Metocean conditions and scenario selection. Points of client input are indicated in blue.



Resource Impact Factor		Recovery			
		1	2	3	4
		>10 years	3-10 years	1-3 years	<1 year
A	High	1A	2A	3A	4A
B	Medium-High	1B	2B	3B	4B
C	Medium-Low	1C	2C	3C	4C
D	Low	1D	2D	3D	4D

Figure 2. Levels of concern (LOC) for RAR will be assigned using a matrix that includes the magnitude of the resource impact factor (RIF) and the expected recovery period for the RAR.

Q-SIMA Framework
(Exponent, *unpublished*)



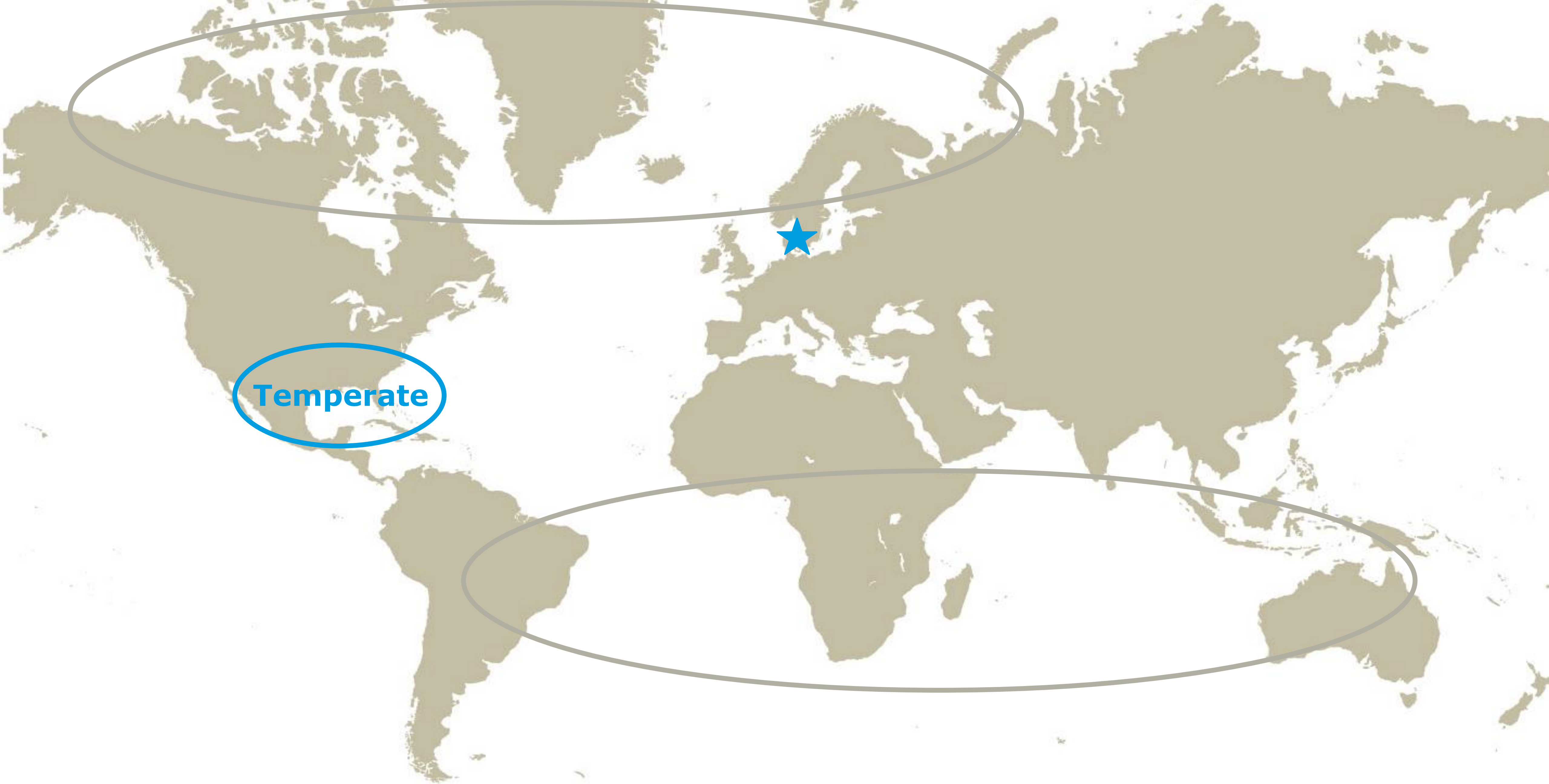
Oil spill risk BN-model
(Goerlandt & Montewka 2015)

sNEBA, NEBA and SIMA

NEBA Approaches in the Arctic & Elsewhere

Applying SIMA

Concluding Thoughts


Temperate

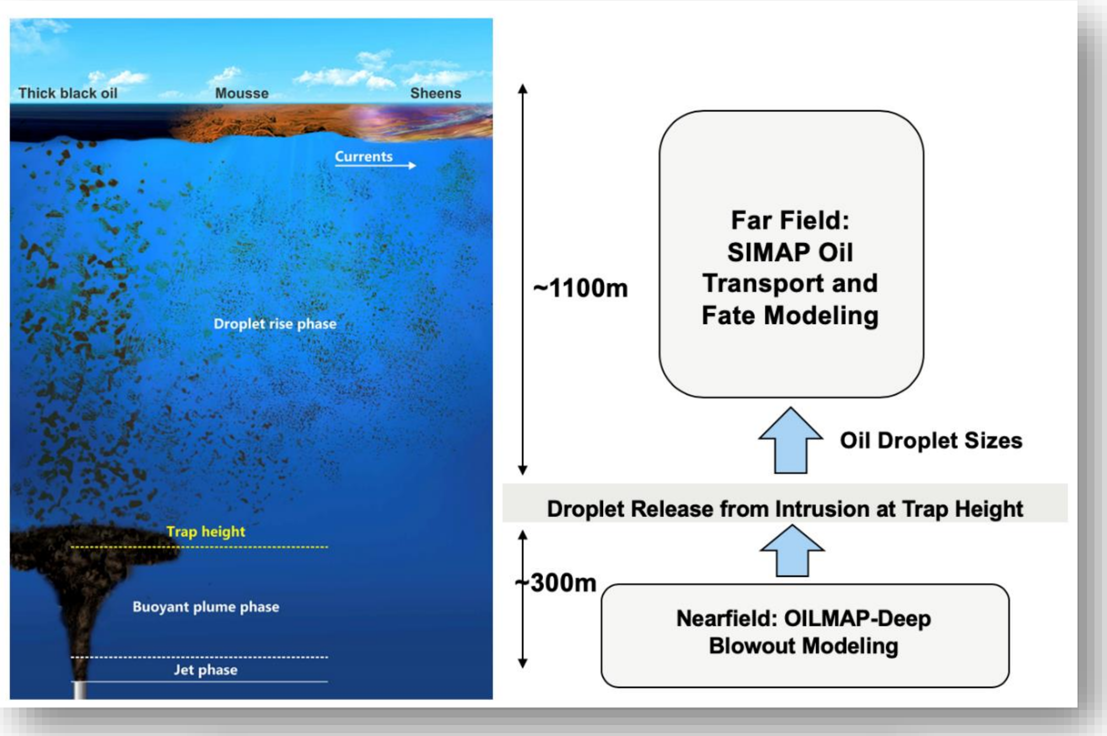
NORTHERN GULF OF MEXICO
CONCEPTUAL FRAMEWORK

Goal:

- Create an OSR-support tool that provides decision makers with objective, science-based, transparent information to enable technically-sound choices for mitigating consequences of a deepwater well blowout

Focus:

- Compare exposures, risks and tradeoffs of different OSR options
  - In-situ burning
  - Mechanical
  - Natural recovery
  - Surface Dispersants
  - Subsea Dispersant Injection (SSDI)

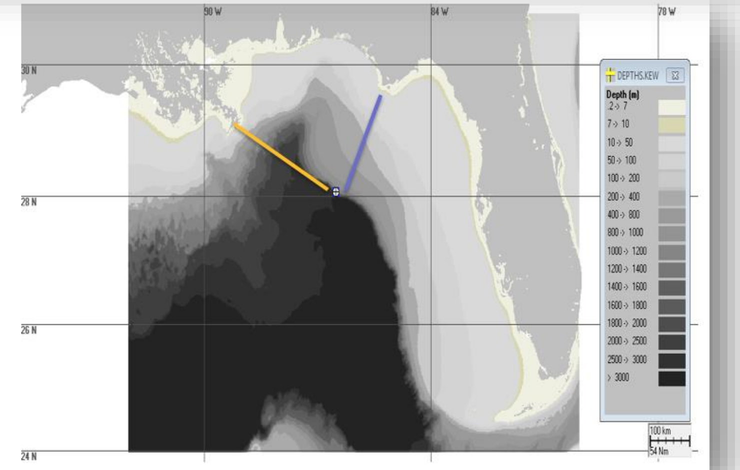


Far Field: SIMAP Oil Transport and Fate Modeling

Oil Droplet Sizes

Droplet Release from Intrusion at Trap Height

Nearfield: OILMAP-Deep Blowout Modeling



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Comparative Risk Assessment of spill response options for a deepwater oil well blowout: Part 1. Oil spill modeling

Deborah French-McCay[a,*], Deborah Crowley[a], Jill J. Rowe[a], Michael Bock[b], Hilary Robinson[c], Richard Wenning[b], Ann Hayward Walker[d], John Joeckel[d], Tim J. Nedwed[e], Thomas F. Parkerton[f]

[a] *RPS ASA, South Kingstown, RI, USA*
[b] *Ramboll, Portland, ME, USA*
[c] *Ramboll, Arlington, VA, USA*
[d] *SEA Consulting Group, Cape Charles, VA, USA*
[e] *ExxonMobil Upstream Research Company, Spring, TX, USA*
[f] *ExxonMobil Biomedical Sciences, Spring, TX, USA*

ARTICLE INFO

Keywords:
Oil fate modeling
Oil exposure modeling
Gulf of Mexico
Net Environmental Benefit Analysis
Oil spill response
Subsea dispersant injection

ABSTRACT

Oil spill model simulations of a deepwater blowout in the Gulf of Mexico De Soto Canyon, assuming no intervention and various response options (i.e., subsea dispersant injection SSDI, in addition to mechanical recovery, in-situ burning, and surface dispersant application) were compared. Predicted oil fate, amount and area of surfaced oil, and exposure concentrations in the water column above potential effects thresholds were used as inputs to a Comparative Risk Assessment to identify response strategies that minimize long-term impacts. SSDI reduced human and wildlife exposure to volatile organic compounds; dispersed oil into a large water volume at depth; enhanced biodegradation; and reduced surface water, nearshore and shoreline exposure to floating oil and entrained/dissolved oil in the upper water column. Tradeoffs included increased oil exposures at depth. However, since organisms are less abundant below 200 m, results indicate that overall exposure of valued ecosystem components was minimized by use of SSDI.

1. Introduction

Subsea dispersant injection (SSDI) was a new oil spill response method first deployed to mitigate the effects of a deepwater oil-well blowout during the Deepwater Horizon incident in 2010. Since then, a significant amount of research has been completed to understand how injecting dispersants into a jet of oil released in deepwater modifies the oil fate (Brandvik et al., 2016, 2017; Nedwed, 2017). This and other research has been used to validate near-field blowout and oil spill transport and fate models that predict the volume and location of water that will contain oil above a specified concentration, the thicknesses and locations of surface oil, and the amount and locations of oil that could strand on shorelines with and without SSDI application (French-McCay, 2003, 2004; French-McCay and Rowe, 2004; Spaulding et al., 2015, 2017; French-McCay et al., 2015, 2016, 2018a,b,c; Li et al., 2017a,b). Further, these models can be used to estimate how application of various oil spill response methods or combinations of methods modify the fate of the oil (e.g., USCG, 2009; French-McCay et al., 2004, 2005; Buchholz et al., 2016). A logical next step to guide response decisions is combining the results of oil spill modeling with a method for quantifying the exposure and recovery of various valued ecosystem components (VECs) that could potentially be exposed to oil. That is, a well-constructed methodology would allow a quantitative comparison of exposure and recovery of organisms within an ecosystem to a hypothetical oil spill depending on the oil released, the magnitude and location of the release, the environmental conditions present during the release, and the response strategy.

For this reason, we developed a Comparative Risk Assessment (CRA) approach to combine predictions from an oil spill fate model with a novel method of quantifying valued ecosystem component (VEC) exposures and recovery to evaluate an offshore deepwater well-control incident in order to identify an oil spill response strategy (including considering SSDI) that would minimize relative risks to local organisms, reduce exposure of surface dwelling wildlife and response workers to volatile organic compounds (VOCs), and minimize socioeconomic disturbance. The approach was used to evaluate the implications of various response strategies, i.e., no intervention, mechanical recovery, in-situ burning (ISB), surface dispersant application, and SSDI at the source, individually and in combination. Stakeholders typically accept the use of mechanical recovery equipment when it is feasible and

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[*] Corresponding author.
E-mail address: debbie.frenchmccay@rpsgroup.com (D. French-McCay).

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Oil Modeling

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Comparative risk assessment of oil spill response options for a deepwater oil well blowout: Part II. Relative risk methodology

Michael Bock[a,*], Hilary Robinson[b], Richard Wenning[a], Deborah French-McCay[c], Jill Rowe[c], Ann Hayward Walker[d]

[a] *Ramboll, 136 Commercial Street, Suite 402, Portland, ME 04101, United States*
[b] *Ramboll, 4350 N Fairfax Drive, Suite 300, Arlington, VA 22203, United States*
[c] *RPS ASA, 55 Village Square Drive, Wakefield, RI 02879, United States*
[d] *SEA Consulting Group, 325 Mason Avenue, Cape Charles, VA 23310, United States*

ARTICLE INFO

Keywords:
Gulf of Mexico
Deepwater oil spill
Comparative risk assessment
Oil spill response
Net environmental benefits analysis (NEBA)
Subsea dispersant injection

ABSTRACT

Subsea dispersant injection (SSDI) was a new oil spill response (OSR) technology deployed during the Deepwater Horizon accident. To integrate SSDI into future OSR decisions, a hypothetical deepwater oil spill to the Gulf of Mexico was simulated and a comparative risk assessment (CRA) tool applied to contrast three response strategies: (1) no intervention; (2) mechanical recovery, in-situ burning, and surface dispersants; and, (3) SSDI in addition to responses in (2). A comparative ecological risk assessment (CRA) was applied to multiple valued ecosystem components (VECs) inhabiting different environmental compartments (ECs) using EC-specific exposure and relative VEC population density and recovery time indices. Results demonstrated the added benefit of SSDI since relative risks to shoreline, surface wildlife and most aquatic life VECs were reduced. Sensitivity of results to different assumptions was also tested to illustrate flexibility of the CRA tool in addressing different stakeholder priorities for mitigating the impacts of a deepwater blowout.

1. Introduction

The goal of oil spill response (OSR) is to mitigate the impacts of spilled oil on valued resources while limiting the negative effects of the response. As such, OSR seeks to strike a balance between reducing injury to some resources without unacceptably increasing the injury to other resources. By necessity, OSR planning is a predictive process that depends upon evaluating (1) the oil release conditions, (2) the fate and transport of the released oil, (3) exposure of humans, biological and socioeconomic resources to oil hydrocarbons and response activities, (4) the potential effects on valued resources, and (5) how different oil spill response strategies influence the factors listed above. OSR response planning requires consideration of these factors by the stakeholders.

Subsurface dispersant injection (SSDI) is a promising recent innovation in oil spill response. The use of SSDI in a deepwater oil and gas well blowout can have many benefits including improving the effectiveness of dispersant treatment over that achievable at the water surface; reducing the volume of oil that reaches the water surface; reducing human and wildlife exposure to volatile organic compounds (VOCs); dispersing the oil over a large water volume at depth; reducing the persistence of any oil that does surface; enhancing oil biodegradation; and reducing surface, nearshore and shoreline exposures to oil. Potential negative effects include increased water column and benthic resource exposures to oil at depth.

To better understand the implications of SSDI use, work was conducted to model a hypothetical well blowout in the northern Gulf of Mexico (GOM) to predict oil fate and compare the environmental exposure for no intervention to various combinations of four response options - mechanical recovery, in-situ burning (ISB), surface dispersant application (MBSD), and SSDI. Probabilistic modeling was used to evaluate the influence of variable metocean conditions (i.e., winds, currents and temperature) on oil trajectory and fate. Using individual runs representative of specific metocean conditions (e.g., Fig. 1, worst case for oiling of shorelines), several different modeling simulations and combinations of response options were compared to quantify oil fate, the amount of surfaced as opposed to dispersed oil, and the area or volume of different surface and subsurface environmental compartments in which predicted exposure concentrations exceeded screening thresholds for potential effects. A comparative risk assessment methodology was used to compare the various OSR options. This work was undertaken in consultation with a large group of stakeholders who provided input and guidance on all aspects of the modeling, input

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[*] Corresponding author.
E-mail address: mbock@ramboll.com (M. Bock).

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CRA / SIMA

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Comparative risk assessment of spill response options for a deepwater oil well blowout: Part III. Stakeholder engagement

Ann Hayward Walker[a,*], Debra Scholz[b], Melinda McPeek[a], Deborah French-McCay[c], Jill Rowe[c], Michael Bock[d], Hilary Robinson[e], Richard Wenning[e]

[a] *SEA Consulting Group, 325 Mason Ave., Cape Charles, VA, USA*
[b] *SEA Consulting Group, Silver Spring, MD, USA*
[c] *RPS ASA, South Kingstown, RI, USA*
[d] *Ramboll Environ, Portland, ME, USA*
[e] *Ramboll Environ, Arlington, VA, USA*

ARTICLE INFO

Keywords:
Oil spill preparedness
Dispersant policy and decision making
Stakeholder engagement
Response strategy
Subsea dispersant injection
Comparative risk assessment

ABSTRACT

This paper describes oil spill stakeholder engagement in a recent comparative risk assessment (CRA) project that examined the tradeoffs associated with a hypothetical offshore well blowout in the Gulf of Mexico, with a specific focus on subsea dispersant injection (SSDI) at the wellhead. SSDI is a new technology deployed during the Deepwater Horizon (DWH) oil spill response. Oil spill stakeholders include decision makers, who will consider whether to integrate SSDI into future tradeoff decisions. This CRA considered the tradeoffs associated with three sets of response strategies: (1) no intervention; (2) mechanical recovery, in-situ burning, and surface dispersants; and, (3) SSDI in addition to responses in (2). For context, the paper begins with a historical review of U.S. policy and engagement with oil spill stakeholders regarding dispersants. Stakeholder activities throughout the project involved decision-maker representatives and their advisors to inform the approach and consider CRA utility in future oil spill preparedness.

1. Introduction

Oil spill response (OSR) seeks to mitigate the impacts of spilled oil on valued resources while limiting the negative effects of the response, that is, to strike a balance between reducing injury to some resources without unacceptably increasing the injury to other resources. By necessity, OSR planning is a predictive process that depends upon evaluating (1) the oil release conditions, (2) the fate and transport of the released oil, (3) exposure of humans, biological and socioeconomic resources to oil hydrocarbons and response activities, (4) the potential effects on valued resources, and (5) how different oil spill response methods influence these factors. OSR response planning requires consideration of these factors by decision makers and other stakeholders.

Subsurface dispersant injection (SSDI) is a recent innovation in oil spill response. The use of SSDI in a deepwater oil and gas well blowout offers potential significant benefits including effective dispersant treatment of discharging oil at the source; reducing the volume of oil that reaches the water surface; reducing human and wildlife exposure to volatile organic compounds (VOCs); dispersing the oil over a large water volume at depth; reducing the persistence of any SSDI-treated oil that does surface; enhancing oil biodegradation; and reducing surface, nearshore and shoreline exposures to floating and surface-water entrained/dissolved oil. Potential negative consequences include increased water column and benthic resource exposures to oil at depth.

To better understand the implications of SSDI use, work was conducted to model a hypothetical well blowout, located in the northern Gulf of Mexico (GoM) (Fig. 1), to predict oil fate and compare the environmental exposure for no intervention to various combinations of four response options - mechanical recovery (M), in-situ burning (B), M, B, and surface dispersant application (SD), and SSDI. Probabilistic modeling was used to evaluate the influence of variable metocean conditions (i.e., winds, currents and temperature) on oil trajectory and fate. Using individual runs representative of specific metocean conditions several different modeling simulations and combinations of response options were compared to quantify oil fate, the amount of surfaced as opposed to dispersed oil, and the area or volume of different surface and subsurface environmental compartments in which predicted exposure concentrations exceeded screening thresholds for potential effects. A comparative risk assessment methodology was used to compare the various OSR options. This work was undertaken in

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[*] Corresponding author.
E-mail address: ahwalker@seaconsulting.com (A.H. Walker).

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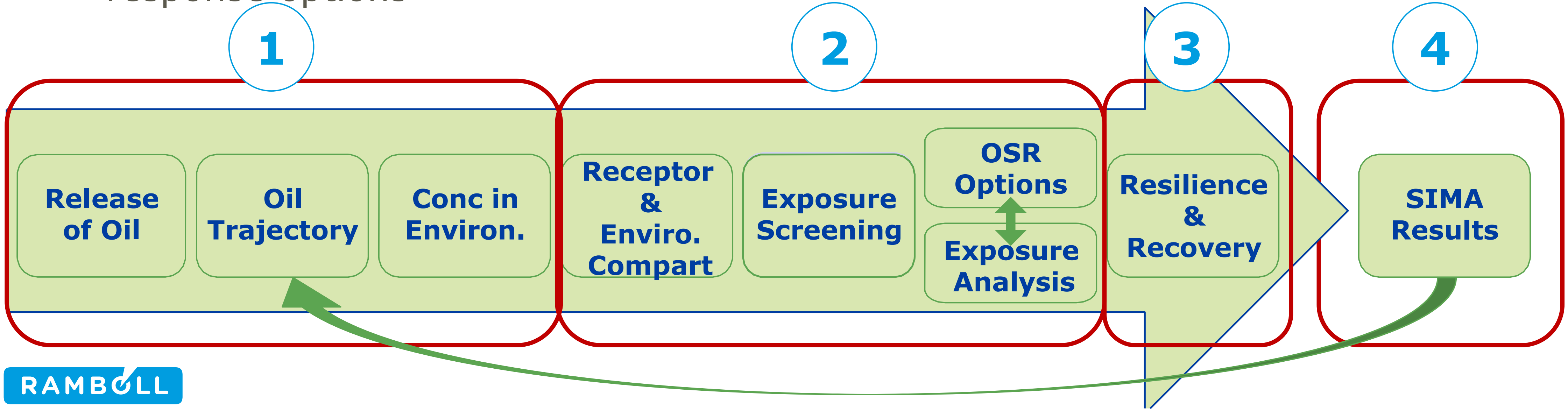
Stakeholder Engagement

STEPWISE ANALYSIS

1. **Oil spill modeling** to evaluate Environmental Compartments (ECs) affected by the release of spilled oil
2. **Exposure analysis** of Valuable Ecosystem Components (VECs) in different affected ECs
3. **Time to recover analysis** to discern short- and long- term consequences to VECs and ECs after exposure
4. **Results**, comparing tradeoffs associated with deployment of different oil spill response options

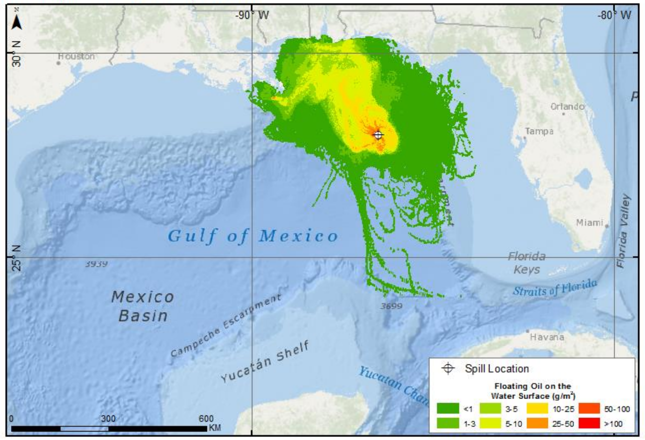


CHARACTERIZE THE SPILL EVENT

Characteristics of the Spilled Oil

Spilled Oil Trajectory

Run 36: Spill Start: 2008 Dec 5, 12:08 UTC

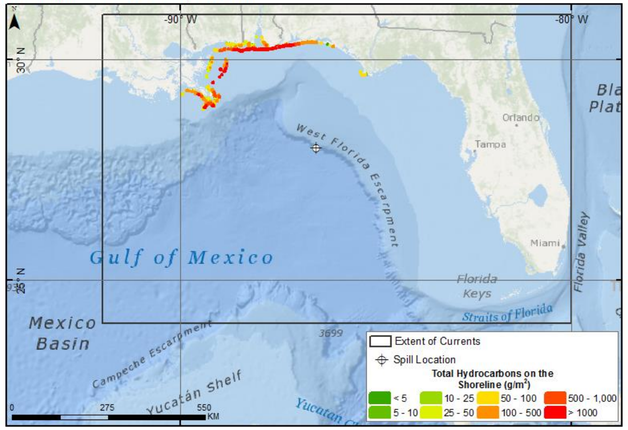


Maximum Exposure, Water Surface

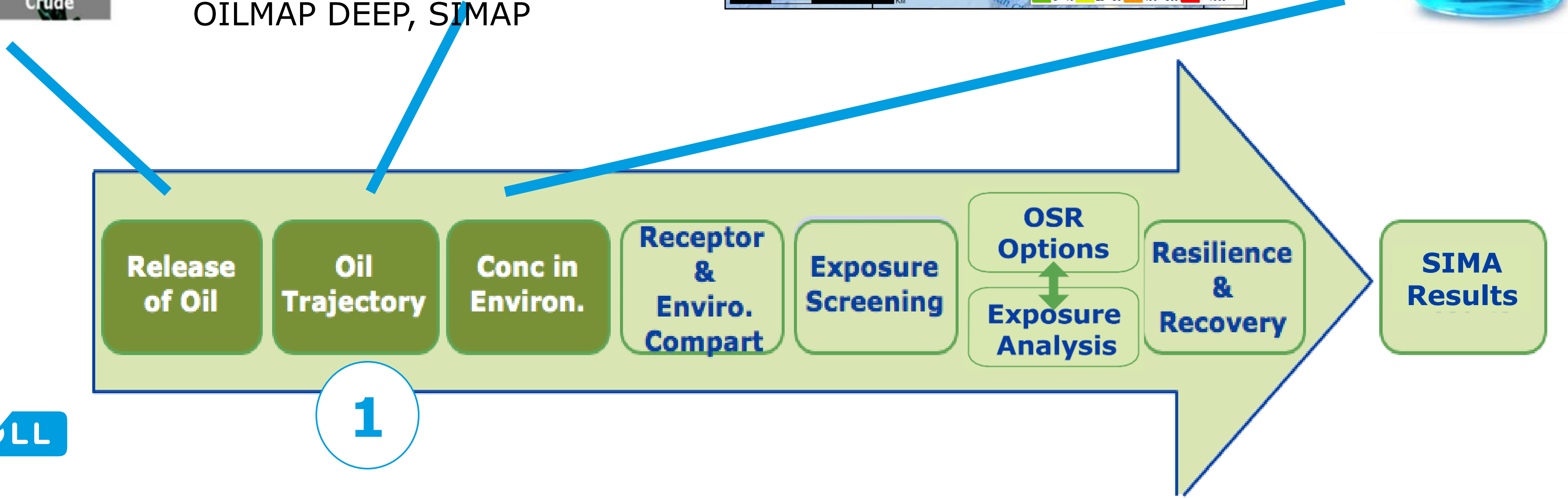
OILMAP DEEP, SIMAP

Maximum Exposure, Shoreline

Run 36: Spill Start: 2008 Dec 5, 12:08 UTC



Area or volume exposed to spilled oil; concentrations in seawater



Release of Oil

Oil Trajectory

Conc in Environ.

Receptor & Enviro. Compart

Exposure Screening

OSR Options

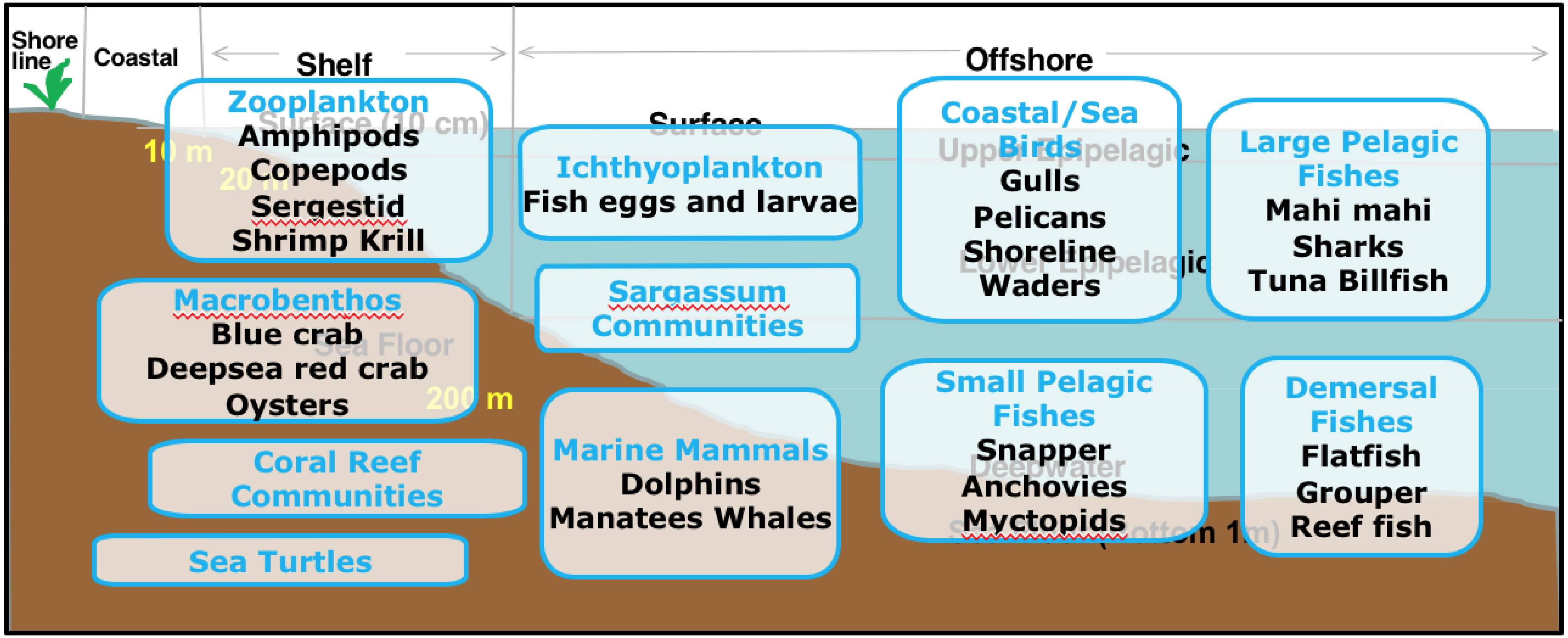
Exposure Analysis

Resilience & Recovery

SIMA Results

1

IDENTIFY ENVIRONMENTS/HABITATS & BIOTA AT RISK



Zooplankton
Amphipods
Copepods
Sergestid
Shrimp Krill

Ichthyoplankton
Fish eggs and larvae

Coastal/Sea Birds
Gulls
Pelicans
Shoreline
Waders

Large Pelagic Fishes
Mahi mahi
Sharks
Tuna Billfish

Macrobenthos
Blue crab
Deepsea red crab
Oysters

Sargassum Communities

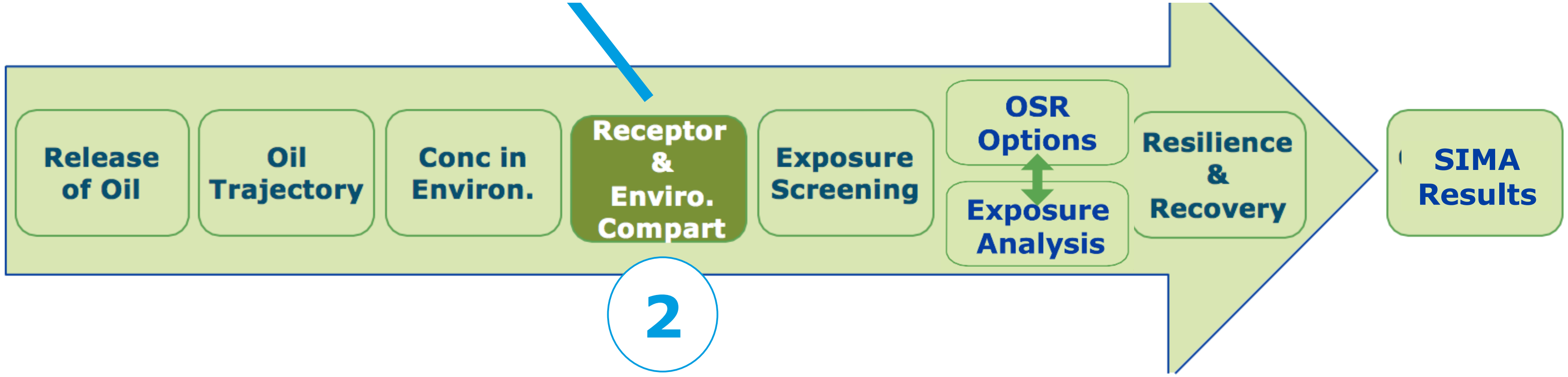
Coral Reef Communities

Sea Turtles

Marine Mammals
Dolphins
Manatees Whales

Small Pelagic Fishes
Snapper
Anchovies
Myctopids

Demersal Fishes
Flatfish
Grouper
Reef fish



Release of Oil

Oil Trajectory

Conc in Environ.

Receptor & Enviro. Compart

Exposure Screening

OSR Options

Exposure Analysis

Resilience & Recovery

SIMA Results

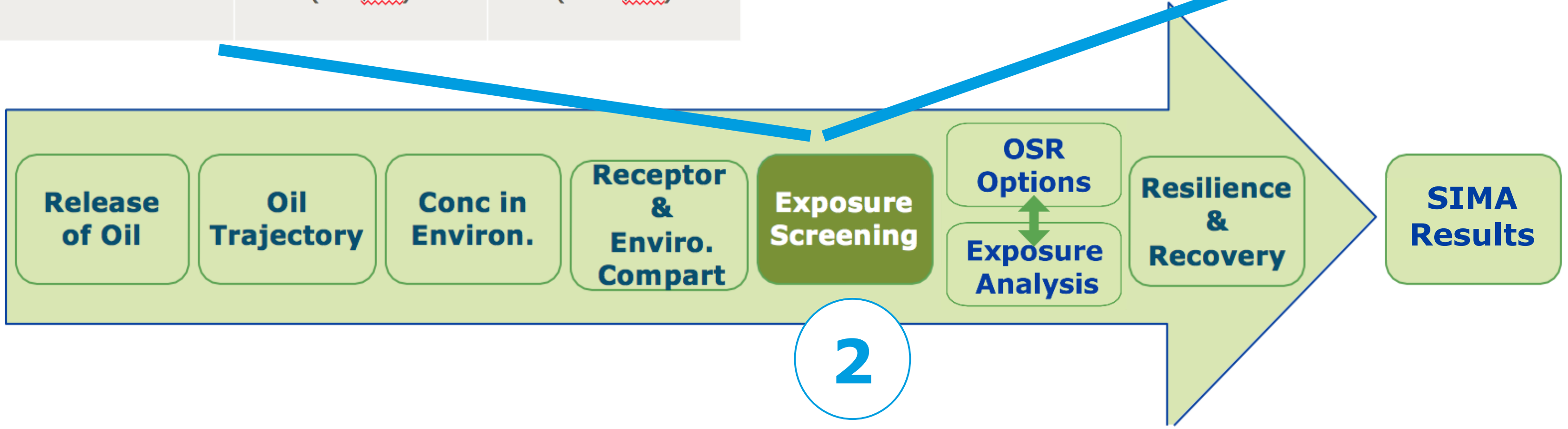
2

IDENTIFY EXPOSURE THRESHOLDS FOR SCREENING

VEC Type	Exposure Measure	Lower Threshold	Higher Threshold
Birds, Mammals, & Reptiles	**Surface floating oil** mass per unit area	10 g/m^2 (10 µm)	100 g/m^2 (100 µm)
Plankton in Upper 20m	**PAH** concentration in water (daily average)	1 µg/L (ppb)	10 µg/L (ppb)
Pelagic in Water Column	**PAH** concentration in water (daily average)	10 µg/L (ppb)	100 µg/L (ppb)
Vegetation & Habitats	**Shoreline oil mass** per unit area	100 g/m^2 (100 µm)	1 kg/m^2 (1 mm)
Intertidal Invertebrates	**Shoreline oil mass** per unit area	10 g/m^2 (10 µm)	100 g/m^2 (100 µm)

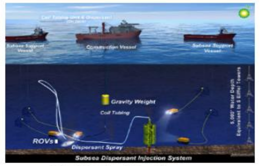
VSC Type	Exposure Measure	Threshold	Appearance
Floating-Oil Related	**Surface floating oil** mass per unit area	0.01 g/m^2 (0.01 µm)	Sheen
Shoreline-Related	**Shoreline oil mass** per unit area	1 g/m^2 (1 µm)	Stain

Area of habitat exposed to oil > threshold amount (g/m^2)
Area of sea surface swept by oil > threshold amount (g/m^2)
Area or length of shoreline oiled by > threshold amount (g/m^2)
Volume of water experiencing concentrations > threshold (µg/l)



CALCULATE EC/VEC EXPOSURES FOR DIFFERENT OSR SCENARIOS


In Situ Burning



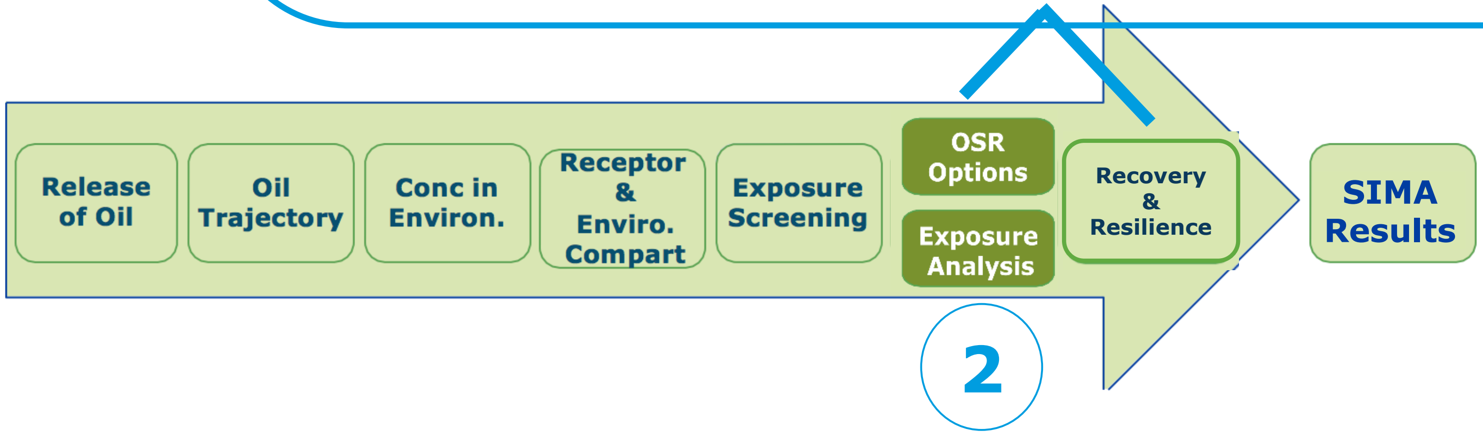
SSDI; Subsea Dispersant Injection


Surface Dispersant


Mechanical Recovery

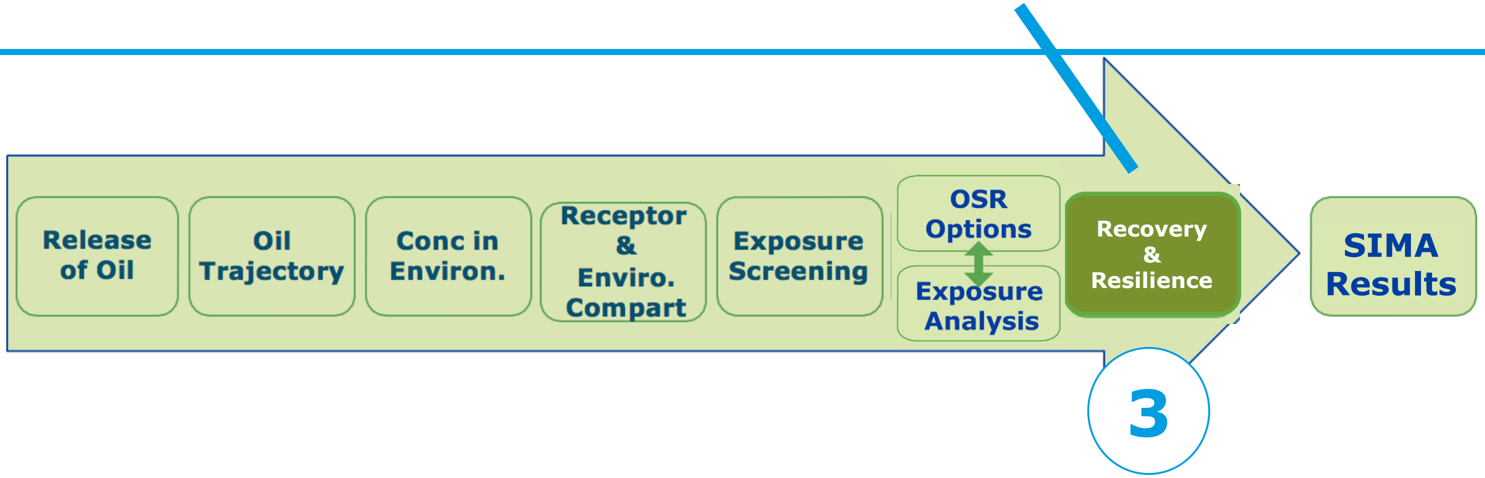

Natural Attenuation

1. Calculate **area - days or volume days exposed** to oil above thresholds in each EC (i.e., as predicted by an oil spill model)
2. Calculate **percent of VEC exposed in each EC**_occupied (VEC:EC) as percent of maximum possible exposure in area-days or volume-days
3. Use relative density data to weight the VEC:EC by **fraction of VEC population** in the entire domain that is in that EC
4. **Score each VEC** in each EC by combining weights and results to identify resources at higher and lower risk


Release of Oil
Oil Trajectory
Conc in Environ.
Receptor & Enviro. Compart
Exposure Screening
OSR Options
Exposure Analysis
Recovery & Resilience
SIMA Results
2

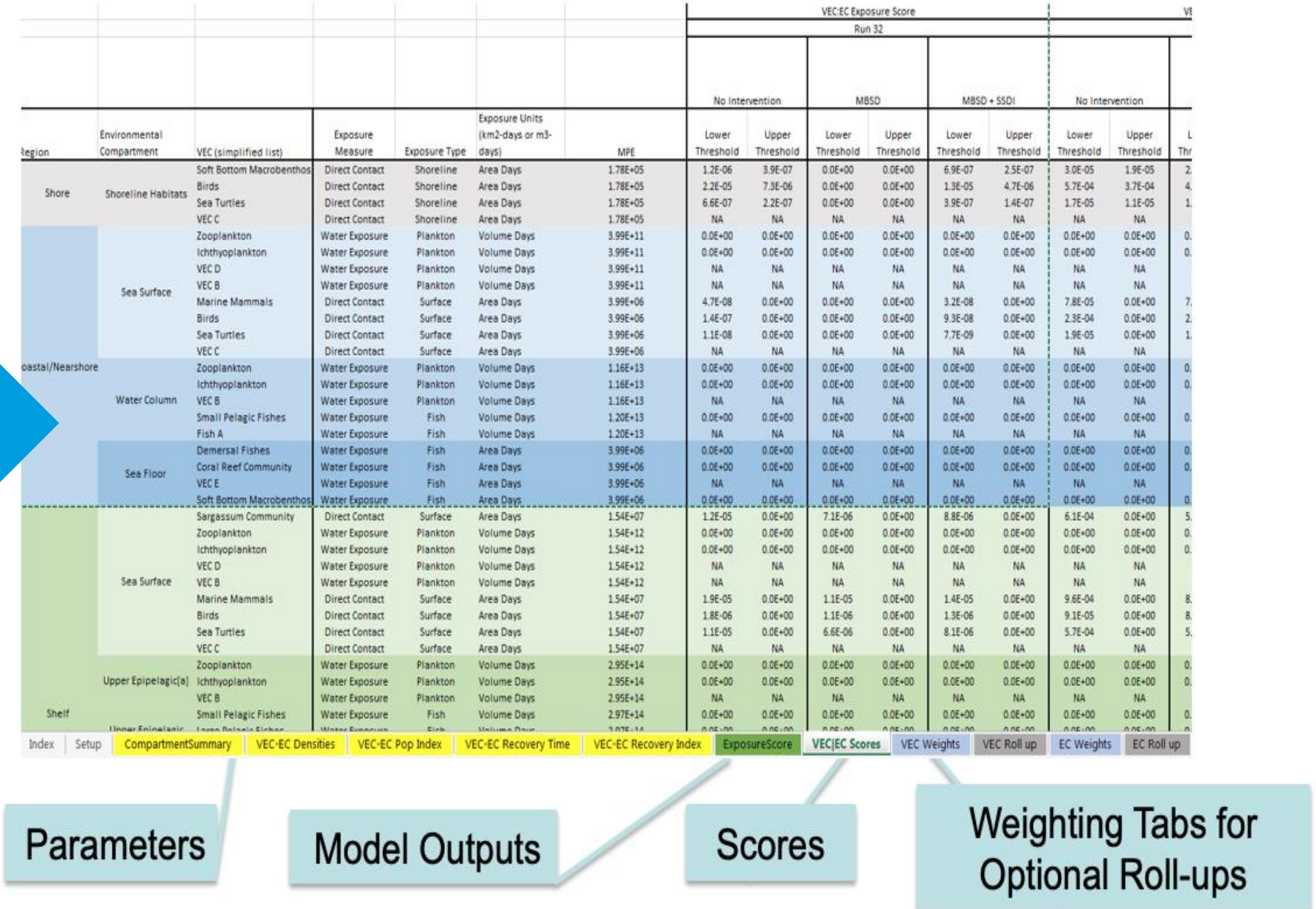
RECOVERY SCORING

- "Recovery" refers to length of time anticipated for VEC group to return to a **stable status**
  - Biological factors: age class, fecundity, spatial distribution, seasonality, migratory behavior
  - Environmental factors: physical weathering, transport mechanisms, biodegradation
- Factors are applied to predict the period of time anticipated for a VEC group to stabilize (or, rebound) after exposure has dissipated
- Use general time periods derived from field studies and case studies reported in science literature for spill events
  - [<1], [>1 to <5], [>5 - <10], [>10] years is basis for calculating **recovery scores**



SCORES, WEIGHTS & RESULTS

1. Predict **area or volume exposed to oil** and the **duration of exposure** in each environmental compartment
2. Calculate **percent of resource exposed** in compartments
3. Calculate **recovery time** required for habitats and VEC populations to stabilize
4. Score each VEC and each habitat type as function of percent of resource exposed & recovery time

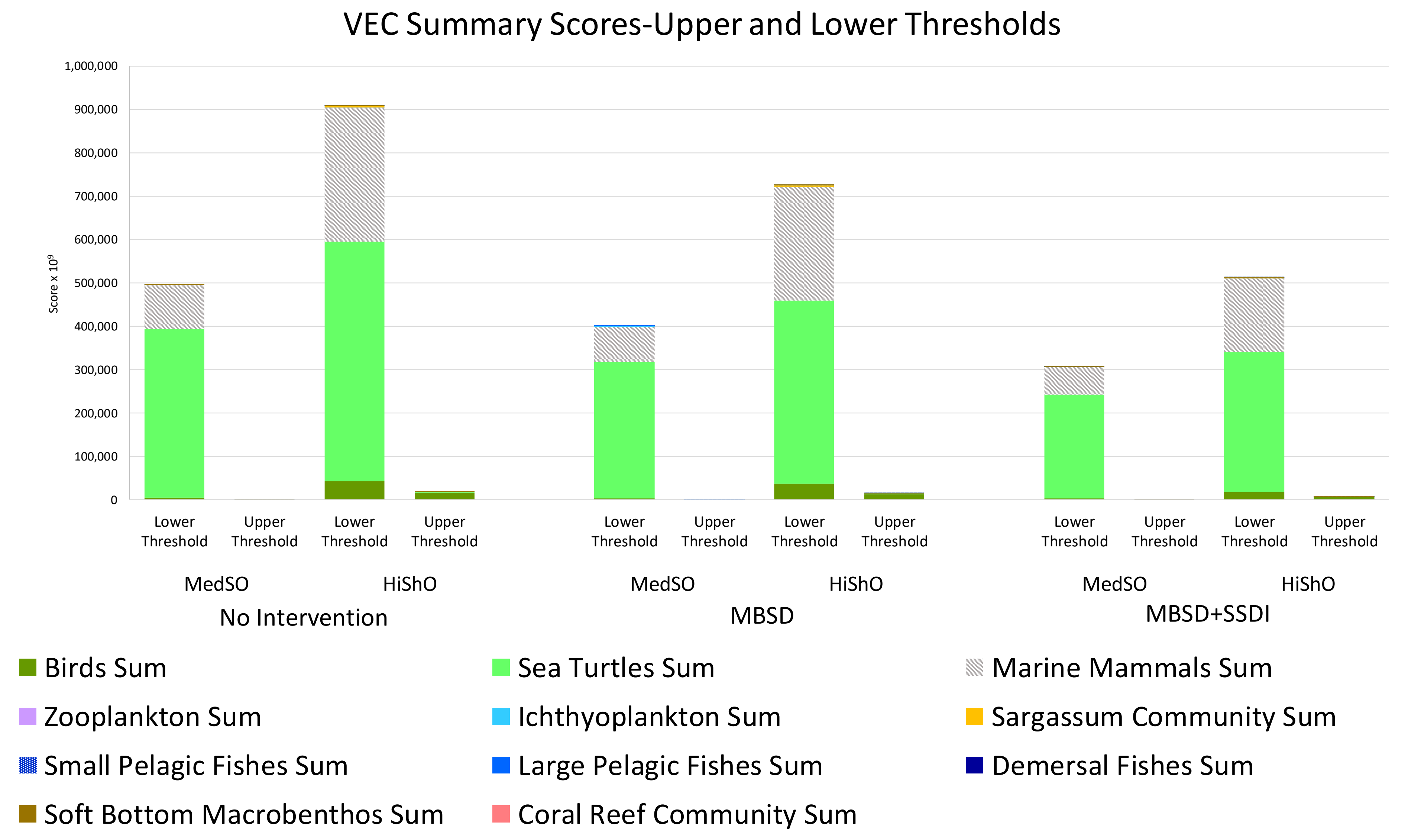


							VEC:EC Exposure Score							
							Run 32							
							No Intervention		MBSD		MBSD + SSDI		No Intervention	
Region	Environmental Compartment	VEC (simplified list)	Exposure Measure	Exposure Type	Exposure Units (km2-days or m3-days)	MPE	Lower Threshold	Upper Threshold	Lower Threshold	Upper Threshold	Lower Threshold	Upper Threshold	Lower Threshold	Upper Threshold
Shore	Shoreline Habitats	Soft Bottom Macrobenthos	Direct Contact	Shoreline	Area Days	1.78E+05	1.2E-06	3.9E-07	0.0E+00	0.0E+00	6.9E-07	2.5E-07	3.0E-05	1.9E-05
		Birds	Direct Contact	Shoreline	Area Days	1.78E+05	2.2E-05	7.3E-06	0.0E+00	0.0E+00	1.3E-05	4.7E-06	5.7E-04	3.7E-04
		Sea Turtles	Direct Contact	Shoreline	Area Days	1.78E+05	6.6E-07	2.2E-07	0.0E+00	0.0E+00	3.9E-07	1.4E-07	1.7E-05	1.1E-05
		VEC C	Direct Contact	Shoreline	Area Days	1.78E+05	NA	NA	NA	NA	NA	NA	NA	NA
oastal/Nearshore	Sea Surface	Zooplankton	Water Exposure	Plankton	Volume Days	3.99E+11	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		Ichthyoplankton	Water Exposure	Plankton	Volume Days	3.99E+11	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		VEC D	Water Exposure	Plankton	Volume Days	3.99E+11	NA	NA	NA	NA	NA	NA	NA	NA
		VEC B	Water Exposure	Plankton	Volume Days	3.99E+11	NA	NA	NA	NA	NA	NA	NA	NA
		Marine Mammals	Direct Contact	Surface	Area Days	3.99E+06	4.7E-08	0.0E+00	0.0E+00	0.0E+00	3.2E-08	0.0E+00	7.8E-05	0.0E+00
		Birds	Direct Contact	Surface	Area Days	3.99E+06	1.4E-07	0.0E+00	0.0E+00	0.0E+00	9.3E-08	0.0E+00	2.3E-04	0.0E+00
		Sea Turtles	Direct Contact	Surface	Area Days	3.99E+06	1.1E-08	0.0E+00	0.0E+00	0.0E+00	7.7E-09	0.0E+00	1.9E-05	0.0E+00
		VEC C	Direct Contact	Surface	Area Days	3.99E+06	NA	NA	NA	NA	NA	NA	NA	NA
	Water Column	Zooplankton	Water Exposure	Plankton	Volume Days	1.16E+13	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		Ichthyoplankton	Water Exposure	Plankton	Volume Days	1.16E+13	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		VEC B	Water Exposure	Plankton	Volume Days	1.16E+13	NA	NA	NA	NA	NA	NA	NA	NA
		Small Pelagic Fishes	Water Exposure	Fish	Volume Days	1.20E+13	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		Fish A	Water Exposure	Fish	Volume Days	1.20E+13	NA	NA	NA	NA	NA	NA	NA	NA
	Sea Floor	Demersal Fishes	Water Exposure	Fish	Area Days	3.99E+06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		Coral Reef Community	Water Exposure	Fish	Area Days	3.99E+06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		VEC E	Water Exposure	Fish	Area Days	3.99E+06	NA	NA	NA	NA	NA	NA	NA	NA
		Soft Bottom Macrobenthos	Water Exposure	Fish	Area Days	3.99E+06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Shelf	Sea Surface	Sargassum Community	Direct Contact	Surface	Area Days	1.54E+07	1.2E-05	0.0E+00	7.1E-06	0.0E+00	8.8E-06	0.0E+00	6.1E-04	0.0E+00
		Zooplankton	Water Exposure	Plankton	Volume Days	1.54E+12	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		Ichthyoplankton	Water Exposure	Plankton	Volume Days	1.54E+12	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		VEC D	Water Exposure	Plankton	Volume Days	1.54E+12	NA	NA	NA	NA	NA	NA	NA	NA
		VEC B	Water Exposure	Plankton	Volume Days	1.54E+12	NA	NA	NA	NA	NA	NA	NA	NA
		Marine Mammals	Direct Contact	Surface	Area Days	1.54E+07	1.9E-05	0.0E+00	1.1E-05	0.0E+00	1.4E-05	0.0E+00	9.6E-04	0.0E+00
		Birds	Direct Contact	Surface	Area Days	1.54E+07	1.8E-06	0.0E+00	1.1E-06	0.0E+00	1.3E-06	0.0E+00	9.1E-05	0.0E+00
		Sea Turtles	Direct Contact	Surface	Area Days	1.54E+07	1.1E-05	0.0E+00	6.6E-06	0.0E+00	8.1E-06	0.0E+00	5.7E-04	0.0E+00
		VEC C	Direct Contact	Surface	Area Days	1.54E+07	NA	NA	NA	NA	NA	NA	NA	NA
	Upper Epipelagic[a]	Zooplankton	Water Exposure	Plankton	Volume Days	2.95E+14	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		Ichthyoplankton	Water Exposure	Plankton	Volume Days	2.95E+14	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
		VEC B	Water Exposure	Plankton	Volume Days	2.95E+14	NA	NA	NA	NA	NA	NA	NA	NA
		Small Pelagic Fishes	Water Exposure	Fish	Volume Days	2.97E+14	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00

BIOTA (VEC) SCORES FOR DIFFERENT OSR ACTIONS

MedSO
Median Spill;
Minimal
Shoreline Oiling

HiShO
Worst-Case Spill;
High
Shoreline Oiling



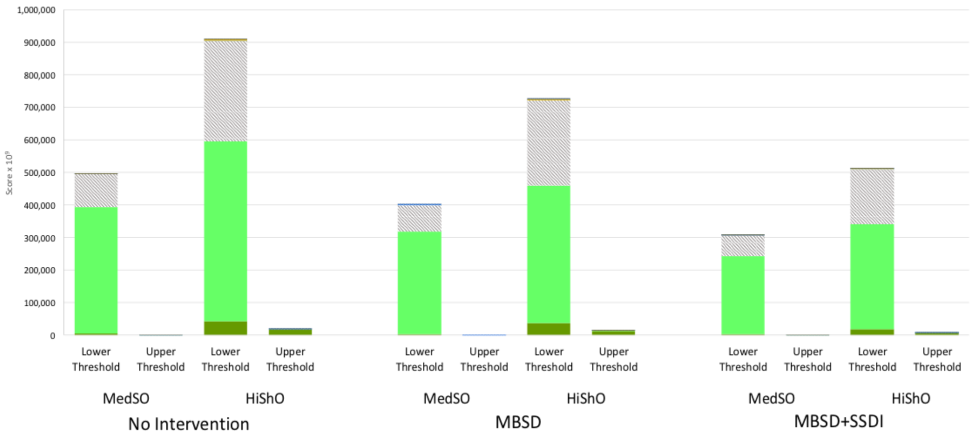
BIOTA (VEC) SCORES

HABITAT (EC) SCORES

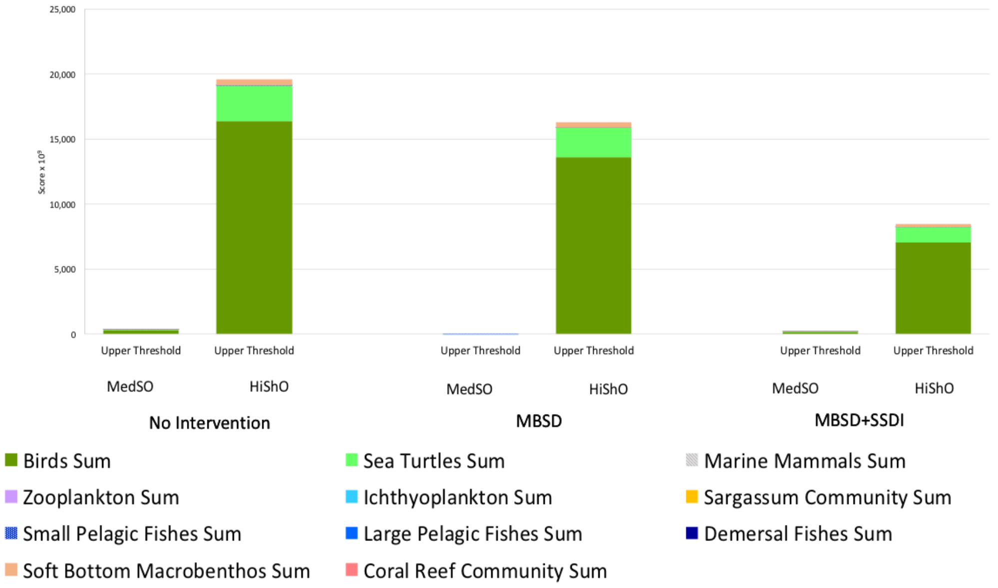
MedSO
Median Spill; Minimal Shoreline Oiling

HiShO
Worst-Case Spill; High Shoreline Oiling

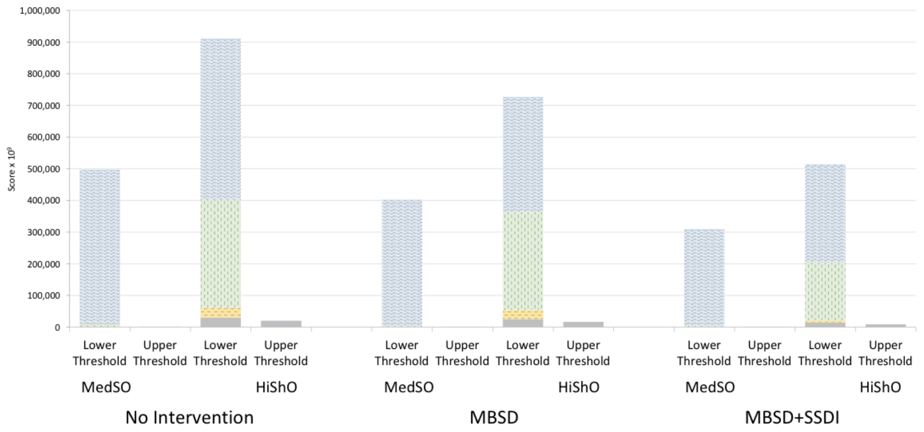
VEC Summary Scores-Upper and Lower Thresholds



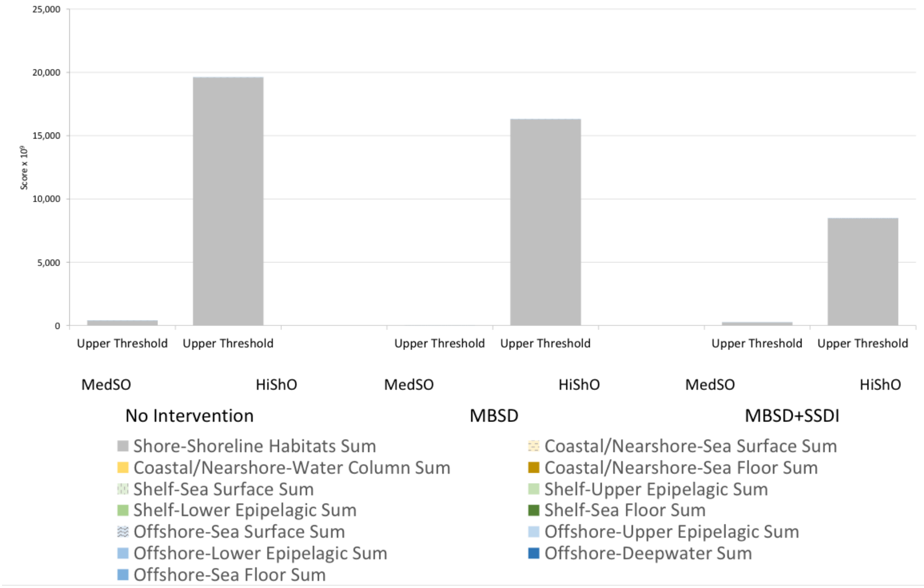
VEC Summary Scores-Upper Threshold Only



EC Summary Scores-Upper and Lower Thresholds



EC Summary Scores-Upper Threshold Only



DISCUSSION

sNEBA, NEBA and SIMA

NEBA Approaches in the Arctic & Elsewhere

Applying SIMA

Concluding Thoughts

“RULES OF THUMB”

Identify plausible/credible oil release scenarios 1

Consider both at-sea and shoreline OSR strategies, and include a mix of options, deployed at different locations and times during the incident; no single option is likely to be fully effective 2

Increasing SIMA complexity and analyzing resources at greater detail should only be undertaken when it is reliably expected to bring significant insights to OSR strategy development 3

BUT…. OIL SPILLS ARE ASSOCIATED WITH UNCERTAINTY AND VARIABILITY

Not every plausible oil spill scenario can be anticipated **4**

Environmental and ecological attributes interact in complex ways that may or may not be relevant or not well understood **5**

All oil does not look alike; its difficult to differentiate between oil types and degree of weathering prior to treatment **6**

Operational factors (e.g., weather) affect exposure and consequences and are difficult to predict **7**

WHAT SHOULD SNEBA DO?

- Identify the **resources at risk appropriate to the season**
- Aim to minimize the **ecological footprint** of an oil spill
- Aim to avoid or minimize the **environmental consequences** of the spill event, as well as the response actions
- **Before work begins, determine the priorities and tradeoffs** between the social and environmental considerations
- **Identify plausible response(s)** that match the likely spill event to the likely environmental conditions
- **Strive to optimize the efficacy of spill response options**

THANK YOU

Integrated
oil spill response
actions and
environmental effects
GRACE
2016-2019

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Michael Bock, Ramboll US, ME
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RAMBOLL

EPPR

EMERGENCY PREVENTION PREPAREDNESS AND RESPONSE
COPENHAGEN, NOVEMBER 22, 2018

WWW.EPPR.ORG

EMERGENCY PREVENTION,
PREPAREDNESS AND RESPONSE

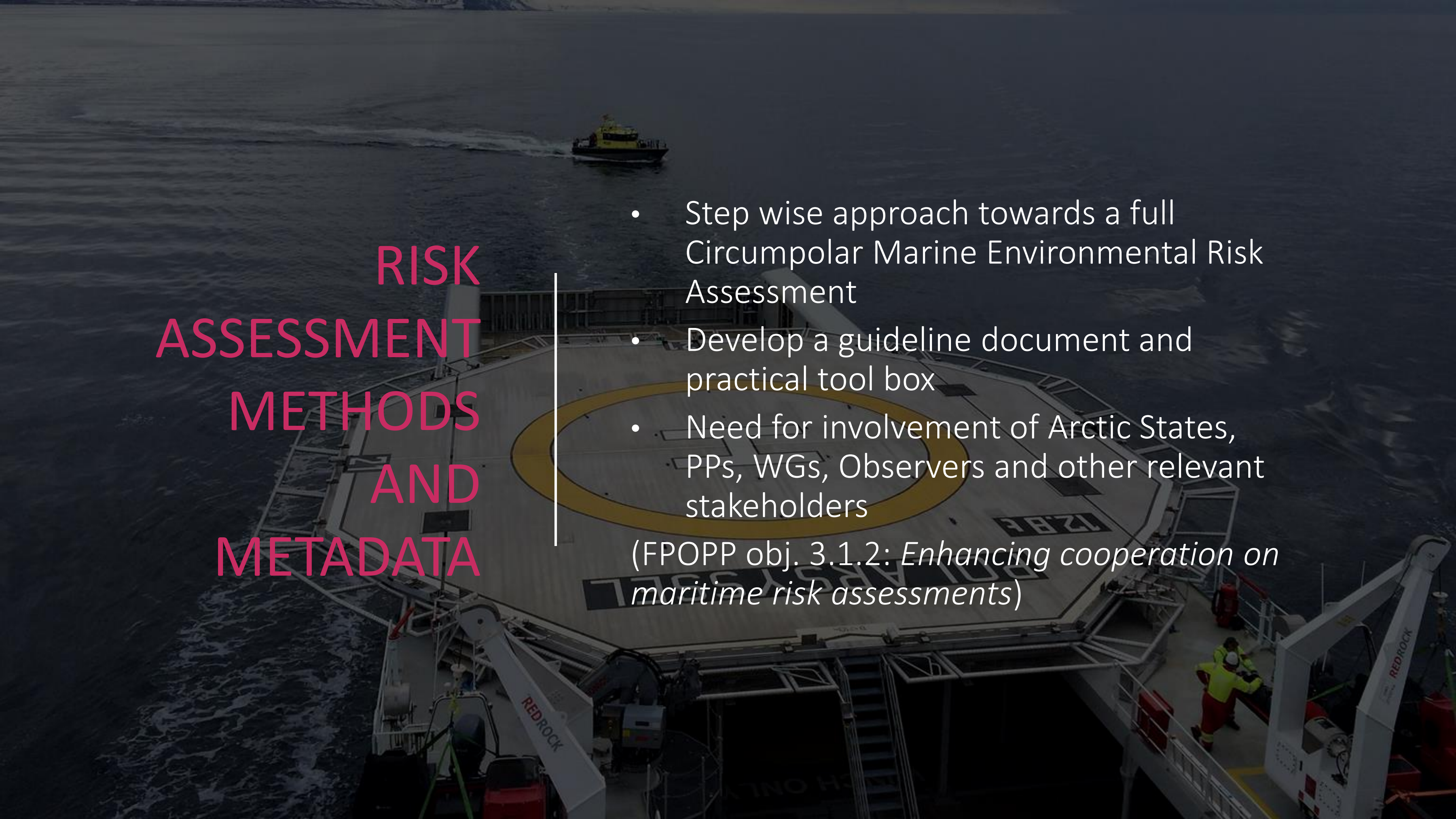
ARCTIC COUNCIL

EPPR AND MERA

- Through prevention and response avoid damage to ecosystems from accidental releases of pollutants
- Limiting potential cascading consequences from pollutions

ACTIONS NEEDED TO ENHANCE POLLUTION PREVENTION AND RESPONSE

- Risk based contingency planning
- Knowledge of risks
- Shared standards for input data to risk assessments
- Datasharing
- Cooperation – cross sectoral / cross state
- Involvement from all stakeholders / inclusion



RISK ASSESSMENT METHODS AND METADATA

- Step wise approach towards a full Circumpolar Marine Environmental Risk Assessment
- Develop a guideline document and practical tool box
- Need for involvement of Arctic States, PPs, WGs, Observers and other relevant stakeholders

(FPOPP obj. 3.1.2: *Enhancing cooperation on maritime risk assessments*)

HOW THE GUIDELINE AND TOOL WILL HELP PREVENTION AND RESPONSE

- Simple data access
- One stop shop
- Comparability between risk assessments

THANK YOU

EPPR - EMERGENCY PREVENTION PREPAREDNESS AND RESPONSE

WWW.EPPR.ORG

EPPR EMERGENCY PREVENTION, PREPAREDNESS AND RESPONSE

KYSTVERKET NORWEGIAN COASTAL ADMINISTRATION

ARCTIC COUNCIL

EPPR Guideline and Tools for Arctic Marine Risk Assessments

sNEBA workshop, Copenhagen

Hans Petter Dahlslett
22 November 2018

Talking points

- ***Project outline***
  - *Guideline and tools for marine risk assessments in the Arctic Region*
- **Status and plans for 2019**
- **Oil Spill Response Viability Analysis – links to sNEBA?**

Project outline:

Guideline and tools for Marine Risk Assessments in the Arctic Region

EP
PR
EMERGENCY PREVENTION, PREPAREDNESS AND RESPONSE

KYSTVERKET
NORWEGIAN COASTAL ADMINISTRATION

ARCTIC COUNCIL

UNIVERSITETET I TROMSØ

Artic Council Framework Plan for Oil Pollution Prevention (2015)

- *3. MEASURES FOR PREVENTION OF OIL POLLUTION FROM ARCTIC MARITIME ACTIVITY*
  - *3.1 Strengthen traffic monitoring and management.*
    - ***3.1.2 Enhancing cooperation on maritime risk assessments.***

      The Participants intend to:

      a) exchange experience and best practices of data collection and analysis for maritime risk assessments;

      b) exchange maritime traffic and environmental sensitivity data and associated methodologies; and

      c) explore the possibility of developing a common and publicly accessible database of Arctic maritime traffic and environmental sensitivity data.

A common approach to marine risk assessments in the Arctic region

- The EPPR Working Group has identified the need for a common approach to marine risk assessments in the Arctic region.

- In all waters, good risk assessments are fundamental for the scoping, planning and conduction of risk reducing maritime safety and response measures.

- Most of the existing risk analysis methods and tools are developed for generic conditions and risk factors found in waters all around the world.

- In the Arctic, conditions often differ from other waters related to for example harsh and cold climate - which in turn makes good risk assessments all the more important.

- It is assumed to be of great value to look at how risk assessment methodologies, tools and input data could be adapted to incorporate the particular risk factors in the Arctic

Scoping Work Shop (October 2017, Ålesund, Norway)

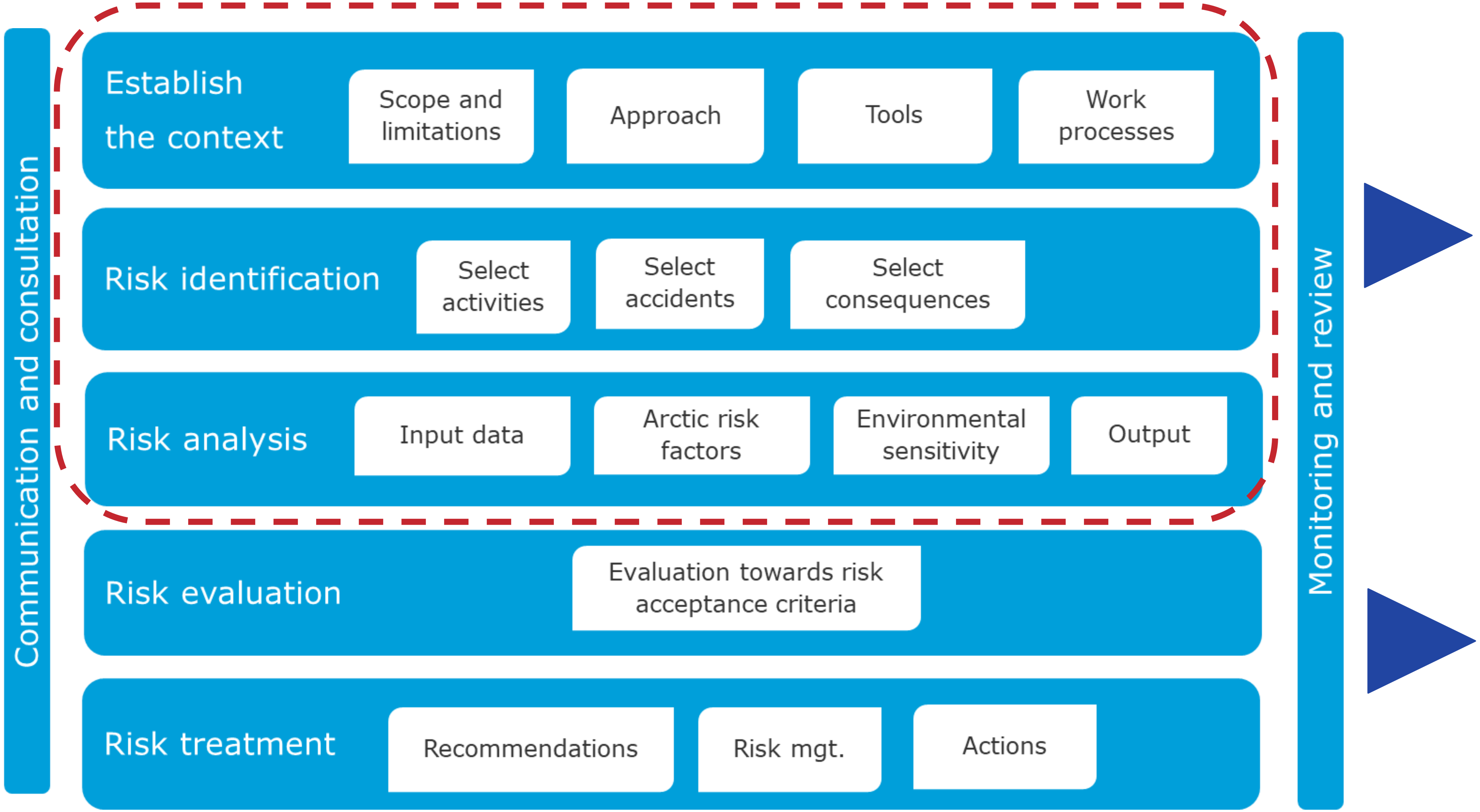
- Recommended a step-wise approach for a main project:
  - Develop a Guideline for Arctic marine risk assessments
  - Develop a toolbox including best practice document(s) and an overview of applicable and available data

- Geographical scope of Guideline:
  - Functional approach
  - Where arctic specific factors apply
- Maritime activities to be covered by guideline
  - Shipping
  - *Petroleum E&P installations/facilities not to be included*

The purpose of a Guideline and toolbox for Arctic Marine Risk Assessments

- **The Guideline**
  - Create a common approach for conducting qualitative and quantitative Arctic Marine Risk Assessments, enabling comparable assessments.
  - Better understand and communicate the different risks and risk influencing factors associated with marine activities in the Arctic.
  - Better foundation and decision support for establishing optimized risk management strategies.
- **The toolbox**
  - Include the best practice document(s) and overview of available tools, data sources, incl. their accessibility, quality, completeness/coverage, contact persons, etc.

Risk Assessment process (Based on ISO 31000 - 2009)



Communication and consultation

Establish the context
- Scope and limitations
- Approach
- Tools
- Work processes

Risk identification
- Select activities
- Select accidents
- Select consequences

Risk analysis
- Input data
- Arctic risk factors
- Environmental sensitivity
- Output

Risk evaluation
- Evaluation towards risk acceptance criteria

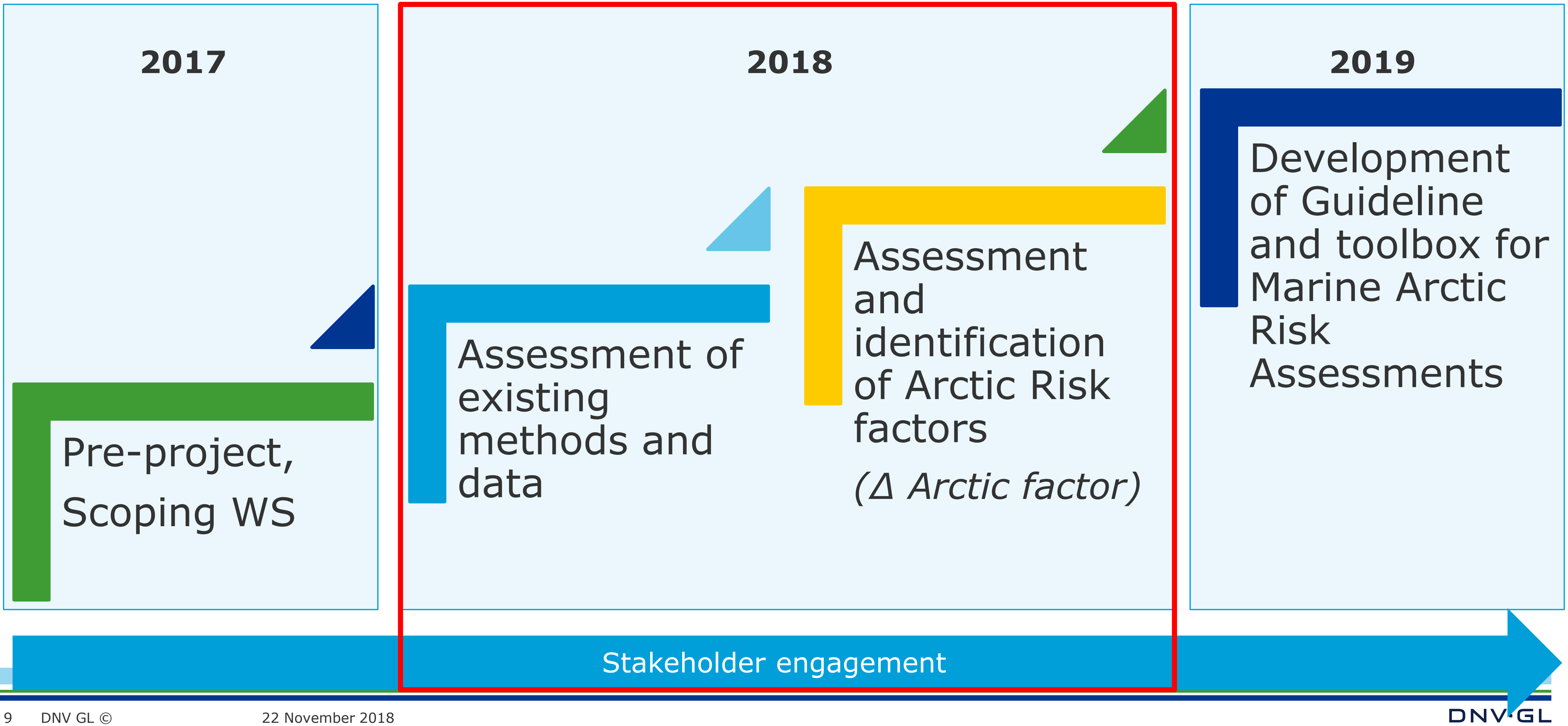
Risk treatment
- Recommendations
- Risk mgt.
- Actions

Monitoring and review

It was suggested that the first 3 steps have the highest potential for harmonizing through Arctic Guideline and Toolbox

The last two steps remains relevant for a future Circumpolar Marin Risk assessment

Project activities and timeline



2017

Pre-project,
Scoping WS

2018

Assessment of existing methods and data

Assessment and identification of Arctic Risk factors

(Δ Arctic factor)

2019

Development of Guideline and toolbox for Marine Arctic Risk Assessments

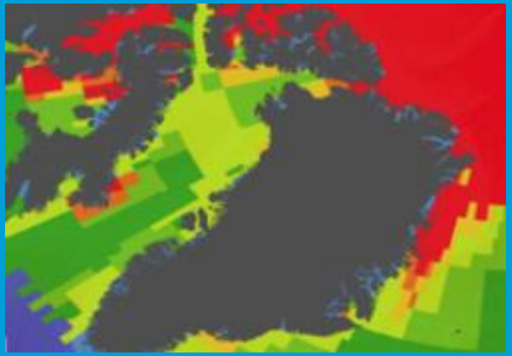
Stakeholder engagement

Work process

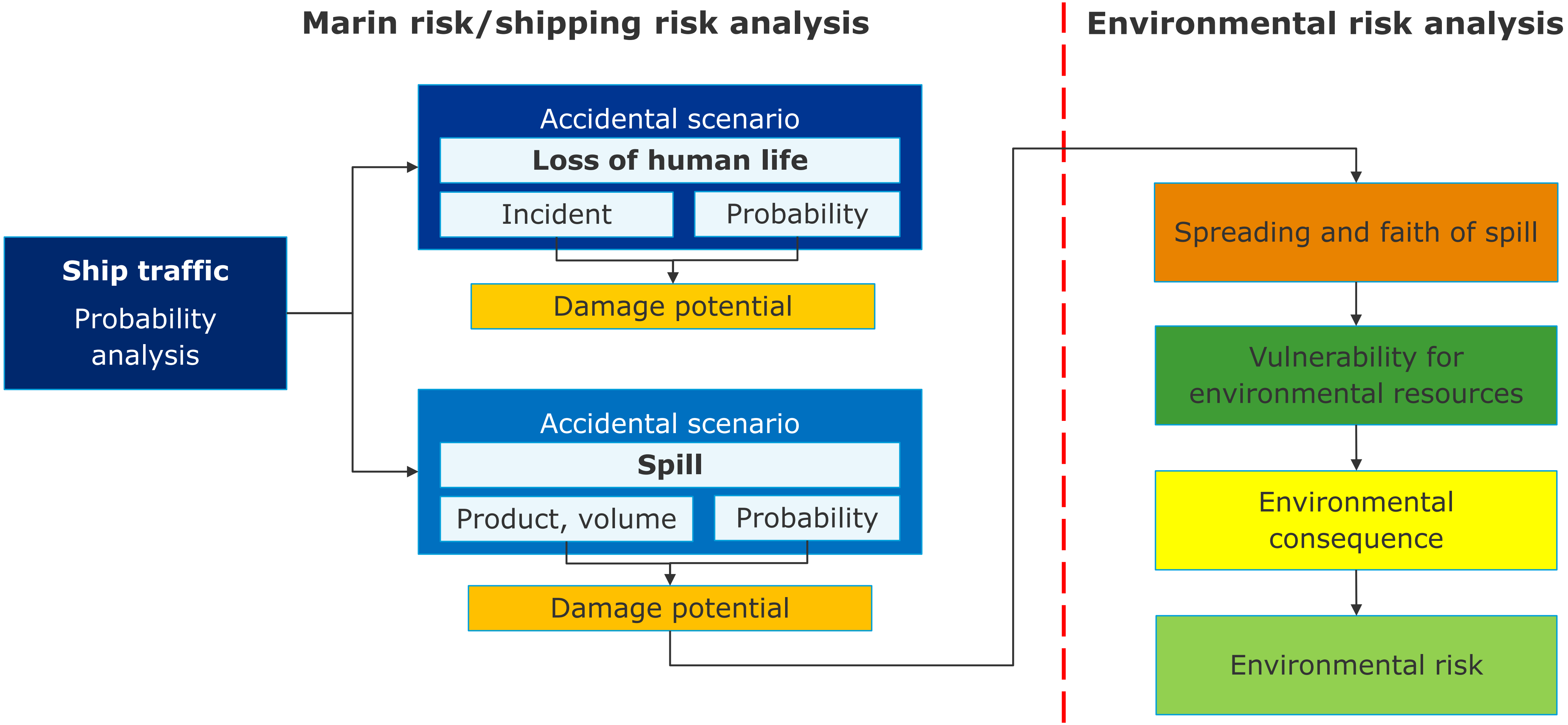
- Outreach phase (performed by EPPR, DNV GL and UIT The Arctic University of Norway):
  - Literature review
  - Direct contact (e-mail, phone, etc.)
  - Webinars (5th and 25th of September, 18), including feedback
  - Cross cutting event during CAFF conference in Rovaniemi, Finland (8th of October, 18)
  - Summary report to EPPR II – December 18

- Previous activities
  - Survey among Arctic States prior to Scoping Workshop
  - Participation in Open Risk Workshop

2018 assessments of:
- Existing methods and data
- Arctic Risk Factors



Marin risk analysis – possible elements and endpoints



Marin risk/shipping risk analysis

Environmental risk analysis

Ship traffic

Probability analysis

Accidental scenario

Loss of human life

Incident

Probability

Damage potential

Accidental scenario

Spill

Product, volume

Probability

Damage potential

Spreading and faith of spill

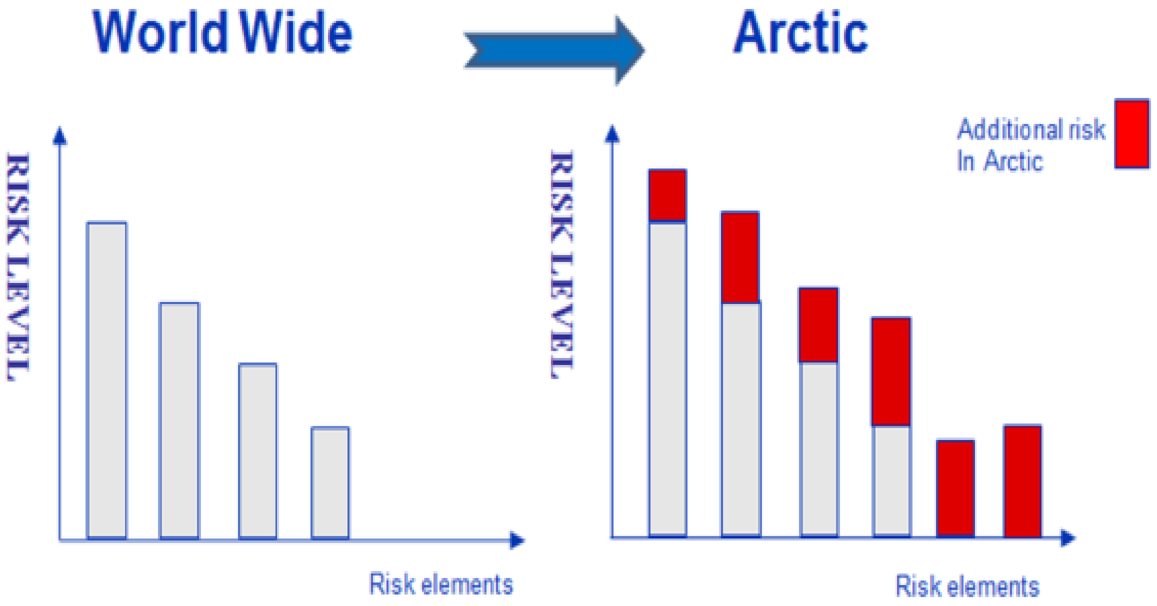
Vulnerability for environmental resources

Environmental consequence

Environmental risk

Identifying methods and tools for assessment of marine/shipping risks that are, *or could be*, used for Arctic areas.

- Do they include **arctic accident categories**?
  E.g. contact with ice
- Do they include **arctic risk shaping factors**?



- **Risk shaping factors from IMO Polar Code:**
  - Operation in low air temperature
  - Operation in ice
  - Operation in high latitude
  - Potential for abandonment onto ice or land
  - Topside icing
  - Extended periods of darkness or daylight
  - Remoteness
  - Potential lack of ship crew experience in polar operations
  - Potential lack of suitable emergency response equipment
  - Rapidly changing and severe weather conditions
  - The environment with respect to sensitivity

Marine Shipping Risk Assessments methods

Quantitative methods

- Safety Assessment Models for Shipping and Offshore in the North Sea (SAMSON) - MARIN
- MarinRisk – MARIN (ongoing development)
- Sub-regional risk of spill of oil and hazardous substances in the Baltic Sea (BRISK model) → Be-Aware method – Bonn Agreement/COWI
- NavRisk method → AISy Risk – Norwegian Coastal Administration/DNV GL (ongoing development)
- Arctic Shipping Risk and Arctic Risk Map – DNV GL
- Risk management model of winter navigation operations – Aalto University
- GRACAT → BASSY toolbox → IALA Waterway Risk Assessment Programme (IWRAP Mk2) – IALA/Gatehouse
- Marine Accident Risk Calculation System (MARCS) – DNV GL
- Event Risk Classification - Maritime (ERC-M)
- Accidental Damage and Spill Assessment Model for Collision/Grounding (ADSAM-C/G)
- Method to identify close situations between vessels - SSPA
- COLLIDE – Safetec
- SHIPCOF - Rambøll
- The Ports and Waterways Safety Assessment (PAWSA)
- *Arctic Ice Regime Shipping System (AIRSS) – Transport Canada*
- *Operational Limit Assessment Risk Indexing System (POLARIS)*

Qualitative and semi-quantitative methods

- Viking Supply - Risk Management model
- Association of Arctic Expedition Cruise Operators (AECO) Risk Assessment method
- IMO Polar Code Risk Assessment
- MARPART project - Risk Assessment
- ++

Quantitative methods including arctic risk elements

Marine Environmental Risk Assessments methods

Quantitative

- Assessment of Marine Oil Spill Risk and Environmental Vulnerability for the State of Alaska. NOAA. RPS ASA, Env Research Cons., RPI, Louis Berger Group (2014)
  - Spill Risk Calculator tool
- Environmental Risk Assessment of oil spills from shipping activities around Svalbard and Jan Mayen. Norwegian Coastal Administration. DNV GL (2014)
- Marine Environmental Risk Assessment – Greenland. Defence Command Denmark. DNV GL (2015)
- Risk Assessment for Marine Spills in Canadian Waters. Phase 2, Part B: Spills of Oil and Select HNS Transported as Bulk North of the 60th Parallel North. Transport Canada. WSP / SL Ross (2014)
- Area Risk Assessment methodology for ship-source spills in Canadian waters. Transport Canada. Dillon, MARIN, RPS ASA, Royal HaskonigDHV (2017)
- Sub-Regional Risk of Spill of Oil and Hazardous Substances in the Baltic Sea (BRISK), HELCOM 2009-2012
- BE-AWARE I and II. Bonn Agreement. COWI (2012-15)
- ERA approaches in Russia
  - Vulnerability assessment Russia (EcoProject, Murmansk Marine Biological Institute, WWF)

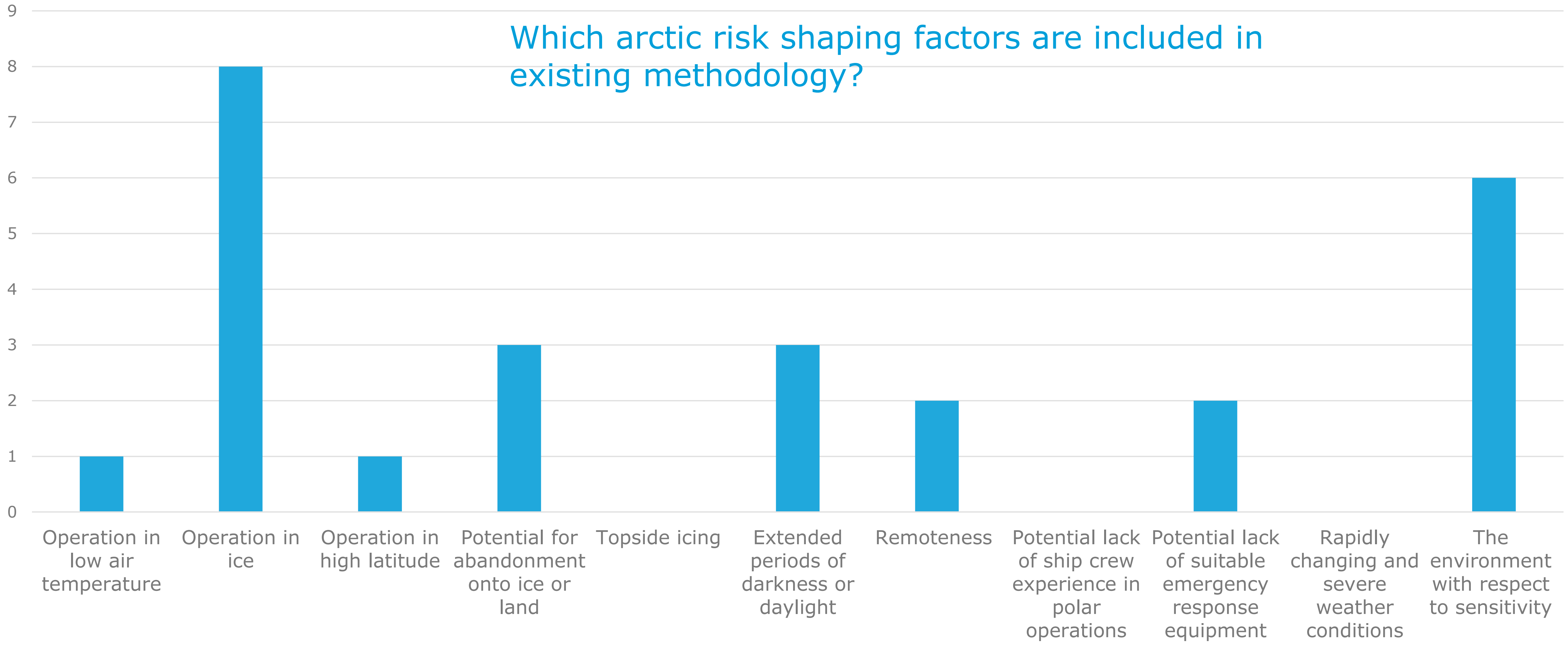
Qualitative and semi-quantitative methods

- Maritime activity and risk patterns in the High North. Nord University, Norway (2016)

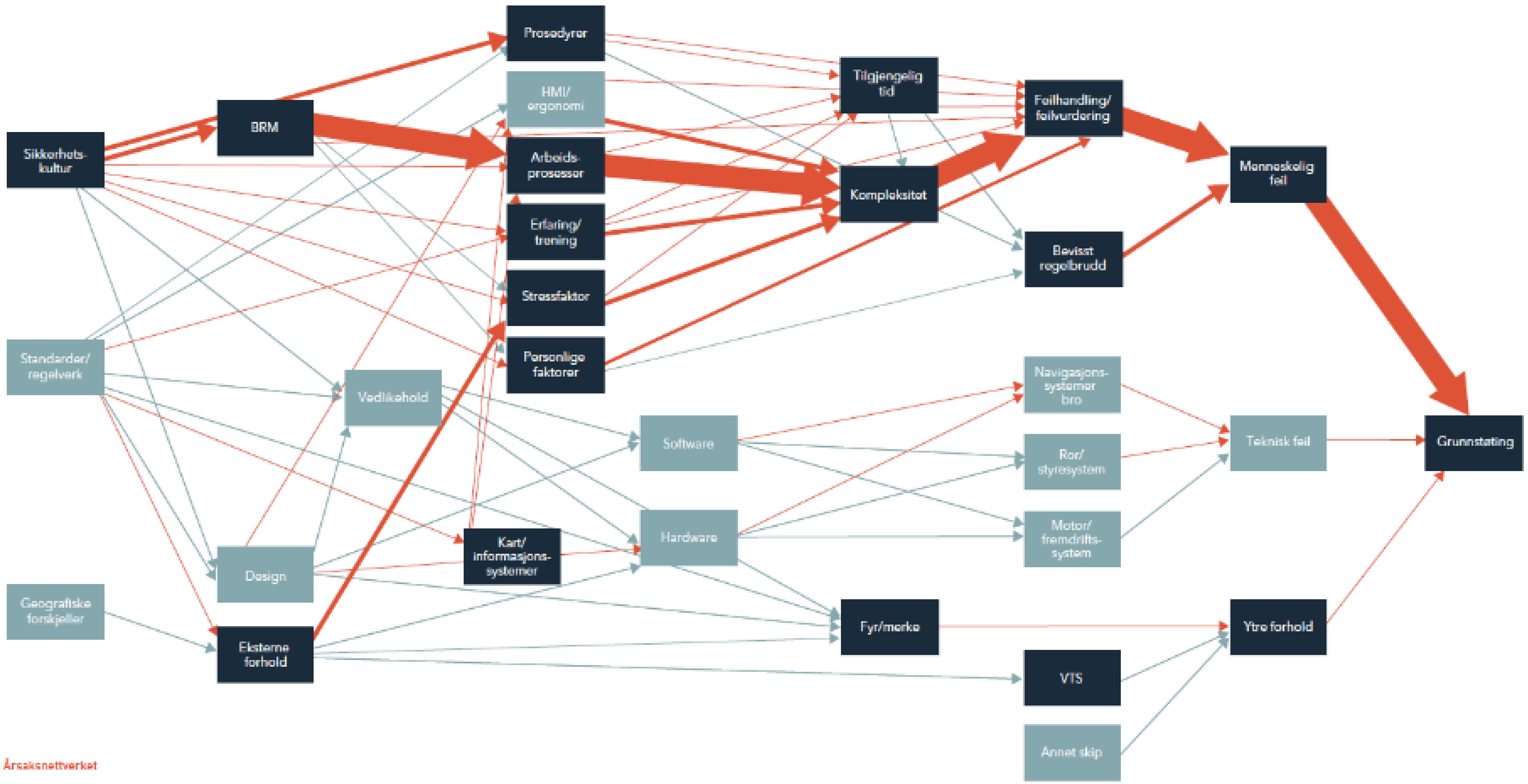
sNEBA

Quantitative methods including arctic risk elements

Quantitative area-wide methods – that includes arctic accident types and/or arctic risk shaping factors



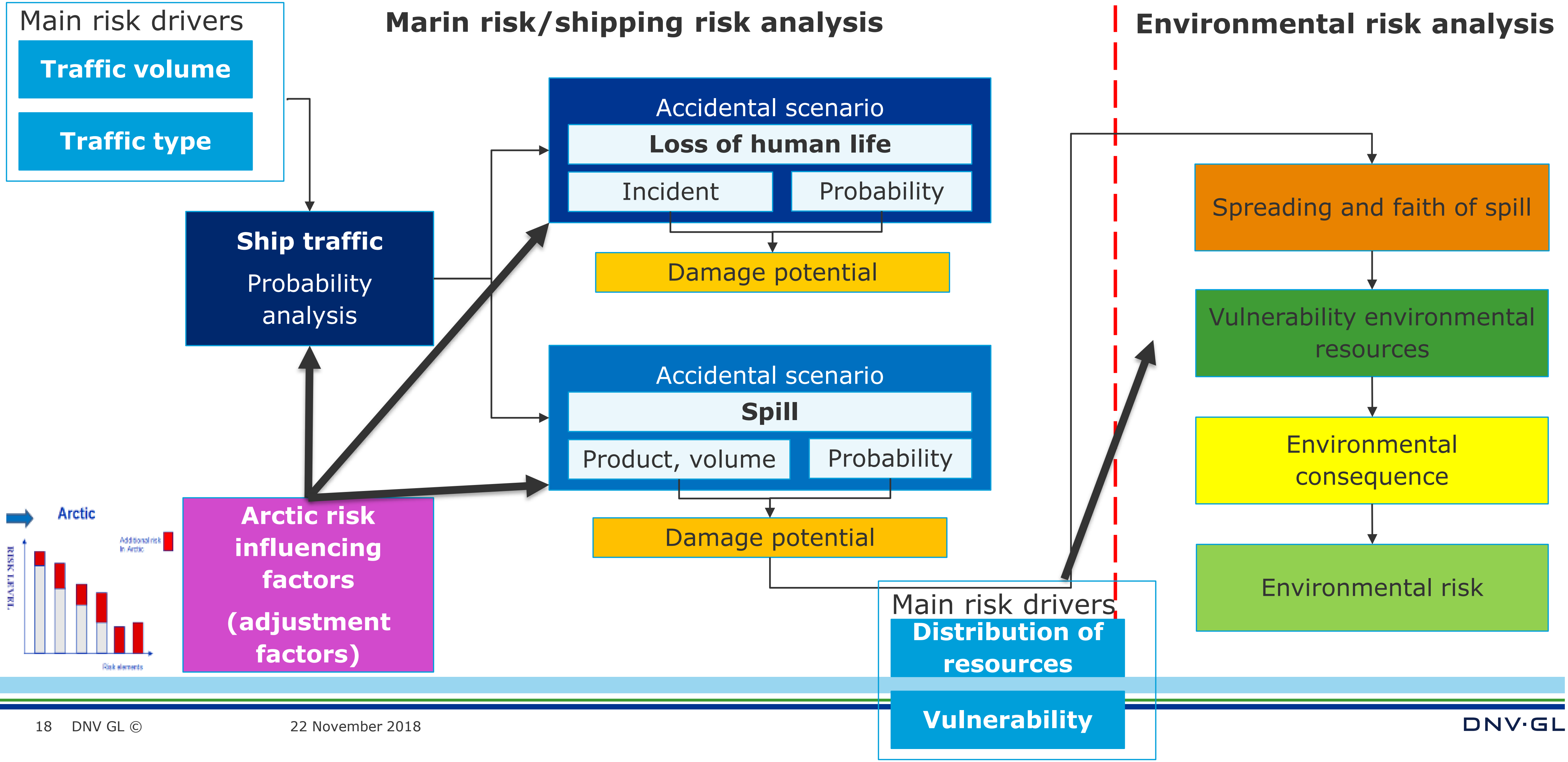
Identification of Root causes in Polar Shipping Operational assessments



Figur 1: Årsaksnettverket

Example of Cause Network from NCA Traffic Safety Analysis (2015)

How Arctic Risk Factors influence



Main risk drivers

Traffic volume

Traffic type

Marin risk/shipping risk analysis

Ship traffic

Probability analysis

Arctic risk influencing factors

(adjustment factors)

Accidental scenario

Loss of human life

Incident

Probability

Damage potential

Accidental scenario

Spill

Product, volume

Probability

Damage potential

Main risk drivers

Distribution of resources

Vulnerability

Environmental risk analysis

Spreading and faith of spill

Vulnerability environmental resources

Environmental consequence

Environmental risk

Marin risk/shipping risk analysis
- as input to marine pollution and loss of life assessments for Arctic

Main risk drivers

Critical minimum

- ✓ Traffic volume (AIS)
- ✓ Traffic characteristics (types of ships and what they carry)
- ✓ All major accident types (grounding, collision, fire/explosion, foundering, etc.)
- ✓ Grid

Best-practice (in general, world-wide)

High resolution AIS data

Categorisation of different types of fuel and cargo, also using voyage info.

Fine mesh grid, e.g. 1x1km

Best-practice for "delta arctic"

Remoteness

Lack of experience

Ice

Low temperature

Need to include arctic risk influencing factors!

"arctic risk drivers"

Calculation engine/method should deliver:

Marine pollution:

1. Oil spill quantity (frequency of spills in certain spill size categories)
2. Oil type (Heavy vs light)
3. Per location (grid)

Loss of life:

1. Fatality rate (frequency of fatalities and number of fatalities)
2. Per location (grid)

Types of data that could be used to quantify the delta-risk for Arctic

Arctic risk influencing factors

Type	Ice		Topside icing		Low temperature		Extended periods of darkness or daylight		High latitude		Remoteness		Potential lack of ship crew experience in polar operations		Potential lack of suitable emergency response equipment		Rapidly changing and severe weather conditions	
Description	May affect hull structure, stability characteristics, machinery systems, navigation, the outdoor working environment, maintenance and emergency preparedness tasks and malfunction of safety equipment and systems.		Potential reduction of stability and equipment functionality		Affects the working environment and human performance, maintenance and emergency preparedness tasks, material properties and equipment efficiency, survival time and performance of safety equipment and systems.		May affect navigation and human performance;		As it affects navigation systems, communication systems and the quality of ice imagery information.		Possible lack of accurate and complete hydrographic data and information, reduced availability of navigational aids and seamarks with increased potential for groundings compounded by remoteness, limited readily deployable SAR facilities, delays in emergency response and limited communications capability, with the potential to affect incident response.		Potential for human error		With the potential for limiting the effectiveness of mitigation measures.		Potential for escalation of incidents.	
Types of data	EXT	Ice extent (10% conc.)	AIR	Air temperature	WCI	Wind Chill Index	DAY	Daylight/ darkness	COM	Communication coverage and quality	BAT	Bathymetry data coverage and quality	DAY	Daylight/ darkness	LSA	Ship's life saving equipment	WIN	Wind speed and direction
	ICE	Ice concentration	PRE	Precipitation	AIR	Air temperature					TOP	Topography data and quality	AIR	Air temperature			WAV	Wave height
	TIC	Ice thickness	VIS	Visibility/fog	WIN	Wind speed and direction					COA	Coastline data (shape files)					AIR	Air temperature
	ITY	Ice type									SAR	SAR resources and capacities					PRE	Precipitation
	BER	Ice berg									OIL	Oil pollution prevention resources and capacity					TOP	Topography data and quality
	FLO	Floe size									ONS	Onshore facilities/assets						
											POP	Onshore population						
											POR	Airport and harbour location and facilities						
											AIS	AIS data						
											ATN	Aids to navigation coverage and quality						
											PIL	Mandatory pilotage areas						
											CAU	Precaution areas and areas to be avoided						

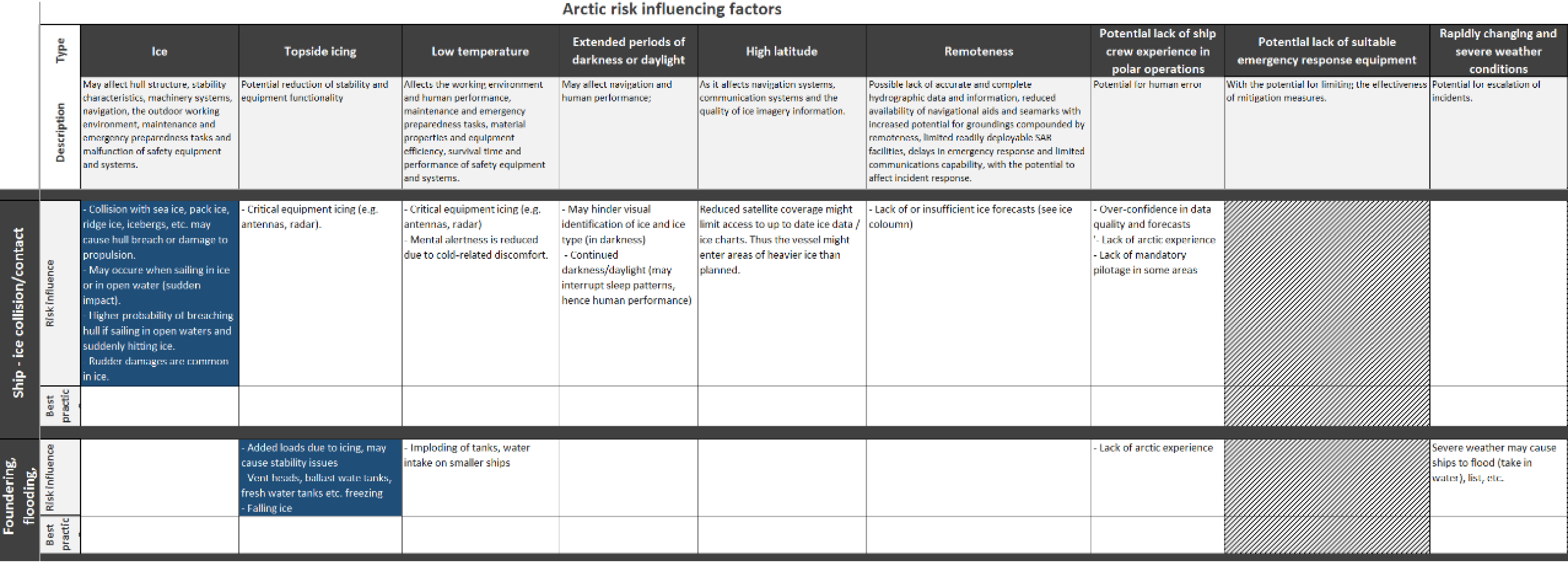
Code	Ship traffic	Data sources						
AIS	AIS data	HAVBASE (Norway)	Marin Traffic	Vesselfinder	ASTD			
	Metocean	**ESRL/NOAA**	**NORA10**	**ECMWF**	**ICOADS**	**Met Norway**	**DMI**	**BOEM**
DAY	*Daylight/darkness*							
AIR	*Air temperature*							
SEA	*Sea surface temperature*							
PRE	*Precipitation*							
VIS	*Visibility/fog*							
WAV	*Wave height*							
WIN	*Wind speed and direction*							
CUR	*Current*							
WCI	*Wind Chill Index*							
	Ice	**NSIDC/NIC**	**met.no**	**Canadian ice service**	**AARI in Russia**	**DMI ice service**	**OSI SAF**	**Uni Bremen**
EXT	*Ice extent (10% conc.)*							
ICE	*Ice concentration*							
TIC	*Ice thickness*							
ITY	*Ice type*							
BER	*Ice berg*							
FLO	*Floe size*							
	Emergency services	ESRI Data						
SAR	*SAR resources and capacities*							
OIL	*Oil pollution prevention resources and capacity*							
ONS	*Onshore facilities/assets*							
POP	*Onshore population*							
POR	*Airport and harbour location and facilities*							
	Ship characteristics	**Vesselfinder**	**Equasis**	**GISIS**	**IHS Maritime/Seaweb**	**Lloyd's List Intelligence**		
CLA	*Ships's ice class*							
AGE	*Ship's age*							
PRO	*Ship's propulsion*							
STA	*Ship's damage stability*							
SUP	*Number of icebreakers and support vessels*							
LSA	*Ship's life saving equipment*							
	Geo boundaries	**WWF Terrestrial**	**NOAA**	**Kartverket (Norway)**				
BAT	*Bathymetry data coverage and quality (shape files)*							
TOP	*Topography data and quality*							
COA	*Coastline data (shape files)*							
	Aids to navigation and communication							
ATN	*Aids to navigation coverage and quality*							
COM	*Communication coverage and quality*							
PIL	*Mandatory pilotage areas*							
CAU	*Precaution areas and areas to be avoided*							

Probability of accidents:
- Grounding
- Ship-ship collision

Arctic risk influencing factors

	Type	Ice	Topside icing	Low temperature	Extended periods of darkness or daylight	High latitude	Remoteness	Potential lack of ship crew experience in polar operations	Potential lack of suitable emergency response equipment	Rapidly changing and severe weather conditions
	Description	May affect hull structure, stability characteristics, machinery systems, navigation, the outdoor working environment, maintenance and emergency preparedness tasks and malfunction of safety equipment and systems.	Potential reduction of stability and equipment functionality	Affects the working environment and human performance, maintenance and emergency preparedness tasks, material properties and equipment efficiency, survival time and performance of safety equipment and systems.	May affect navigation and human performance;	As it affects navigation systems, communication systems and the quality of ice imagery information.	Possible lack of accurate and complete hydrographic data and information, reduced availability of navigational aids and seamarks with increased potential for groundings compounded by remoteness, limited readily deployable SAR facilities, delays in emergency response and limited communications capability, with the potential to affect incident response.	Potential for human error	With the potential for limiting the effectiveness of mitigation measures.	Potential for escalation of incidents.
Grounding (sea bed)	Risk influence	- May cause machinery to seize up, vessel drifting with ice and results in e.g. grounding. - Operating with less margins (to avoid ice and icebergs). - Deviating from planned route due to avoid ice and icebergs. - Follow old channel in ice. - AtoN moved or not possible to see due to ice.	- Deviating from planned route due to due icing. - Critical equipment icing (e.g. antennas, radar).	- Deviating from planned route due to low temp. - Critical equipment icing (e.g. antennas, radar) and freezing of fluid-containing systems. - Mental alertness is reduced due to cold-related discomfort.	- Continued darkness/daylight (may interrupt sleep patterns, hence human performance)	- Lack of AIS coverage, coast radio /VHF (failure to communicate) - Reduced satellite coverage	- Uncertain bathymetry (depth) data - Insufficient or wrong charts - Missing or insufficient AtoN - Isolation and remoteness may cause psychological reactions, hence affect human performance.	- Over-confidence in data quality and charts '- Lack of arctic experience - Lack of mandatory pilotage in some areas	▨	- Challening local conditions, small scale atmospheric phenomena, such as; polar lows. - Sparse weather stations. - Weather forecasts generally more uncertain. - Snow may hinder visibility significantly, also in daylight.
	Best practice								▨	
Ship-ship collision	Risk influence	- Passing ships in channel, overtaking, headon collision etc. - Collisions between assisted ships and icebreakers - Loss of maneuverability - Drifting with ice	- Critical equipment icing (e.g. antennas, radar).	- Critical equipment icing (e.g. antennas, radar) and freezing of fluid-containing systems. - Mental alertness is reduced due to cold-related discomfort.	- Continued darkness/daylight (may interrupt sleep patterns, hence human performance)	- Lack of AIS coverage, coast radio /VHF (failure to communicate) - Reduced satellite coverage	- Isolation and remoteness may cause psychological reactions, hence affect human performance.	- Over-confidence in data quality and charts '- Lack of arctic experience - Lack of mandatory pilotage in some areas	▨	- Fog - Challening local conditions, small scale atmospheric phenomena, such as; polar lows. - Sparse weather stations. - Weather forecasts generally more uncertain.
	Best practic								▨	

Probability of accidents:
- Ship-ice collision/contact
- Foundering



Arctic risk influencing factors

	Type	Ice	Topside icing	Low temperature	Extended periods of darkness or daylight	High latitude	Remoteness	Potential lack of ship crew experience in polar operations	Potential lack of suitable emergency response equipment	Rapidly changing and severe weather conditions
	Description	May affect hull structure, stability characteristics, machinery systems, navigation, the outdoor working environment, maintenance and emergency preparedness tasks and malfunction of safety equipment and systems.	Potential reduction of stability and equipment functionality	Affects the working environment and human performance, maintenance and emergency preparedness tasks, material properties and equipment efficiency, survival time and performance of safety equipment and systems.	May affect navigation and human performance;	As it affects navigation systems, communication systems and the quality of ice imagery information.	Possible lack of accurate and complete hydrographic data and information, reduced availability of navigational aids and seamarks with increased potential for groundings compounded by remoteness, limited readily deployable SAR facilities, delays in emergency response and limited communications capability, with the potential to affect incident response.	Potential for human error	With the potential for limiting the effectiveness of mitigation measures.	Potential for escalation of incidents.
Ship - ice collision/contact	Risk influence	- Collision with sea ice, pack ice, ridge ice, icebergs, etc. may cause hull breach or damage to propulsion. - May occure when sailing in ice or in open water (sudden impact). - Higher probability of breaching hull if sailing in open waters and suddenly hitting ice. - Rudder damages are common in ice.	- Critical equipment icing (e.g. antennas, radar).	- Critical equipment icing (e.g. antennas, radar) - Mental alertness is reduced due to cold-related discomfort.	- May hinder visual identification of ice and ice type (in darkness) - Continued darkness/daylight (may interrupt sleep patterns, hence human performance)	Reduced satellite coverage might limit access to up to date ice data / ice charts. Thus the vessel might enter areas of heavier ice than planned.	- Lack of or insufficient ice forecasts (see ice coloumn)	- Over-confidence in data quality and forecasts '- Lack of arctic experience - Lack of mandatory pilotage in some areas	▨	
	Best practic								▨	
Foundering, flooding,	Risk influence		- Added loads due to icing, may cause stability issues - Vent heads, ballast wate tanks, fresh water tanks etc. freezing - Falling ice	- Imploding of tanks, water intake on smaller ships				- Lack of arctic experience	▨	Severe weather may cause ships to flood (take in water), list, etc.
	Best practic								▨	

Probability of accidents:
- Fire/explosion
- Stuck in ice

Arctic risk influencing factors

	Type	Ice	Topside icing	Low temperature	Extended periods of darkness or daylight	High latitude	Remoteness	Potential lack of ship crew experience in polar operations	Potential lack of suitable emergency response equipment	Rapidly changing and severe weather conditions
	Description	May affect hull structure, stability characteristics, machinery systems, navigation, the outdoor working environment, maintenance and emergency preparedness tasks and malfunction of safety equipment and systems.	Potential reduction of stability and equipment functionality	Affects the working environment and human performance, maintenance and emergency preparedness tasks, material properties and equipment efficiency, survival time and performance of safety equipment and systems.	May affect navigation and human performance;	As it affects navigation systems, communication systems and the quality of ice imagery information.	Possible lack of accurate and complete hydrographic data and information, reduced availability of navigational aids and seamarks with increased potential for groundings compounded by remoteness, limited readily deployable SAR facilities, delays in emergency response and limited communications capability, with the potential to affect incident response.	Potential for human error	With the potential for limiting the effectiveness of mitigation measures.	Potential for escalation of incidents.
Fire and explosion	Risk influence	- Operating machinery to max due to ice (fishing vessels etc.) - More fire hazards (more heaters, electrical heater equipment, etc.)	- Not direct cause to fire; but might hinder access to fire fighting equipment - Icing in equipment if the fire fighting equipment are not properly protected.						▨	
	Best practice								▨	
Stuck in ice	Risk influence	- Ships get stuck in ice when they operate in higher concentrations of sea ice. - Once stuck compression in ice field might cause huge loading on ship sides and eventually structural damage. This might lead to breach in the hull and flooding. Ice pressure might cause severe list to the vessel. - Ship might drift aground with ice once stuck.	- Critical equipment icing (e.g. antennas, radar).	- Critical equipment icing (e.g. antennas, radar) - Mental alertness is reduced due to cold-related discomfort.	- May hinder visual identification of ice and ice type (in darkness) - Continued darkness/daylight (may interrupt sleep patterns, hence human performance)	Reduced satellite coverage might limit access to up to date ice data / ice charts. Thus the vessel might enter areas of heavier ice than planned.	- Lack of or insufficient ice forecasts (see ice coloumn)	- Over-confidence in data quality and forecasts '- Lack of arctic experience - Lack of mandatory pilotage in some areas	▨	Severe weather may cause the ice field to move leading to ship drift to ground and/or cause pressure in ice field that might endanger the hull
	Best practice								▨	

Consequences of accidents:
- Loss of life
- Marine pollution

Arctic risk influencing factors

	Type	Ice	Topside icing	Low temperature	Extended periods of darkness or daylight	High latitude	Remoteness	Potential lack of ship crew experience in polar operations	Potential lack of suitable emergency response equipment	Rapidly changing and severe weather conditions
	Description	May affect hull structure, stability characteristics, machinery systems, navigation, the outdoor working environment, maintenance and emergency preparedness tasks and malfunction of safety equipment and systems.	Potential reduction of stability and equipment functionality	Affects the working environment and human performance, maintenance and emergency preparedness tasks, material properties and equipment efficiency, survival time and performance of safety equipment and systems.	May affect navigation and human performance;	As it affects navigation systems, communication systems and the quality of ice imagery information.	Possible lack of accurate and complete hydrographic data and information, reduced availability of navigational aids and seamarks with increased potential for groundings compounded by remoteness, limited readily deployable SAR facilities, delays in emergency response and limited communications capability, with the potential to affect incident response.	Potential for human error	With the potential for limiting the effectiveness of mitigation measures.	Potential for escalation of incidents.
Loss of life	Risk influence	- Ice may hinder evacuation, damage lifesaving equipment, lifeboats and limit rescue availability. - However, ice floes may also provide ground for embarked persons (to avoid freezing waters). - Ship data: Ice strenghtened ships, ticker hull plates	- Immediate exposure to cold environment, challenging rescue and evacuation operations - Limit acces to life saving equipment, icing/freezing of equipment. '- May cause slip, trip and falls. - Ice on lifeboats may also hinder rescue from heli.	- May be extreme cold temperature - Survivability in liferafts, lifeboats and freezing waters is reduced. - Higher likelihood of hypothermia. - Cold impairs the human performance of complex emergency and abondon ship tasks.	- Challenging SAR operations in darkness.	- Lack of communication systems, electronic communications challenges - Low bandwith - Challenging to establish Common Operating Picture (COP)	- Reduced SAR resources/capabilities, emergency preparedness - Geographic remoteness; longer time to reach accident location. - Infrastructure and capability to manage accidents (e.g. medical treatment) may be distant or unavailable - Ships nearby that may assist in emergency (AIS data). There might be significantly less ship traffic in remote areas in polar waters than what is common lower latitudes so the closest vessel to assist in distress can far away.	- Lack of arctic experience	- Number of lifesaving equipment in relatation to number of persons onboard, e.g. extra capacity.	Potential for escalation of accident
	Best practice									
Marine pollution	Risk influence	-Escalation, larger hull size - Access to damaged parts due to ice - Ship data: Ice strenghtened ships, ticker hull plates	Working environment and access	- Low temp; may be positive effect on oil outflow of heavy fuel (due to viscosity) - Access to damaged parts	- Challenging oil spill response operations in darkness.	- Lack of communication systems, electronic communications challenges - Low bandwith - Challenging to establish Common Operating Picture (COP)	- Reduced emergency preparedness - Geographic remoteness; longer time to reach accident location. - Infrastructure and capability to manage accidents may be distant or unavailable	- Lack of arctic experience	- Capacity of oil spill preparedness onboard	Potential for escalation of accident
	Best practic									

Status and plans for 2019

Activities 2019 (Draft)

1. Digital solution

2. Implementation of Arctic Risk Influencing Factors

3. Guideline and toolbox implementation

4. Roll-out/ dissemination

Establish governance
- Owner/publisher
- Facilitation/operation
- Updates and maintenance

Establish digital platform
- Back-end solution (Servers, databases)
- Front-end solution (Graphical user interface, functionality)

Implementation of Arctic Risk Influencing Factors

- Develop how ARIF should be implemented in analysis
- Perform WS to get feedback on ARIF and digital solution

Produce/implement guideline and toolbox
- Guideline – glossy paper version
- Guideline and toolbox – digital version

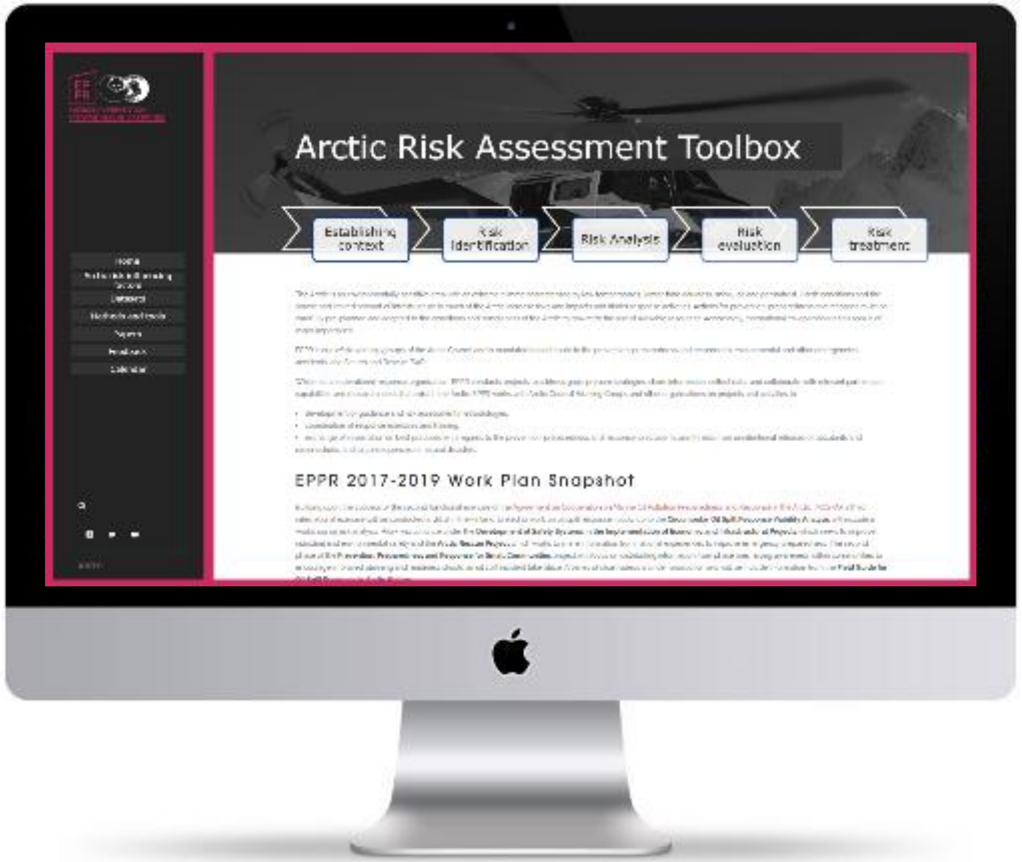
Engagement
- Publishing material
- Webinars/WS
- Conference paper
- Evaluation and feedback
- Summary report (2019)

Timeline and milestones (Draft)

	2019											
Work scope - Description				Q2			Q3			Q4		
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Des
Task 1. Digital solution	🟦	🟦	🟦									
• Ownership/gouvernance	▨	▨										
• Establish digital platform		▨	🟩									
Task 2. Implementation of Arctic Risk Influencing Factors			🟦	🟦	🟦							
• Methodology development			▨	▨	▨							
• Workshop (guideline, methodology and toolbox)					🟩							
Task 3. Guideline and toolbox implementation				🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦
• Guideline and toolbox – digital version				▨	▨	▨	▨	▨	▨	▨	🟩	
• Guideline – glossy paper version									▨	▨	🟩	
Task 4. Roll-out/ dissemination										🟦	🟦	🟦
• Publishing material										▨	▨	
• Webinar?											🟩	
• Conference paper												▨
• Evaluation and feedback											▨	
• Summary report (2019)											▨	🟩

The guideline (Draft)

1. Web-based version with toolbox



Arctic Risk Assessment Toolbox

EPPR 2017-2019 Work Plan Snapshot

2. Paper version

EPPR Emergency Prevention, Preparedness and Response

GUIDELINE

for

Marine risk assessments in the Arctic

ARCTIC COUNCIL

Contact persons

- For questions about the project please contact:
  - Trine Beate Solevågseide: trine.solevaagseide@kystverket.no
  - Patti Bruns, EPPR Executive Secretary: patti@arctic-council.org
  - Hans Petter Dahlslett, Project Manager, DNV GL: hans.petter.dahlslett@dnvgl.com

Oil Spill Response Viability Analysis – links to sNEBA?

Circumpolar Oil Spill Response Viability Analysis

- The purpose of the circumpolar Arctic response viability analysis is to better understand the potential for different oil spill response systems to operate in the Arctic marine environment.

- The analysis estimates how often different type of oil spill systems could be deployed in the Arctic based on defined operational limits and compares these to a hindcast of metocean data.

- The approach may be applicable with sNEBA

EP
PR

CIRCUMPOLAR OIL SPILL
RESPONSE VIABILITY ANALYSIS

TECHNICAL REPORT

ARCTIC COUNCIL

Effects of Arctic metocean conditions on Oil Spill Response

Wind
Sea state
Sea ice
Air temperature
Wind chill
Structural icing
Light conditions
Horizontal visibility
Vertical visibility

Effects on operational platforms

Effects on responders

Effects on response systems

Photo: Norwegian Coastal Administration

Web-based tool

A study of oil spill response viability in Norwegian waters

The oil spill response viability analysis for Norwegian marine waters is a quantitative assessment of how often, statistically, defined oil spill response systems can operate successfully in Norwegian marine waters based on historical data for wind, waves, visibility, temperatures and sea ice. The analysis indicates the seasonal and geographical viability of each of the defined spill response methods and systems in relation to weather and sea states. The analysis identifies how each defined system is influenced by weather and sea states, and which factors are limiting. New users are encouraged to read about the analysis and user manual before accessing the web based planning tool.

Access planning tool >>

Contact us

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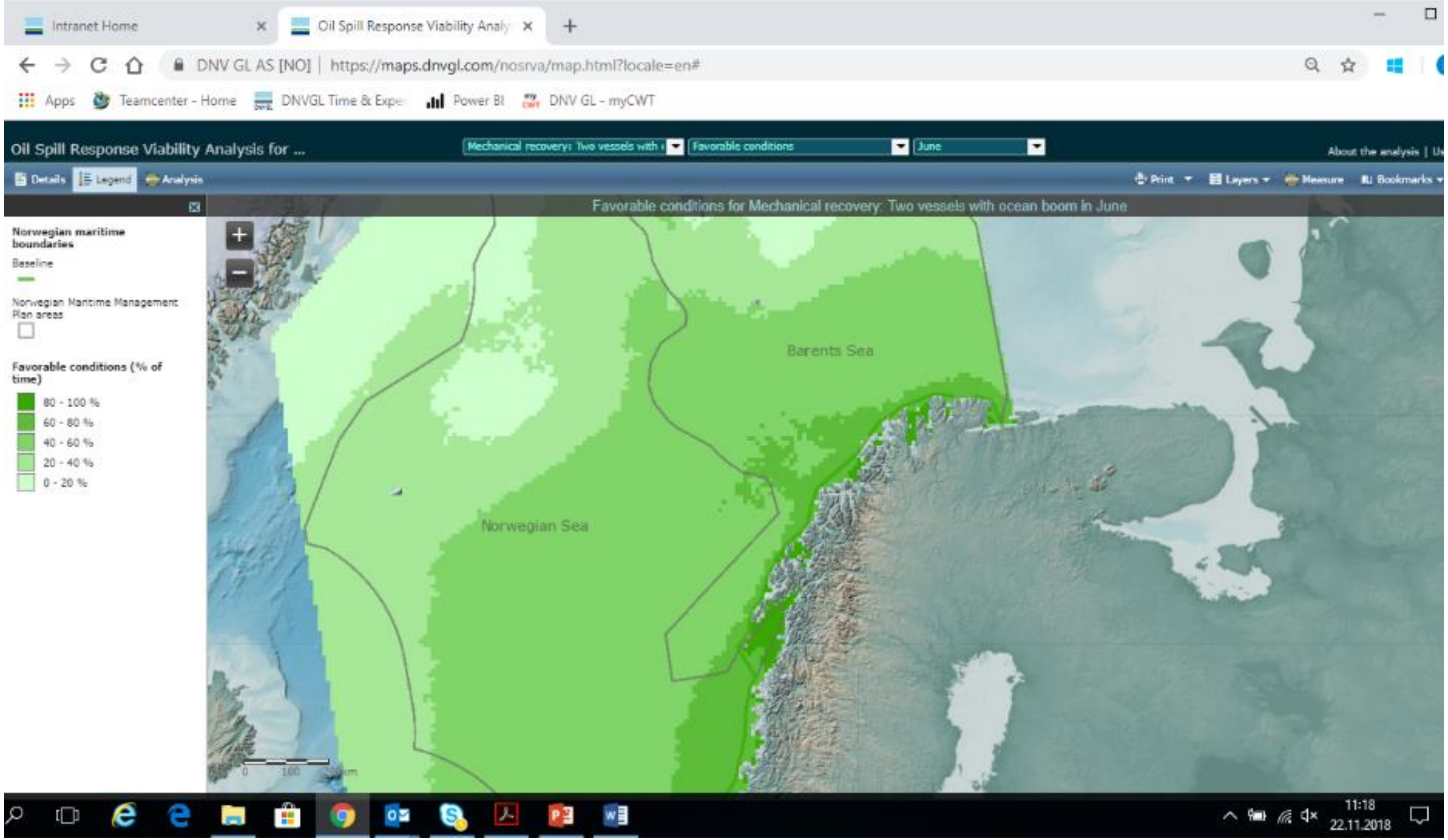
Oil Spill Response Viability



Oil Spill Response Viability Analysis for ...

Mechanical recovery: Two vessels with

Favorable conditions

June

Favorable conditions for Mechanical recovery: Two vessels with ocean boom in June

Norwegian maritime boundaries

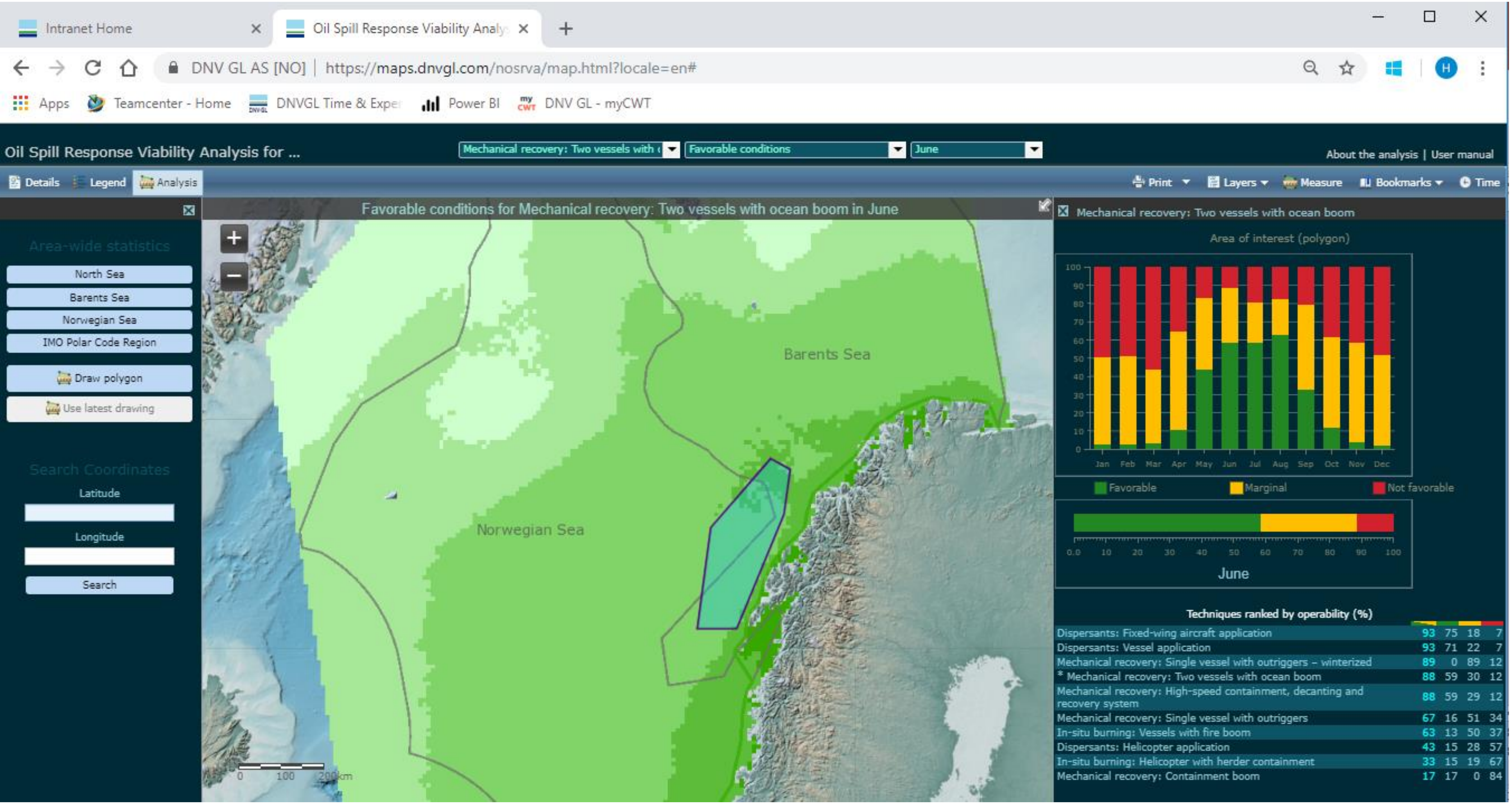
Baseline

Norwegian Maritime Management Plan areas

☐

Favorable conditions (% of time)

🟩 80 - 100 %
🟩 60 - 80 %
🟩 40 - 60 %
🟩 20 - 40 %
🟩 0 - 20 %



Oil Spill Response Viability Analysis for ...

Mechanical recovery: Two vessels with o | Favorable conditions | June

Favorable conditions for Mechanical recovery: Two vessels with ocean boom in June

Mechanical recovery: Two vessels with ocean boom

Area of interest (polygon)

🟩 Favorable 🟨 Marginal 🟥 Not favorable

June

Techniques ranked by operability (%)

	🟩🟨	🟩	🟨	🟥
Dispersants: Fixed-wing aircraft application	93	75	18	7
Dispersants: Vessel application	93	71	22	7
Mechanical recovery: Single vessel with outriggers – winterized	89	0	89	12
* Mechanical recovery: Two vessels with ocean boom	88	59	30	12
Mechanical recovery: High-speed containment, decanting and recovery system	88	59	29	12
Mechanical recovery: Single vessel with outriggers	67	16	51	34
In-situ burning: Vessels with fire boom	63	13	50	37
Dispersants: Helicopter application	43	15	28	57
In-situ burning: Helicopter with herder containment	33	15	19	67
Mechanical recovery: Containment boom	17	17	0	84

Questions?

Thank you for your attention

Hans Petter Dahlslett
hans.petter.dahlslett@dnvgl.com
+47 95 18 66 43

www.dnvgl.com

SAFER, SMARTER, GREENER

SNEBA TOOLS

STEPS:

1) BASIC DATA AND INFORMATION

2) ASSESSMENT

Susse Wegeberg, Janne Fritt-Rasmussen, Kim Gustavson

AARHUS
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SNEBA steps:

1. Basic data and information
2. Assessment
3. Scores for the SNEBA
4. Analysis through decisions trees
5. Interpretation and dissemination of SNEBA results

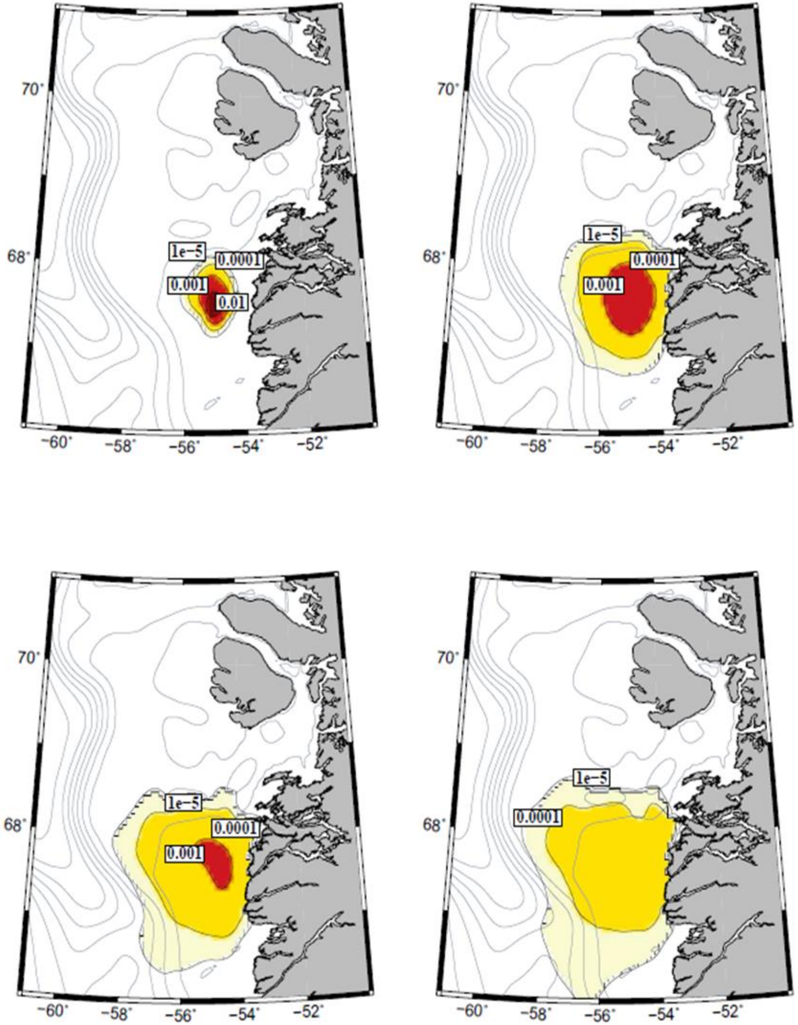
DEFINITION OF ASSESSMENT AREA

The area/region may possess natural limits, like in cases with enclosed sea water basins.

Furthermore, if the area in question is defined in other respects, e.g., within, Arctic Council, Particular Sensitive Sea Area (PSSA)

Examples of areas / regions suitable for SNEBAs:

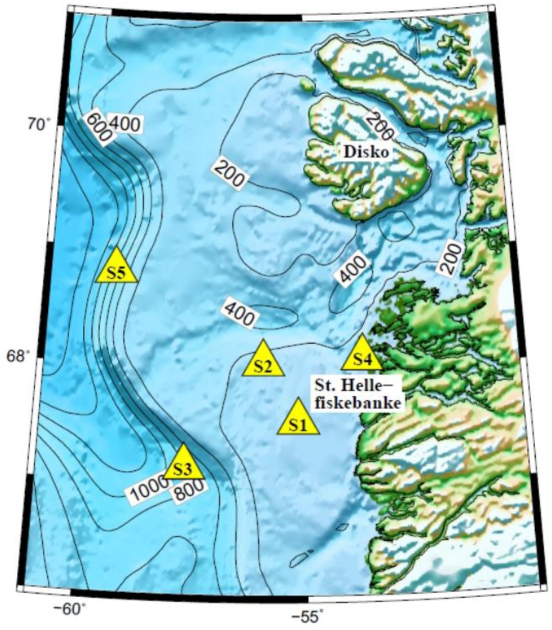
- Enclosed sea basins; fjords, gulfs, inlets, (e.g. White Sea, Black Sea, The Aegean Sea, The Persian Gulf, Gulf of Finland)
- Regions of particular concern (e.g. Polar Sea, the Seas around Antarctica)
- Areas in risk of cross border pollution (e.g. Barents Sea, Baffin Bay/Davis Strait, Bay of Biscay, Baltic Sea).



DEFINITION OF OIL SPILL SCENARIOS

The following basic parameter must be set for the scenarios:

- Oil spill sites (locality, sea surface vs. seabed)
- Oil type (light/heavy crude oil, bunker oil, diesel oil etc.)
- Size of oil spill (rate volume per time, duration)
- Day and time of year (different seasons; to meet differences in temperature (degradation, evaporation) and potential ice cover
- Weather conditions
- Number of scenarios



EVALUATION OF DISTRIBUTION, DISPERSION AND FATE OF THE OIL SPILL IN THE ASSESSMENT AREA

Aim of the oil spill scenarios is to understand the potential distribution, dispersion and fate of the spilled oil.

It is recommended to use hydrodynamic models including met-ocean data and algorithms for weathering of the oil.

In cases where oil spill is less likely, and sensitivity/vulnerability of the organisms/environment in the assessment area is low, hydrodynamic modelling may be substituted by more simple estimations.

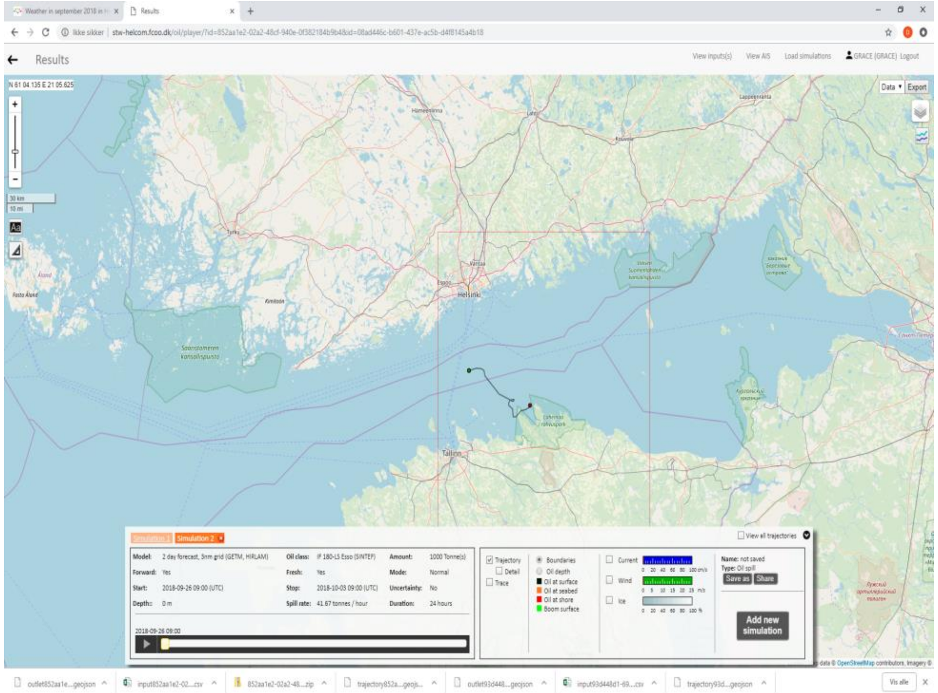
Assessment area / region	
↓ Areas/regions where oil spill is less likely or sensitivity/vulnerability of organisms/environment generally is low	↓ Areas/regions where oil spill is more likely or sensitivity/vulnerability of organisms/environment generally is high
↓ Distribution and fate of specific oil spill is estimated based on: • dominant wind direction and sea current • oil specific solubility, evaporation etc. • worst case calculations of total oil volume - form slick on sea surface - disperse into seawater - reach seabed - reach shoreline	↓ Distribution and fate of specific oil spill is simulated using hydrodynamic modelling

Seatrack Web

The Seatrack Web (STW) is the official HELCOM model used for calculating the drift/dispersion/fate of oil spills in the sea. It is available online for national authorities and certain research organizations.

The model uses forecasted met-oceanic data to simulate drift/dispersion/fate of in three dimensions in the sea.

Seatrack Web has been implemented for the Baltic Sea, parts of the North Sea and coastal waters around Greenland.



Model: 2 day forecast, 3nm grid (GETM, HIRLAM)
Forward: Yes
Start: 2018-09-26 09:00 (UTC)
Depth: 0 m
Oil class: IF 180-LS Esso (SINTEF)
Fresh: Yes
Stop: 2018-10-03 09:00 (UTC)
Spill rate: 41.67 tonnes / hour
Amount: 1000 Tonne(s)
Mode: Normal
Uncertainty: No
Duration: 24 hours
Name: not saved
Type: Oil spill

2018-09-26 09:00

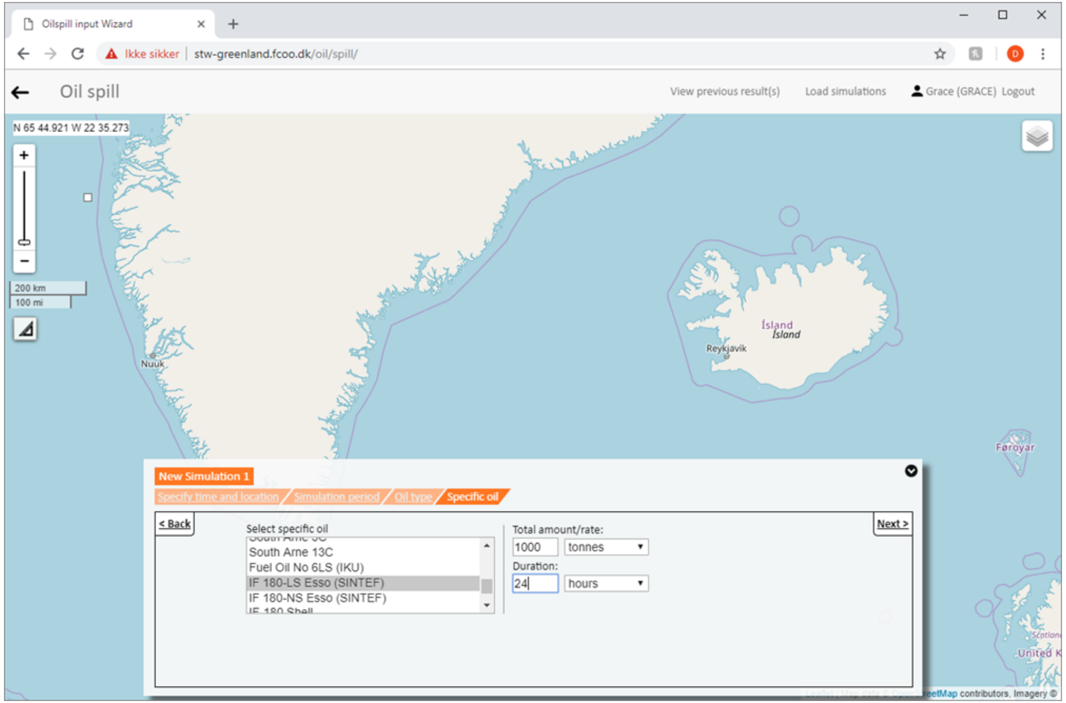
SeaTrack Web

A number of different oils are handled by the model, from gasoline to asphalt.

Choose between:

- Oil classes (light oil, medium oil or heavy oil)
- Specific oil types

The Seatrack Web model includes state-of-the-art oil weathering algorithms for calculating evaporation, emulsification, density and viscosity of these oils over time.



Select specific oil

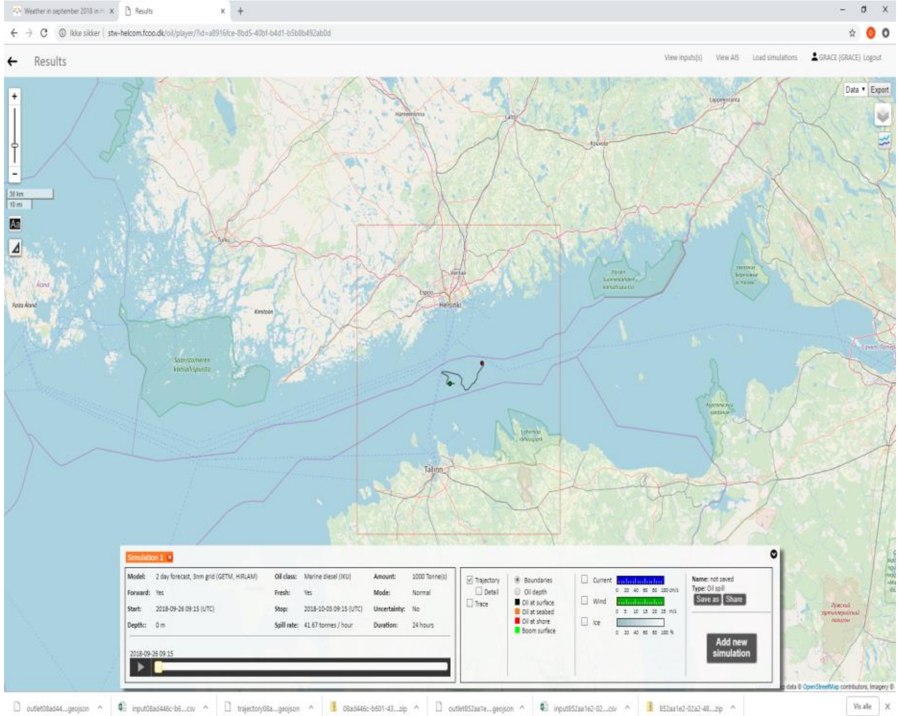
- South Arne 13C
- Fuel Oil No 6LS (IKU)
- IF 180-LS Esso (SINTEF)
- IF 180-NS Esso (SINTEF)

Total amount/rate: 1000 tonnes

Duration: 24 hours

SeaTrack Web - results

Marine diesel



Simulation 1

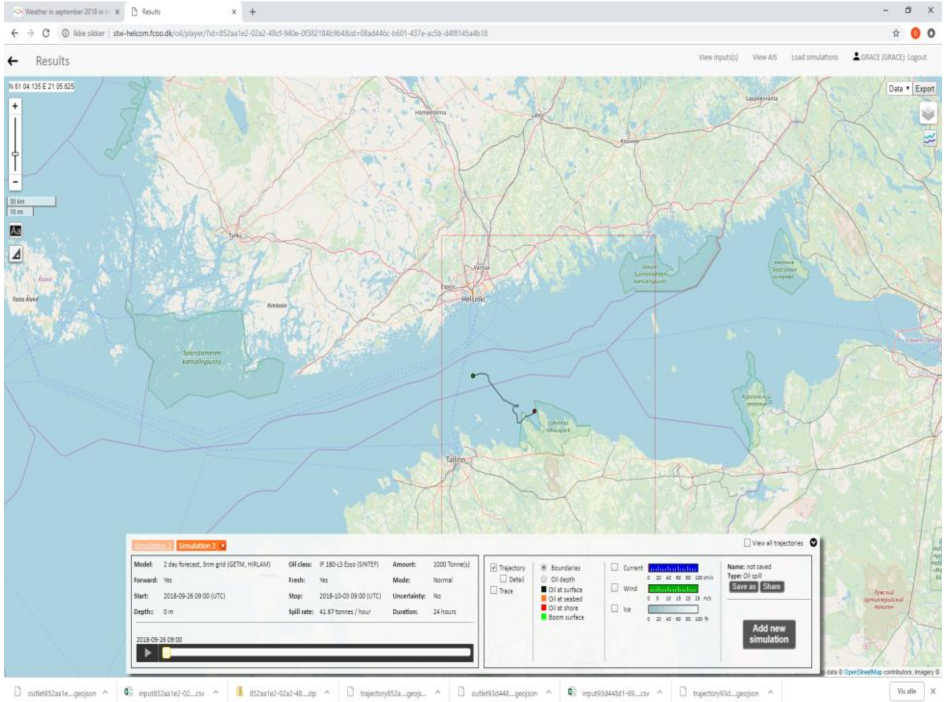
Model: 2 day forecast, 3nm grid (GETM, HIRLAM)
Forward: Yes
Start: 2018-09-26 09:15 (UTC)
Depth:: 0 m
Oil class: Marine diesel (IKU)
Fresh: Yes
Stop: 2018-10-03 09:15 (UTC)
Spill rate: 41.67 tonnes / hour
Amount: 1000 Tonne(s)
Mode: Normal
Uncertainty: No
Duration: 24 hours

2018-09-26 09:15

☑ Trajectory
☐ Detail
☐ Trace

Name: not saved
Type: Oil spill

Heavy fuel oil IFO180



Simulation 1 Simulation 2

Model: 2 day forecast, 3nm grid (GETM, HIRLAM)
Forward: Yes
Start: 2018-09-26 09:00 (UTC)
Depth:: 0 m
Oil class: IF 180-LS Esso (SINTEF)
Fresh: Yes
Stop: 2018-10-03 09:00 (UTC)
Spill rate: 41.67 tonnes / hour
Amount: 1000 Tonne(s)
Mode: Normal
Uncertainty: No
Duration: 24 hours

2018-09-26 09:00

☐ View all trajectories
☑ Trajectory
☐ Detail
☐ Trace

Name: not saved
Type: Oil spill

SeaTrack Web - results

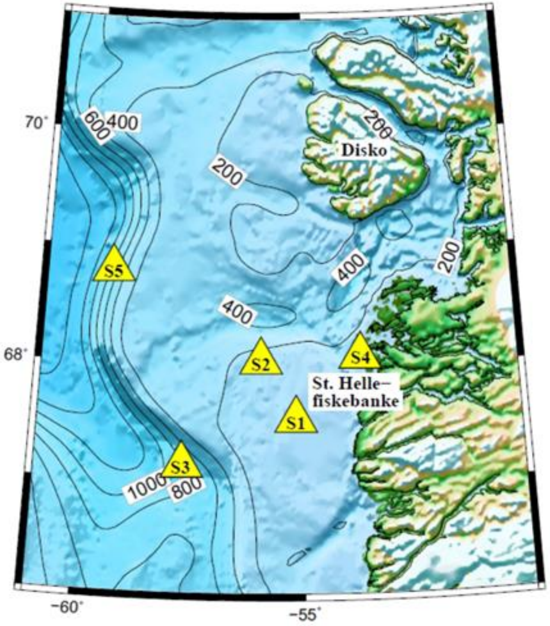
Estimated amount of marine diesel, HFO and Crude oil dissolve/dispersed in seawater, on seabed, on shoreline and sea surface 3 days after an untreated oil spill of 1000 m^3.

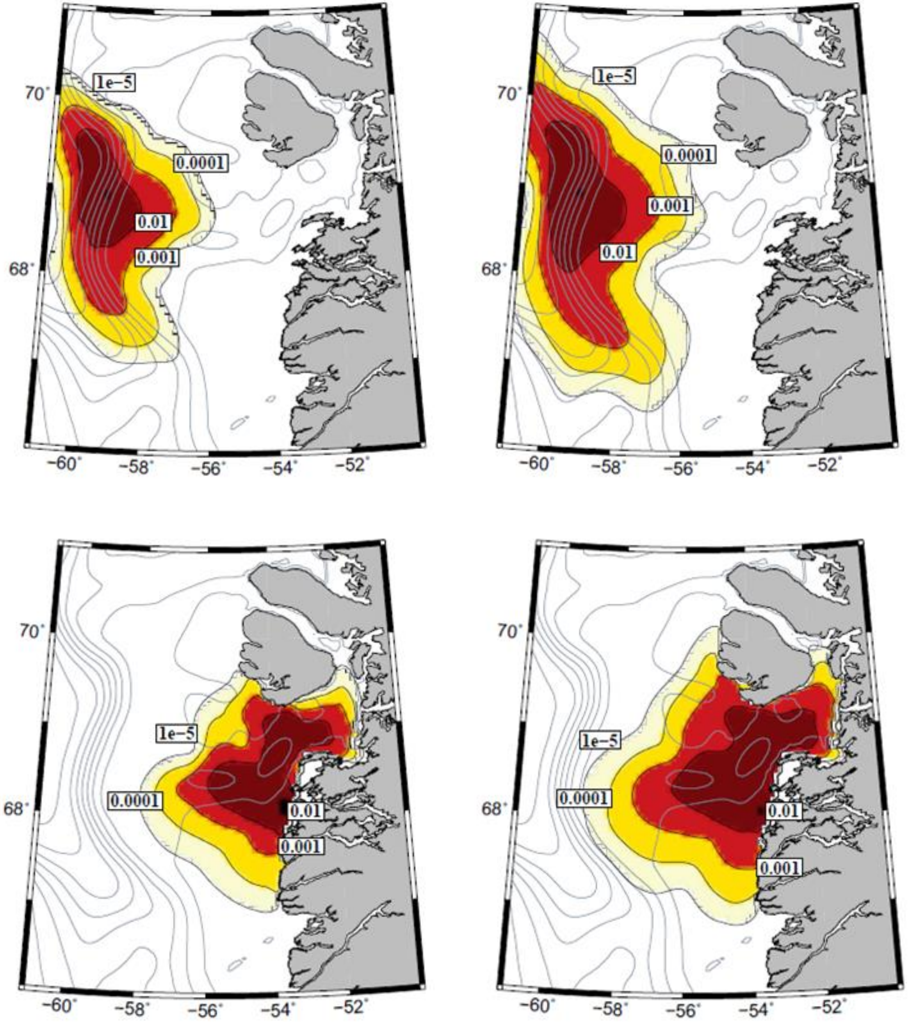
Oil in m^3	Sea surface	Seawater	Seabed	Shoreline	Total Volume
Marine Diesel	5	526	30	0	810
HFO (IFO-180)	1240	65	175	2020	3500
Crude oil (Statfjord)	350	14	126	504	1400

Fate of the oil in percent obtained from Seatrack Web.

Oil in %	Sea surface	Seawater	Seabed	Shoreline	Evaporated	Naturally dispersed	Water content
Marine Diesel	1	65	4	0	31		0
HFO (IFO-180)	28	2	5	62	3		80
Crude oil (Statfjord)	25	1	9	36	40		75

Data from other oil spill model





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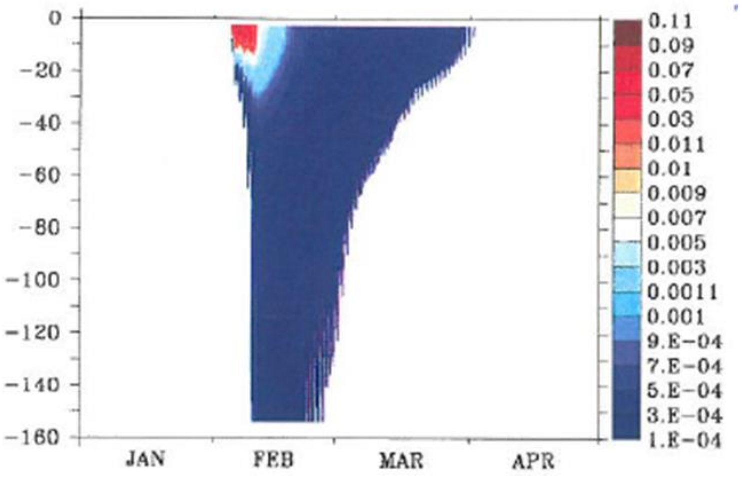
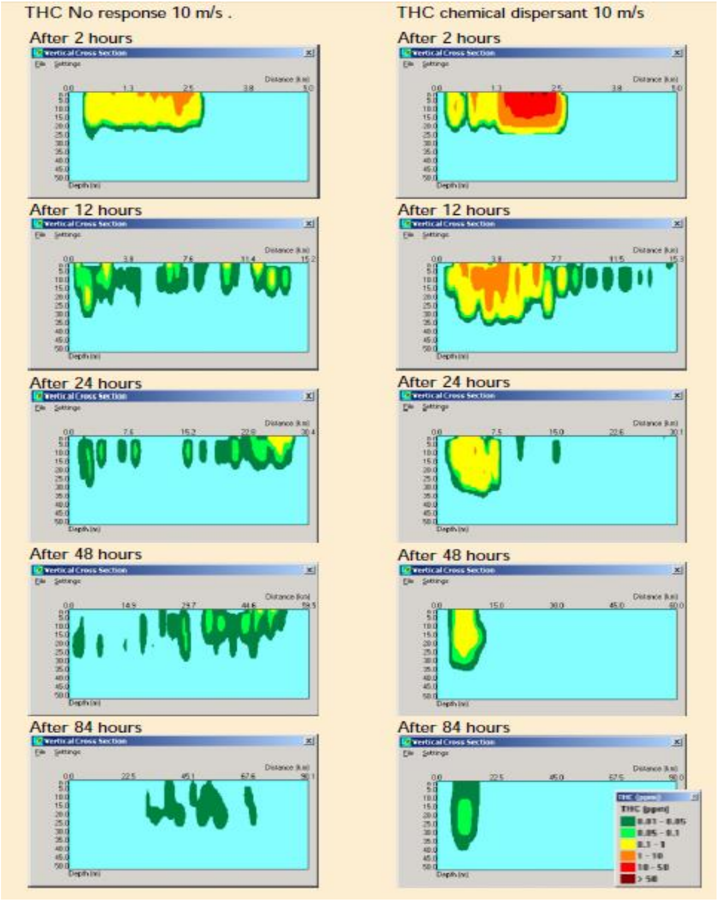
Data from other oil spill model



The vertical distribution of oil concentration with time for simulated chemically dispersed oil of an oil spill of 6000 T in 6 days integrated over a period of 4 months. ClimateLab (2015).



Naturally (left column) and chemically (right column) dispersed oil distribution and dilution with time. Oil on the surface is not shown in the figure. Fra Lewis & Daling (2001).

IDENTIFICATION OF SPECIES / ORGANISM GROUPS OF CONCERN IN THE ASSESSMENT AREA

Species that are considered sensitive/vulnerable or as Valued Ecosystem Components in other analyses (e.g., in national oil spill sensitivity atlases, strategic environmental impact assessments, Particular Sensitive Sea Areas (PSSAs), Marine Protected Areas (MPAs)

IMO / English / Our Work / Marine Environment / Particularly Sensitive Sea Areas

Particularly Sensitive Sea Areas

A **Particularly Sensitive Sea Area (PSSA)** is an area that needs special protection through action by IMO because of its significance for recognized ecological or socio-economic or scientific reasons and which may be vulnerable to damage by international maritime activities. The criteria for the identification of particularly sensitive sea areas and the criteria for the designation of special areas are not mutually exclusive. In many cases a Particularly Sensitive Sea Area may be identified within a Special Area and vice versa.

EASTERN BAFFIN BAY

A strategic environmental impact assessment of hydrocarbon activities

Scientific Report from Danish Centre for Environment and Energy No. 9 2011

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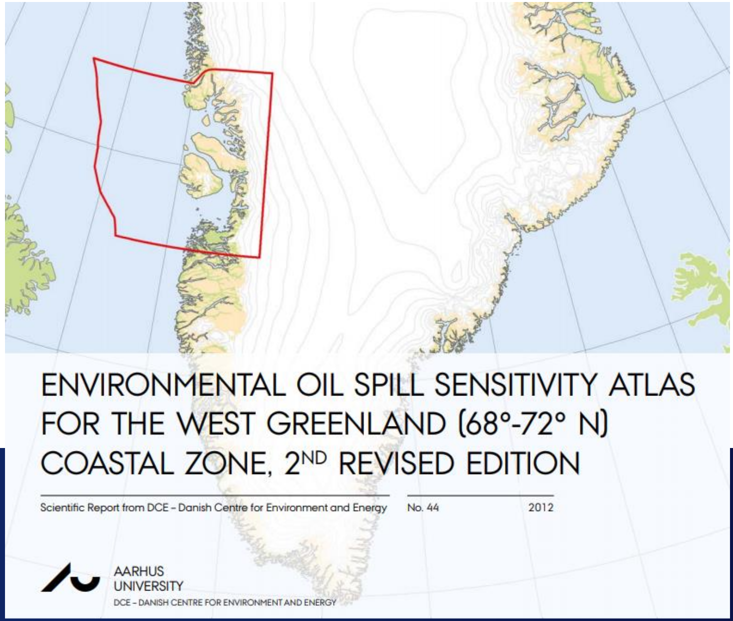
DCE - DANISH CENTRE FOR ENVIRONMENT AND ENERGY



ENVIRONMENTAL OIL SPILL SENSITIVITY ATLAS FOR THE WEST GREENLAND (68°-72° N) COASTAL ZONE, 2ND REVISED EDITION

Scientific Report from DCE – Danish Centre for Environment and Energy No. 44 2012

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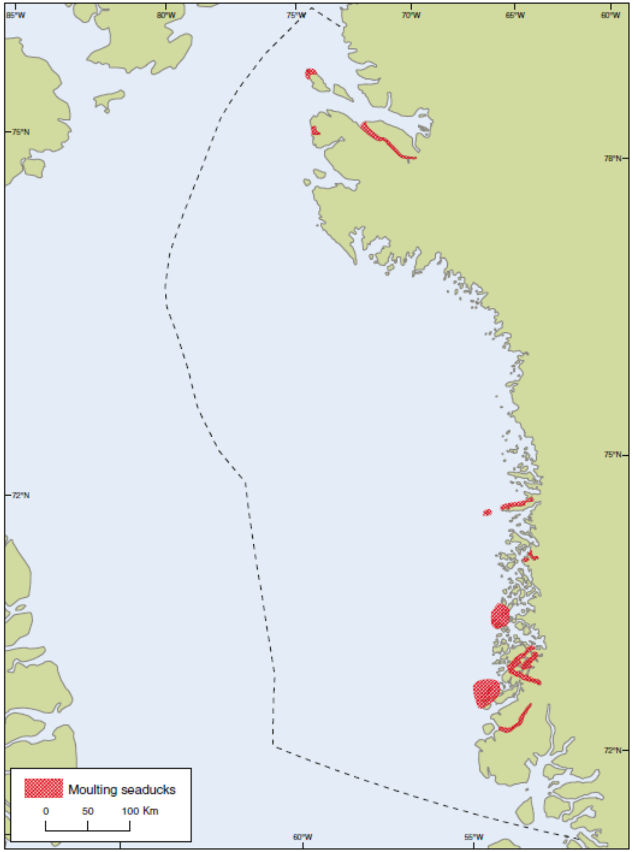
DCE – DANISH CENTRE FOR ENVIRONMENT AND ENERGY

IDENTIFICATION OF SPECIES / ORGANISM GROUPS OF CONCERN IN THE ASSESSMENT AREA

<u>Species considered sensitive to oil spill with regard to</u>:

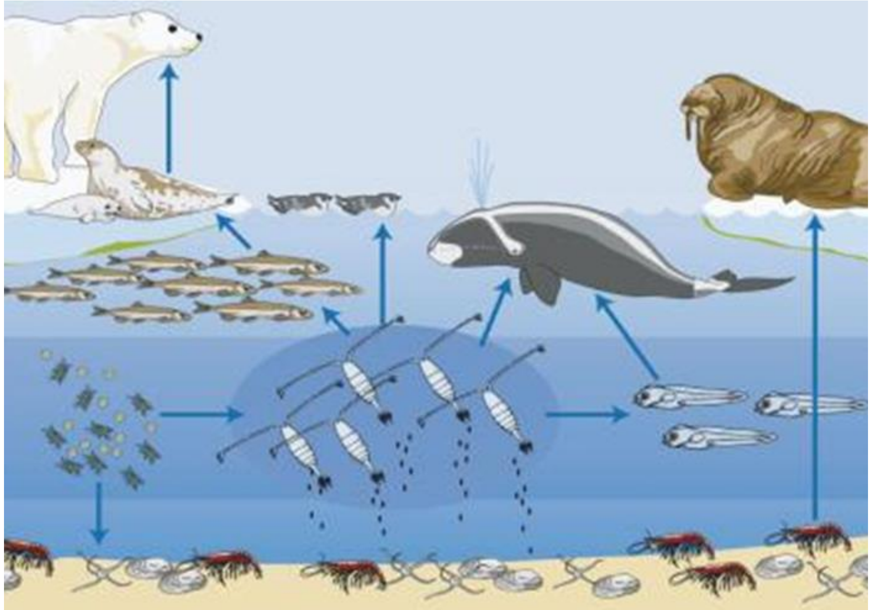
- Sea surface (e.g., seabirds)
- Pelagic species/organism groups (fish egg/fry, copepods)
- Seabed (e.g., marine sponges, corals, benthic communities, seagrass beds)
- Coast (Tidal communities, colonial seabirds)

Some of the bird populations which utilize the assessment area are particularly important and vulnerable (VECs): these include the king eiders moulting in the late summer and autumn.



IDENTIFICATION OF SPECIES / ORGANISM GROUPS OF CONCERN IN THE ASSESSMENT AREA

- Species or organism groups where oil spill may have an impact on the population that reach out of the selected area
- Species or organism groups where oil spill impact on the species or population may affect the ecosystem through the so called cascade effects
- Species where recovery may be expected to be long-term (> xx year)
- Commercial species



The species / organism groups are selected for each season, as the presence of the species of concern may vary throughout the year.

ECOTOXICOLOGICAL DATA

Toxicity of dissolved, natural or chemical dispersed oil in seawater

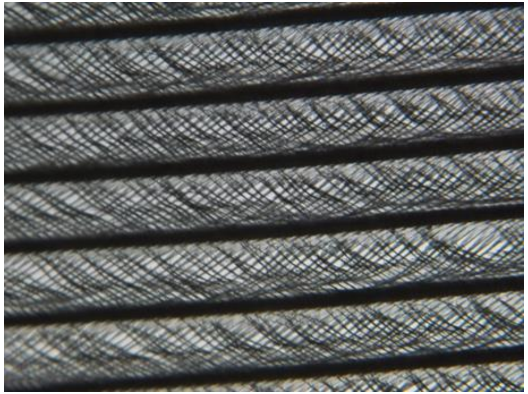
Organism group	**EC_{50} (mg THC/L)**	**No Effect Concentration (NEC) (mg THC/L)**
Algae	10	4
Crustaceans	2.3	0.7
Mussels	2.8	1.5
Fish	12	2

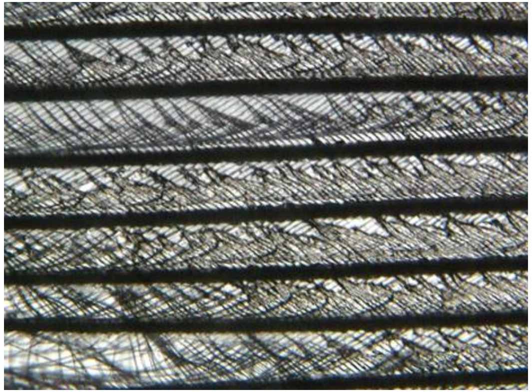
High-Arctic copepods Calanus Hyperboreus (Upper) Calanus Glacialis (Miderst) and Calanus Finmarchicus (Bottom).

ECOTOXICOLOGICAL DATA

Effect of oil sheen/slick on sea surface on seabird feathers

	Oil sheen/slick thicknesses for damage /change in feather microstructure (µm)	**Oil sheen/slick thicknesses for uptake of seawater of feathers (µm)**	**Reference**
Seabird feathers	0.1	3	Morandin & o'Hare (2014)





Microstructures are clearly influenced by oil

CALCULATIONS OF POLLUTION OF SEA SURFACE, SEAWATER, SEABED, AND SHORELINE

Based on worst case results from the SeaTrack Web modeling

Oil in m^3	**Sea surface**	**Seawater**	**Seabed**	**Shoreline**	**Total Volume**
Marine Diesel	5	526	30	0	810
HFO (IFO-180)	1240	65	175	2020	3500
Crude oil (Statfjord)	350	14	126	504	1400

CALCULATIONS OF POLLUTION OF SEA SURFACE

	Oil on sea surface (m^3)	Least oil slick thickness that damage seabird feather structure (µm)	Area sea surface polluted (km^2)
Marine Diesel	5	0.1	0.486
HFO (IFO-180)	1240	0.1	124
Crude oil (Statfjord)	350	0.1	35

It is assumed that 1/10 of the oil volume will cover 90% of the oil slick area at the sea surface and that the least oil slick thickness that damage seabird feather structure is 0.1 µm oil slick thickness.

CALCULATIONS OF POLLUTION OF SEAWATER

	Disolved or natural dispersed oil in seawater (m³)	Lowest EC_{50} or NEC for aquatic organisms (mg/l)	Seawater volume potentially polluted at a toxic level (m³) from natural dispersion	Sea area with potential oil concentration above levels for toxic effects to 15 m's depth from natural dispersion
Marine Diesel	526	0.7	750986	25033
HFO (IFO-180)	65	0.7	92857	3095
Crude oil (Statfjord)	14	0.7	20000	667

	Chemically dispersed oil in seawater (m³)	Lowest EC_{50} or NEC for aquatic organisms (mg/l)	Seawater volume potentially polluted at a toxic level (m³) from chemical dispersion	Sea area with potential oil concentration above levels for toxic effects to 15 m depth from chemical dispersion
Marine Diesel	1000	0.7	750986	25033
HFO (IFO-180)	1000	0.7	92857	3095
Crude oil (Statfjord)	1000	0.7	20000	667

CALCULATIONS OF POLLUTION OF SEABED

	Oil on seabed (m^3)	**Seabed area potentially affected (m^2)**	**Seabed area potentially affected (km^2)**
Marine Diesel	1	1000	0.00
HFO (IFO-180)	175	175000	0.18
Crude oil (Statfjord)	126	126000	0.13

In the calculations is assumed that the sea floor is polluted with 1 litre of oil per square meter seabed, corresponding to deposition of 1mm oil on the seabed.

CALCULATIONS OF POLLUTION OF SHORELINE

	Oil Shoreline (m^3)	Shoreline polluted (m)	Shoreline polluted (km)
Marine Diesel	0	0	0
HFO (IFO-180)	2020	2020000	2020
Crude oil (Statfjord)	504	504000	504

For the calculation of shoreline polluted, it is assumed that it is polluted with 1 litre of oil per square meter shoreline

SNEBA steps:

1. Basic data and information
2. Assessment
3. Scores for the SNEBA
4. Analysis through decisions trees
5. Interpretation and dissemination of SNEBA results

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STRATEGIC NET ENVIRONMENTAL BENEFIT ANALYSIS (SNEBA)

SCORES FOR THE SNEBA

Susse Wegeberg, Janne Fritt-Rasmussen, Kim Gustavson

22 November 2018

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SNEBA steps:

1. Basic data and information
2. Assessment
3. Scores for the sNEBA
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3) SCORES FOR SNEBA

- Net Environmental Benefit (NEB)
- Soot Pollution (SP)
- Damage Reduction (DaR)
- Relative Pollution of Sea Surface (fSSP), SeaWater (fSWP), SeaBed (fSBP) and ShoreLine (fSLP)

Idea behind, considerations – input from you!

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Idea behind, considerations – input from you!

NEB -
Net Environmental BENEFIT Score system

- NEB is the **overall benefit** from a response method to the environment
- Calculated for each response method and season
- NEB may be positive, null or negative
- In detail - NEB is the sum of the highest numeric score from each compartment


Mechanical recovery


Chemical dispersion


In situ burning


Do nothing

NEB -
Net Environmental BENEFIT Score system

Scoring criteria: Score (pros / cons)

Impact on

- individual level +/- 1
- local population +/- 3
- global population +/- 6
- species leading to cascade effects +/- 5

Oil spill response method	Season	Score for Environmental Benefit – Positive effects (+) / No effects (0) / Negative effects (-)					
		Species of concern	Individual	Local population	Global population	Cascade effects	Total species score (Σss, Σsw, Σsb, Σsl)
		Score	**1**	**3**	**6**	**5**	
Mechanical Recovery	Spring	Species 1	1	3	6	5	15
		Species 2	1	3			4
		Species …	1				1
	Summer	Species 1	1	3	6		10
		Species 2	1	3			4
		Species …	1				1
	Autumn	Species 1	1	3			4
		Species 2	1	3			4
		Species …	1				1
	Winter	Species 1	1				1
		Species 2	1				1
		Species …	1				1

NEB - Net Env

	Environmental pros and cons from response method					Net Environmental Benefit from response method
Oil spill response method	Season	Σss	Σsw	Σsb	Σsl	Total score (NEB)
Mechanical recovery	Spring	5	5	5	5	15
	Summer	0	0	0	5	5
	Autumn	0	0	0	5	5
	Winter	0	0	0	5	5
Dispersion	Spring	0	-5	0	5	0
	Summer	0	-5	0	5	0
	Autumn	0	-5	0	5	0
	Winter	0	-5	0	5	0
ISB	Spring	0	0	0	5	5
	Summer	0	0	0	5	5
	Autumn	0	0	0	5	5
	Winter	0	0	0	5	5
Do nothing	Spring	0	0	-5	-5	-10
	Summer	0	0	0	-5	-5
	Autumn	0	0	0	-5	-5
	Winter	0	0	0	-5	-5

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Idea behind, considerations – input from you!

SP
SOOT POLLUTION SCORE system

- Related to In Situ Burning
- By combustion oil is converted to CO_2, water vapour, **soot**, CO, and other products
  - Risk of health (inhabitants / animal congregations)
  - Deposition of soot particles on ice (potential reduced albedo)

SP
SOOT POLLUTION SCORE system

	Score		
	0	2	4
Distance to inhabitation or sensitive organisms on land (km)[1]	> 6	6-3	< 3
Prevailing wind direction towards inhabitation or animal congregations[1]	No		Yes
Ice; red. albedo effect (% cover)[3]	0-30	30-70	>70
			SP


J. Fritt-Rasmussen

3) SCORES FOR SNEBA

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- Soot Pollution (SP)
- Damage Reduction (DaR)
- Relative Pollution of Sea Surface (fSSP), SeaWater (fSWP), SeaBed (fSBP) and ShoreLine (fSLP)

Idea behind, considerations – input from you!

DaR
Damage Reduction

- Damage Reduction (DaR) = NEB × Efficiency (%)

Measure of how the expected efficiency of **mechanical recovery** affect the NEB for each season.

Default efficiency value of 10 % - could be varied for a specific case or if new methods are developed

3) SCORES FOR SNEBA

- Net Environmental Benefit (NEB)
- Soot Polution (SP)
- Damage Reduction (DaR)
- Relative Pollution of Sea Surface (fSSP), SeaWater (fSWP), SeaBed (fSBP) and ShoreLine (fSLP)

Idea behind, considerations – input from you!

SSP
Score for oil Polluted Sea Surface


NOAA

- fSSP (%) = (SSa / WBssa) x 100

a fraction of sea surface area polluted (SSa) in relation to the entire sea surface area for the waterbody of the assessment area (WBssa)

Fraction of oil polluted sea surface area (km^2) fSSP	**<2 %**	**2-10 %**	**>10 %**
Score	0	2	4

SWP
Score for oil Polluted SeaWater

- fSWP (%) = (SWv / WBv) x 100

From the value of seawater volume polluted with oil concentration above LC50 or no effect concentration (NEC) (SWv), and the volume of the waterbody of the assessment area (WBv)

Fraction of oil polluted SeaWater fSWP	<5 %	5-10 %	>10 %
Score	0	2	4

SBP
Score for oil Polluted SeaBed


NOAA, White et al. 2012

- fSBP (%) = (SBa / WBsba) x 100

value of seabed area polluted with oil (SBa) and the seabed area of the waterbody of the assessment area (WBsba)

Fraction of oil polluted Sea Bed fSBP	<2 %	2-10 %	>10 %
Score	0	2	4

SLP
Score for oil Polluted ShoreLine


Independent Santa Barbara

- fSLP (%) = (SLI / WBsII) x 100

Fraction of oil polluted ShoreLine fSLP	<2 %	2-10 %	>10 %
Score	0	2	4

Comparing the data with historical oil spill accidents' shoreline length impacted

~ 4 km *Godafoss:* assessed that environmental impacts were insignificant, and no remediation were initiated.

Server: Environmental impacts were observed; 40 km of shoreline were considered impacted and remediation were initiated.

Exxon Valdez oil spill, 300 km of shoreline were heavily or moderately impacted.

3) SCORES FOR SNEBA

- Net Environmental Benefit (NEB)
- Soot Pollution (SP)
- Damage Reduction (DaR)
- Relative Pollution of Sea Surface (fSSP), SeaWater (fSWP), SeaBed (fSBP) and ShoreLine (fSLP)

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SNEBA
Desicion trees

1) **Mechanical recovery**
2) **Chemical dispersants**
3) **In situ burning**
4) **Do nothing**

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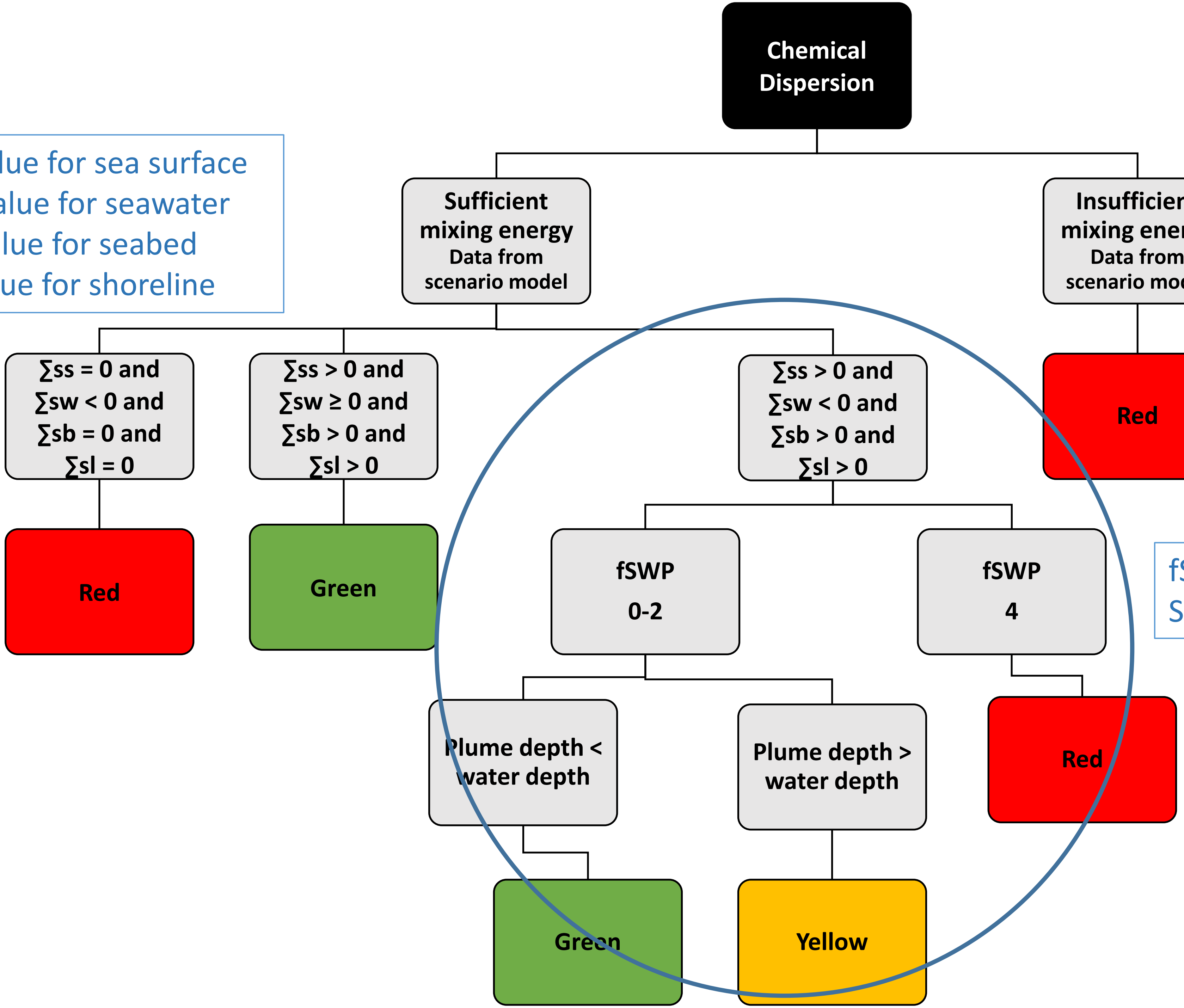
Integrated oil spill response actions and environmental effects
GRACE
2016-2019



$\sum ss$: summed value for sea surface
$\sum sw$: summed value for seawater
$\sum sb$: summed value for seabed
$\sum sl$: summed value for shoreline

Chemical Dispersion

Sufficient mixing energy
Data from scenario model

$\sum ss = 0$ and $\sum sw < 0$ and $\sum sb = 0$ and $\sum sl = 0$

Red

$\sum ss > 0$ and $\sum sw \geq 0$ and $\sum sb > 0$ and $\sum sl > 0$

Green

$\sum ss > 0$ and $\sum sw < 0$ and $\sum sb > 0$ and $\sum sl > 0$

fSWP 0-2

Plume depth < water depth

Green

Plume depth > water depth

Yellow

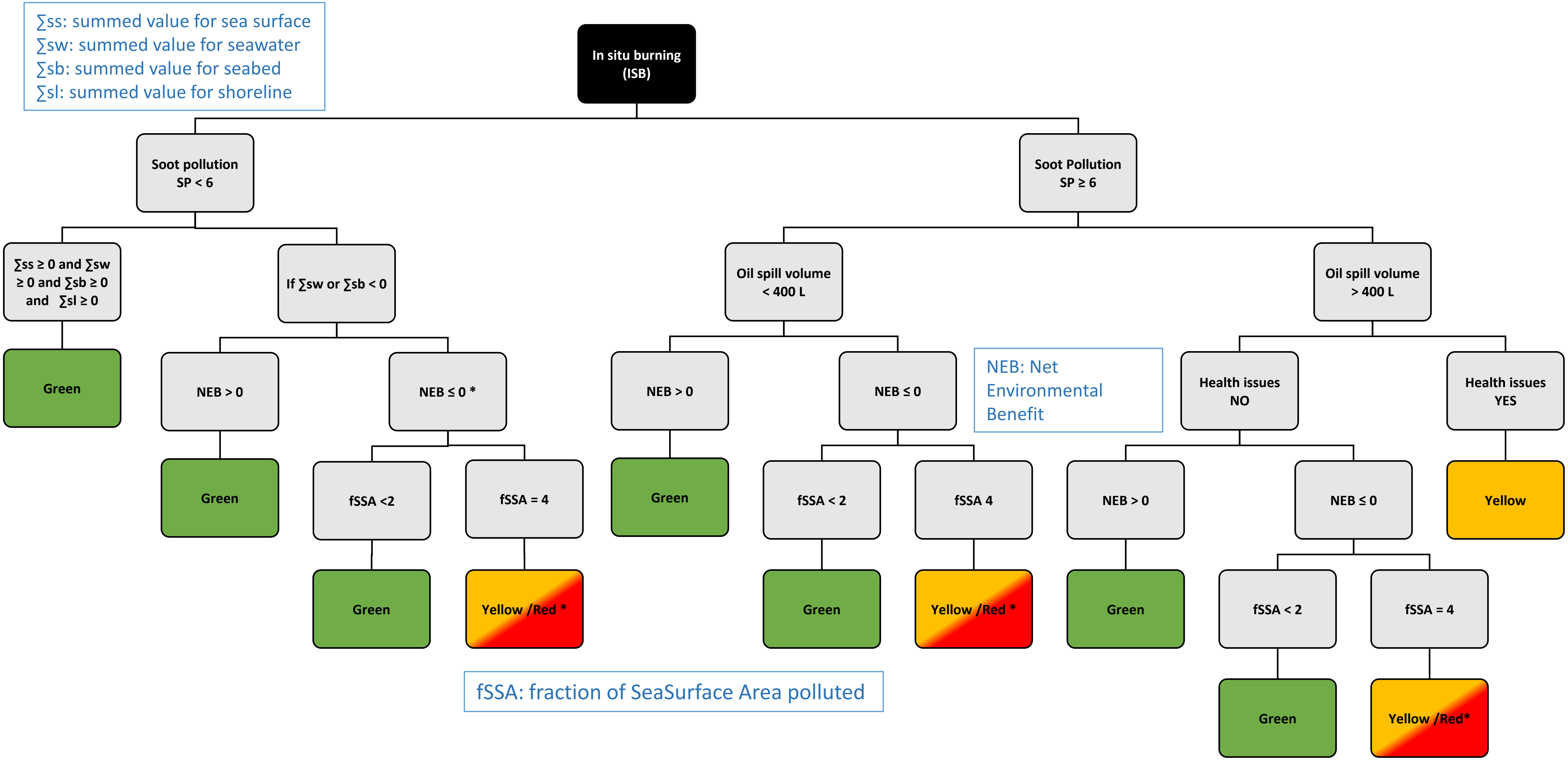
fSWP 4

Red

Insufficient mixing energy
Data from scenario model

Red

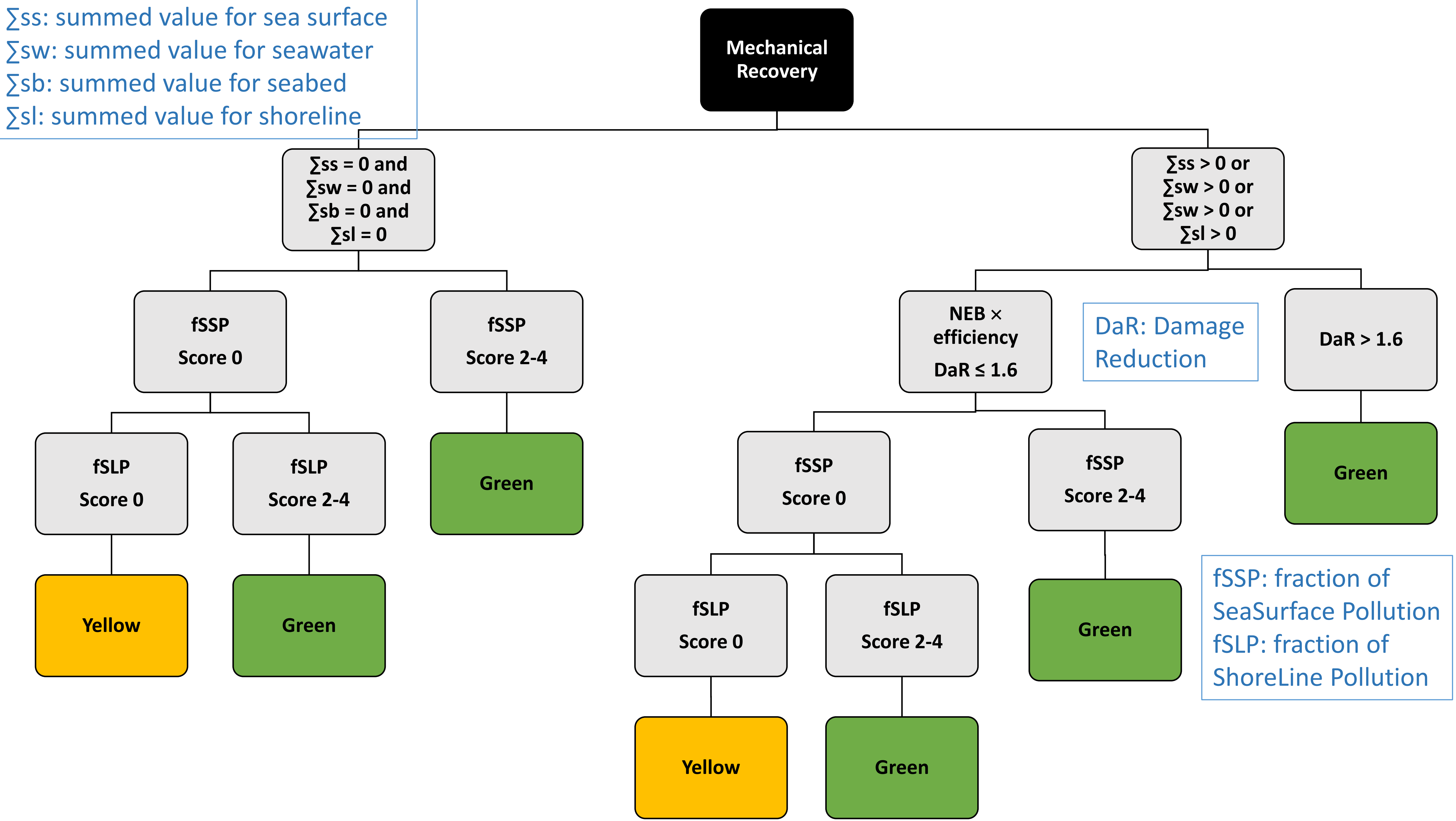
fSWP: fraction of SeaWater Pollution

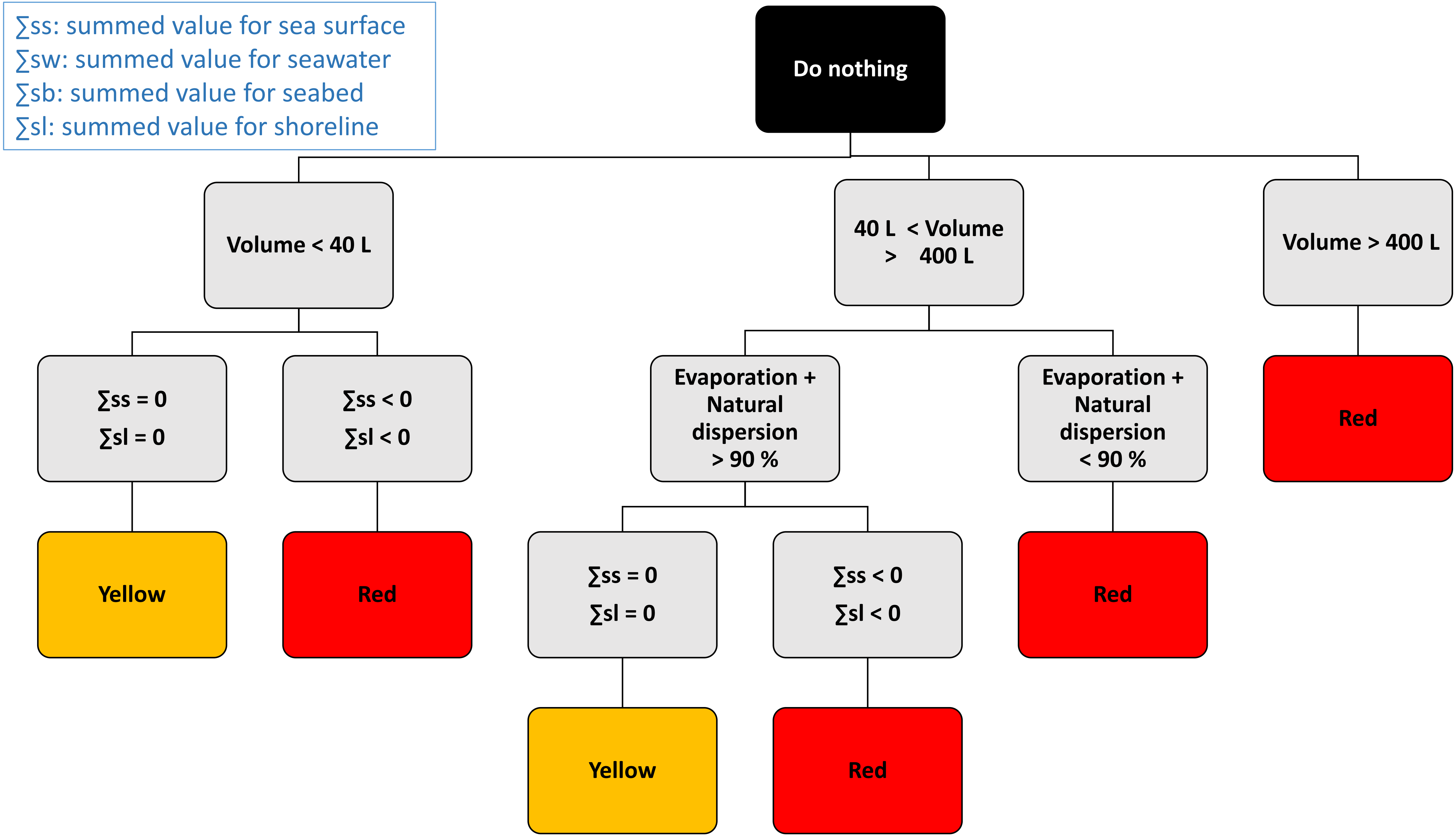


∑ss: summed value for sea surface
∑sw: summed value for seawater
∑sb: summed value for seabed
∑sl: summed value for shoreline

NEB: Net Environmental Benefit

fSSA: fraction of SeaSurface Area polluted


∑ss: summed value for sea surface
∑sw: summed value for seawater
∑sb: summed value for seabed
∑sl: summed value for shoreline
Mechanical Recovery
∑ss = 0 and ∑sw = 0 and ∑sb = 0 and ∑sl = 0
∑ss > 0 or ∑sw > 0 or ∑sw > 0 or ∑sl > 0
fSSP Score 0
fSSP Score 2-4
NEB × efficiency DaR ≤ 1.6
DaR: Damage Reduction
DaR > 1.6
fSLP Score 0
fSLP Score 2-4
Green
fSSP Score 0
fSSP Score 2-4
Green
Yellow
Green
fSLP Score 0
fSLP Score 2-4
Green
fSSP: fraction of SeaSurface Pollution
fSLP: fraction of ShoreLine Pollution
Yellow
Green



∑ss: summed value for sea surface
∑sw: summed value for seawater
∑sb: summed value for seabed
∑sl: summed value for shoreline

SNEBA results

Green

The oil spill response method can be considered an option for oil spill combat in the assessment area for the specific season in order to obtain an overall environmental benefit from the oil spill response method operation.

Yellow

The oil spill response method man be considered an option for oil spill combat in the assessment area for the specific season, however, expert judgement is needed in the specific oil spill situation and season in order to obtain an overall environmental benefit from the oil spill response method operation

Red

The oil spill response method cannot be considered an option for oil spill combat in the assessment area for the specific season in order to obtain an overall environmental benefit from the oil spill response method operation.

The results should be followed by a narrative:
Yellow: expert judgement
Green and red: to exclude potential too intuitive conclusions

SNEBA (not SIMA)

- SNEBA is a planning tool
- Desktop analysis for environmentally assessing and preparing of oil spill combating
    - Potential
    - Strategy
    - Capacity building
- SNEBA results form base for a faster and more robust response in case of oil spill
- Decision-making tool on a scientific basis for, e.g.,:
    - National oil spill strategy
    - Cross-border and trans-boundary co-operation and agreements.

GRACE

sNEBA - Operative add-ons

sNEBA workshop

Copenhagen 22 November 2018

Björn Forsman

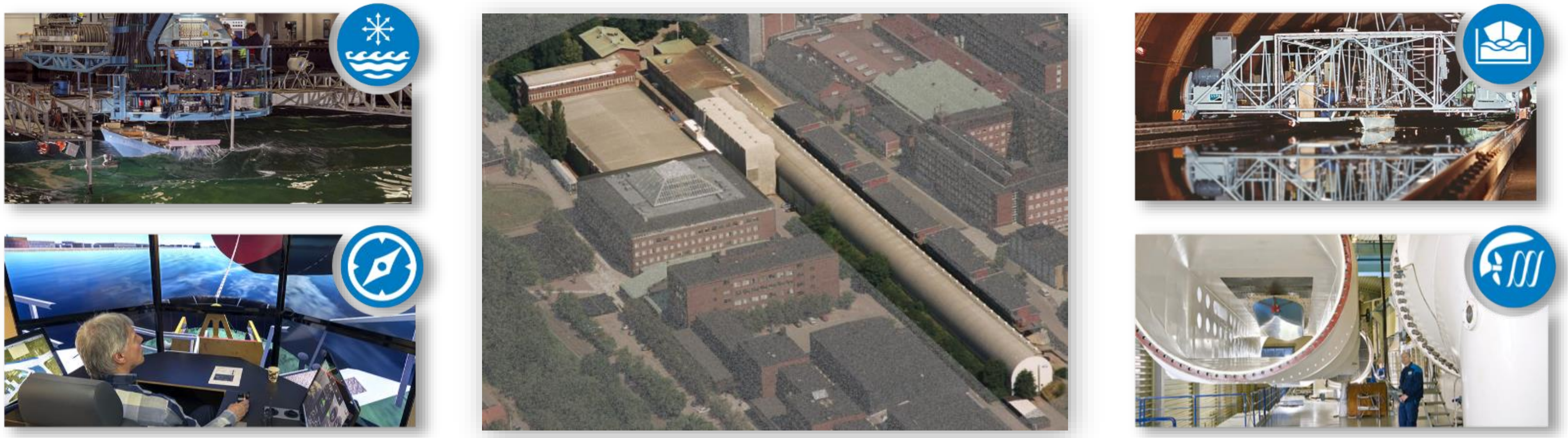
Nelly Forsman

SSPA Your Maritime Solution Partner

European Commission | Horizon 2020 European Union funding for Research & Innovation

GRACE

SSPA Sweden AB.



Independent consultant delivering maritime solutions with a strong focus on sustainability and innovation.

- Over 75 years of experience since starting 1940.
- Since 1983 fully owned by the non-profit foundation; Chalmers University of Technology.
- Testing facilities:
  - Towing tank, Maritime Dynamics Laboratory, Cavitation Tunnel and Simulator.

- 100 employees, Offices in Gothenburg and Stockholm.
- 120 MSEK turnover.
- 20% internationally funded research.
- Main clients are yards, designers, ship owners, authorities etc.
  - Samsung HI, Hyundai, Stena, Aker Arctic, Trafikverket, EU, IMO, EMSA, etc.

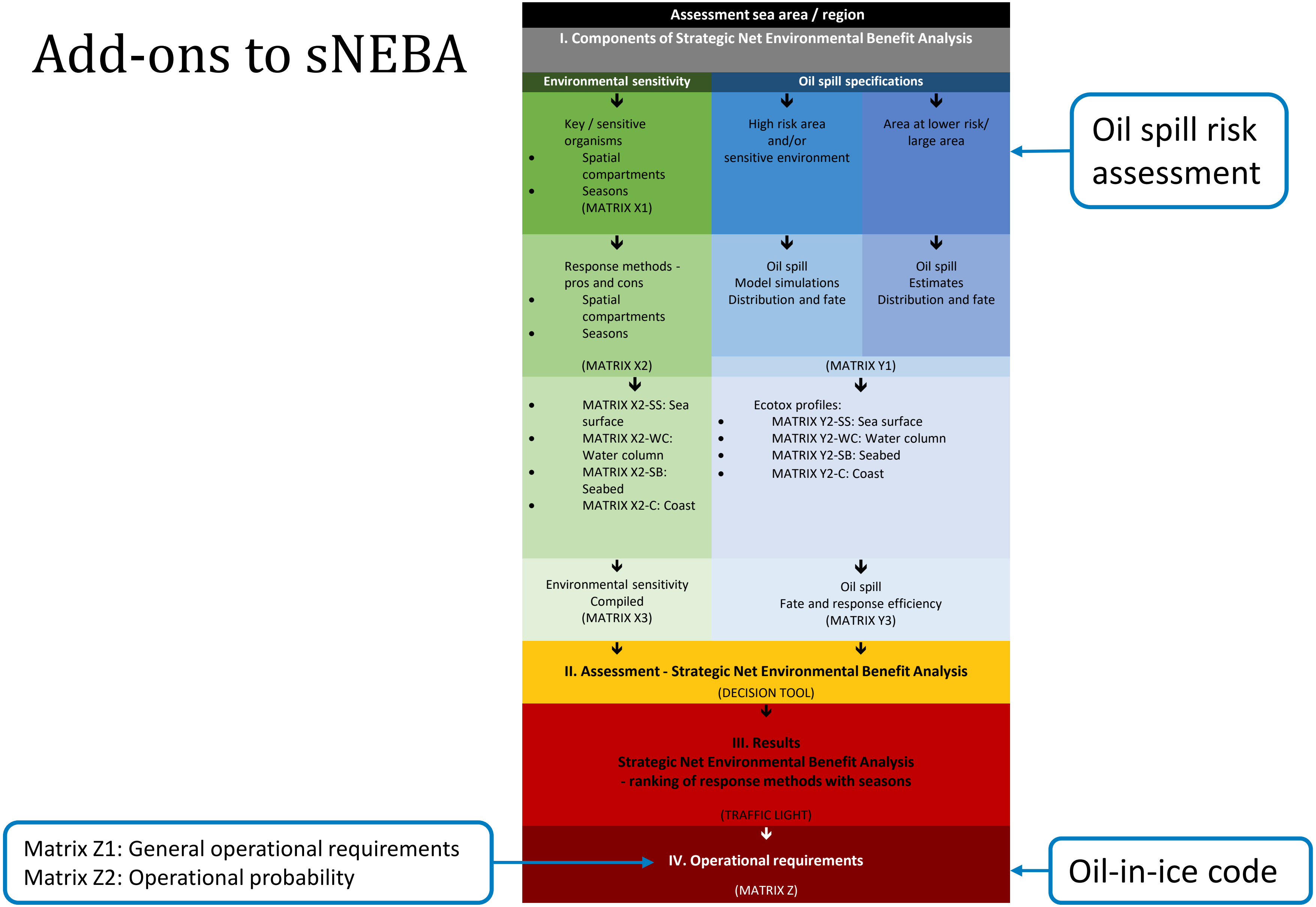
SSPA in GRACE

- WP 1 - Oil spill detection, monitoring, fate and distribution
  - D1.10 Oil spill risk assessment methodology for extreme conditions, incl Arctics

- WP 4 - Combat of oil spill in coastal arctic water - effectiveness and environmental effects
  - D4.5 Oil in ice code

- WP 5 - Strategic Net Environmental Benefit Analysis (sNEBA)
  - D5.4 Matrix(ces) for operational requirements
  - D5.6 Site specific trial application of the developed spill risk assessment methodology

Add-ons to sNEBA



Assessment sea area / region

I. Components of Strategic Net Environmental Benefit Analysis

Environmental sensitivity

Key / sensitive organisms
- Spatial compartments
- Seasons

(MATRIX X1)

Response methods - pros and cons
- Spatial compartments
- Seasons

(MATRIX X2)

- MATRIX X2-SS: Sea surface
- MATRIX X2-WC: Water column
- MATRIX X2-SB: Seabed
- MATRIX X2-C: Coast

Environmental sensitivity
Compiled
(MATRIX X3)

Oil spill specifications

High risk area and/or sensitive environment

Area at lower risk/ large area

Oil spill
Model simulations
Distribution and fate

Oil spill
Estimates
Distribution and fate

(MATRIX Y1)

Ecotox profiles:
- MATRIX Y2-SS: Sea surface
- MATRIX Y2-WC: Water column
- MATRIX Y2-SB: Seabed
- MATRIX Y2-C: Coast

Oil spill
Fate and response efficiency
(MATRIX Y3)

II. Assessment - Strategic Net Environmental Benefit Analysis

(DECISION TOOL)

III. Results
Strategic Net Environmental Benefit Analysis
- ranking of response methods with seasons

(TRAFFIC LIGHT)

IV. Operational requirements

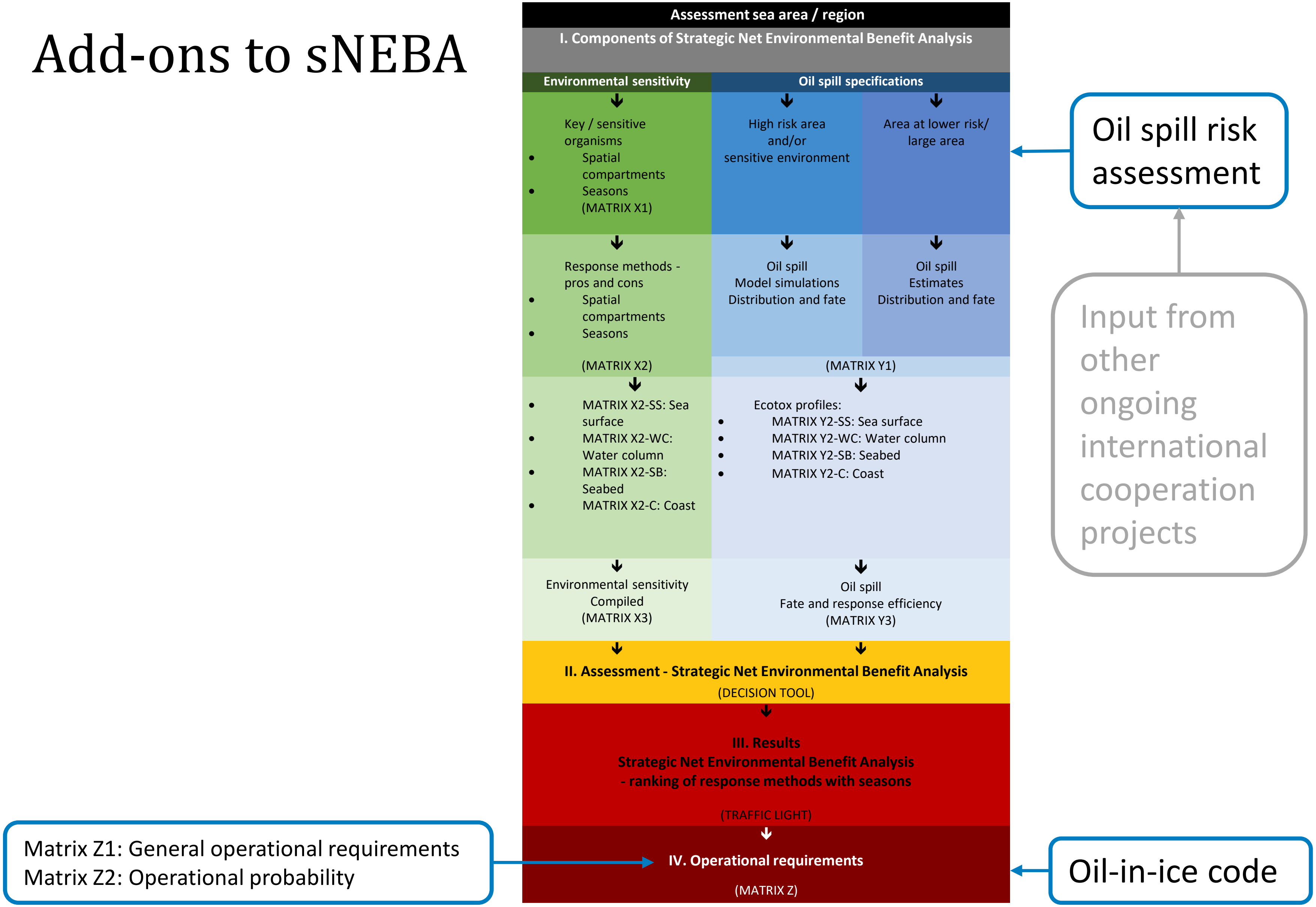
(MATRIX Z)

Oil spill risk assessment

Matrix Z1: General operational requirements
Matrix Z2: Operational probability

Oil-in-ice code

Add-ons to sNEBA



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Oil spill
Fate and response efficiency
(MATRIX Y3)

II. Assessment - Strategic Net Environmental Benefit Analysis
(DECISION TOOL)

III. Results
Strategic Net Environmental Benefit Analysis
- ranking of response methods with seasons

(TRAFFIC LIGHT)

IV. Operational requirements

(MATRIX Z)

Oil spill risk assessment

Input from other ongoing international cooperation projects

Oil-in-ice code

Matrix Z1: General operational requirements
Matrix Z2: Operational probability

GRACE and oil spill risk assessment

Design of adequate integrated oil spill response actions and identification of environmental effects, needs input on:

- Where?
- How often?
- What type of oil?
- and how large oil spills may be excepted?

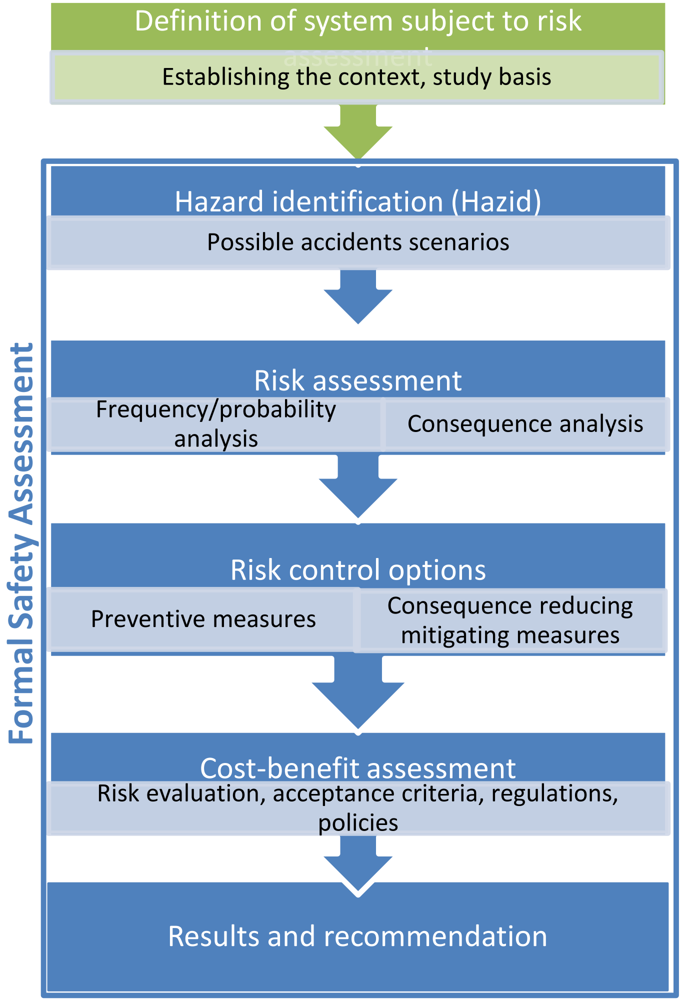
-> Spill risk assessment will provide answers

Formal Safety Assessment (FSA) methodology

IMO´s proactive process to be used as a tool in the rulemaking process

The FSA preferably addresses a specific ***category of ships*** or ***navigational area*** but may also be applied to specific maritime ***safety or pollution prevention*** issue to identify cost effective risk reduction options.

In line wit the ISO 31 000 standard.



Definition of system subject to risk assessment

Establishing the context, study basis

Formal Safety Assessment

Hazard identification (Hazid)

Possible accidents scenarios

Risk assessment

Frequency/probability analysis

Consequence analysis

Risk control options

Preventive measures

Consequence reducing mitigating measures

Cost-benefit assessment

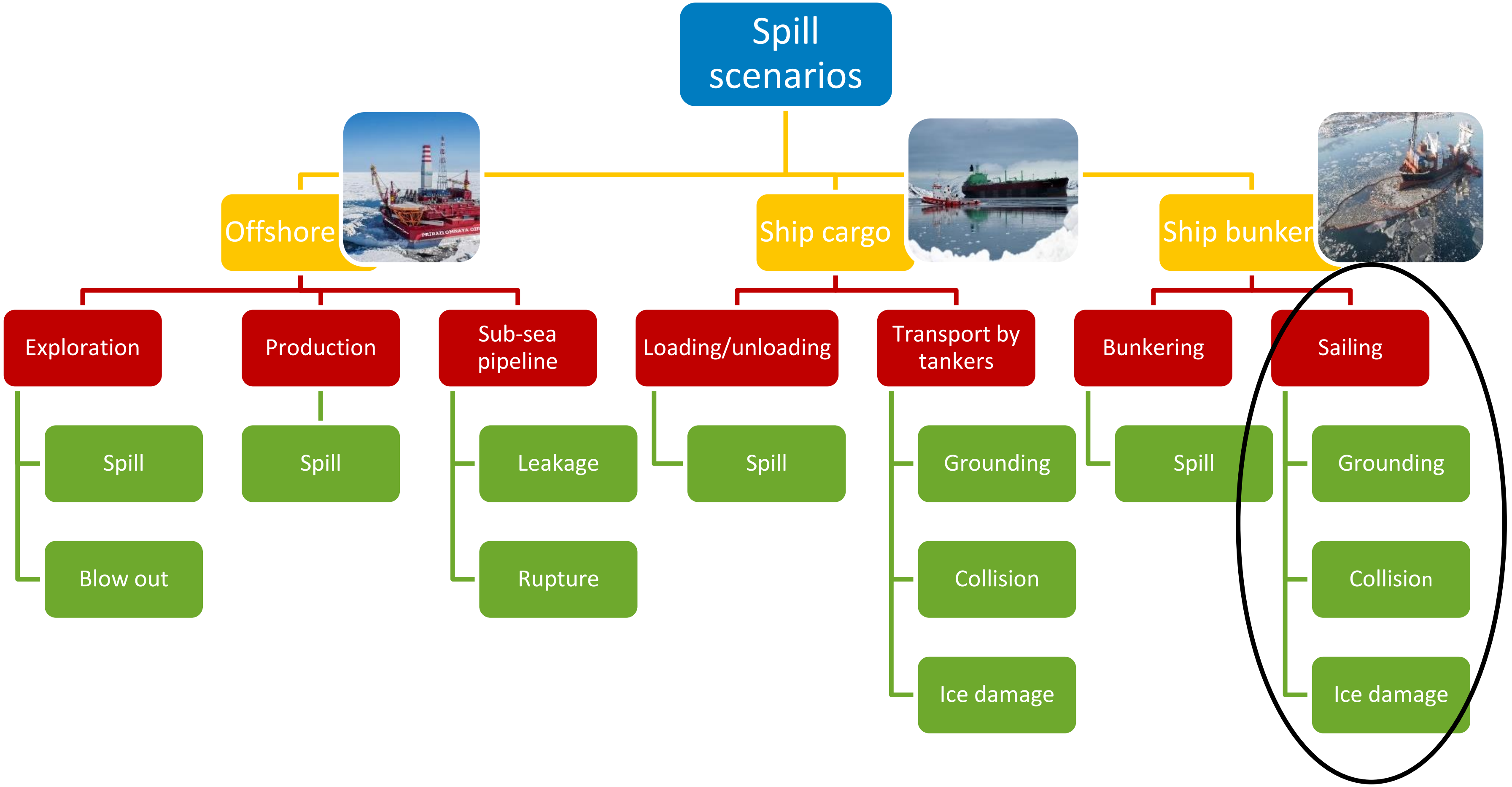
Risk evaluation, acceptance criteria, regulations, policies

Results and recommendation

FSA structure applied for oil spill risk assessment

1. **Definition of study basis**
   Geographical area and review of previous studies
2. **Hazid**
   Identification of oil spill scenarios
3. **Traffic analysis to quantify probability**
   Traffic statistics combined with probability for failure, grounding, collision etc.
4. **Traffic analysis to quantify consequences**
   Quantification of potential spills
5. **Risk evaluation**
   Risk matrix combines probability and consequences – identification of worst credible scenario
6. **Risk control measures**
   Preventive measure and determination of needs for response capacity based on sNEBA output

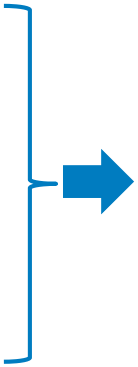
Hazid – Potential spill scenarios



- Spill scenarios
  - Offshore
    - Exploration
      - Spill
      - Blow out
    - Production
      - Spill
    - Sub-sea pipeline
      - Leakage
      - Rupture
  - Ship cargo
    - Loading/unloading
      - Spill
    - Transport by tankers
      - Grounding
      - Collision
      - Ice damage
  - Ship bunker
    - Bunkering
      - Spill
    - Sailing
      - Grounding
      - Collision
      - Ice damage

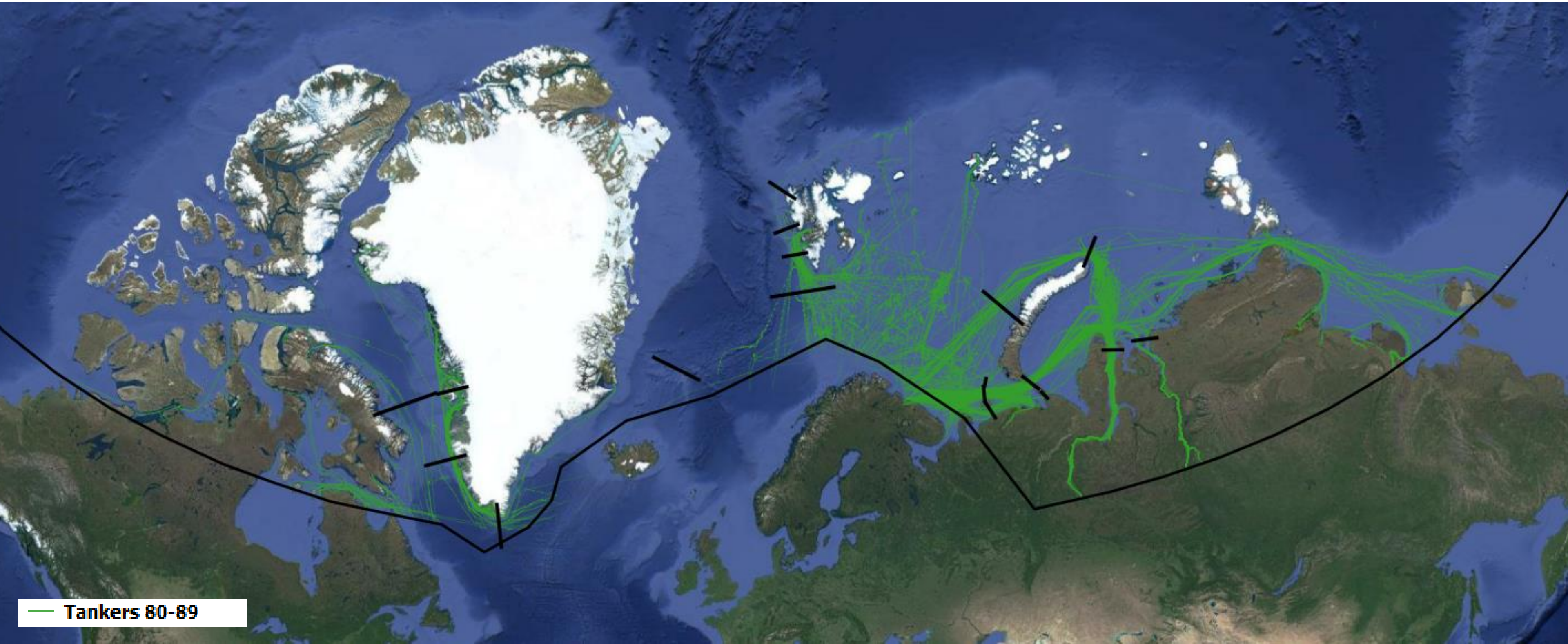
Your Maritime Solution Partner

AIS-analysis

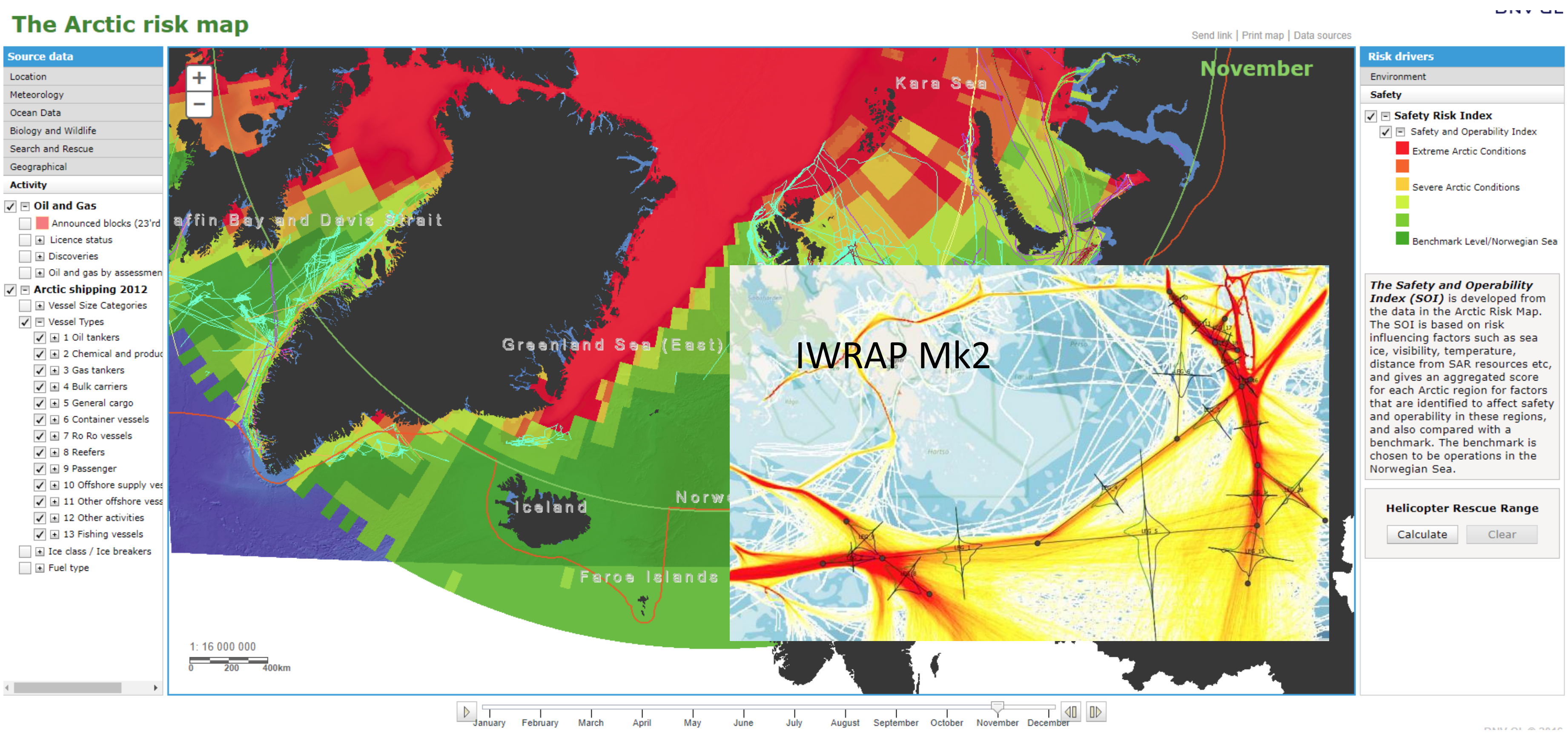


- Statistics passage lines
- Sailed distances in the area
- Sailed distances in ice
- Total operational time

Input for calculation of spill probability and potential consequences

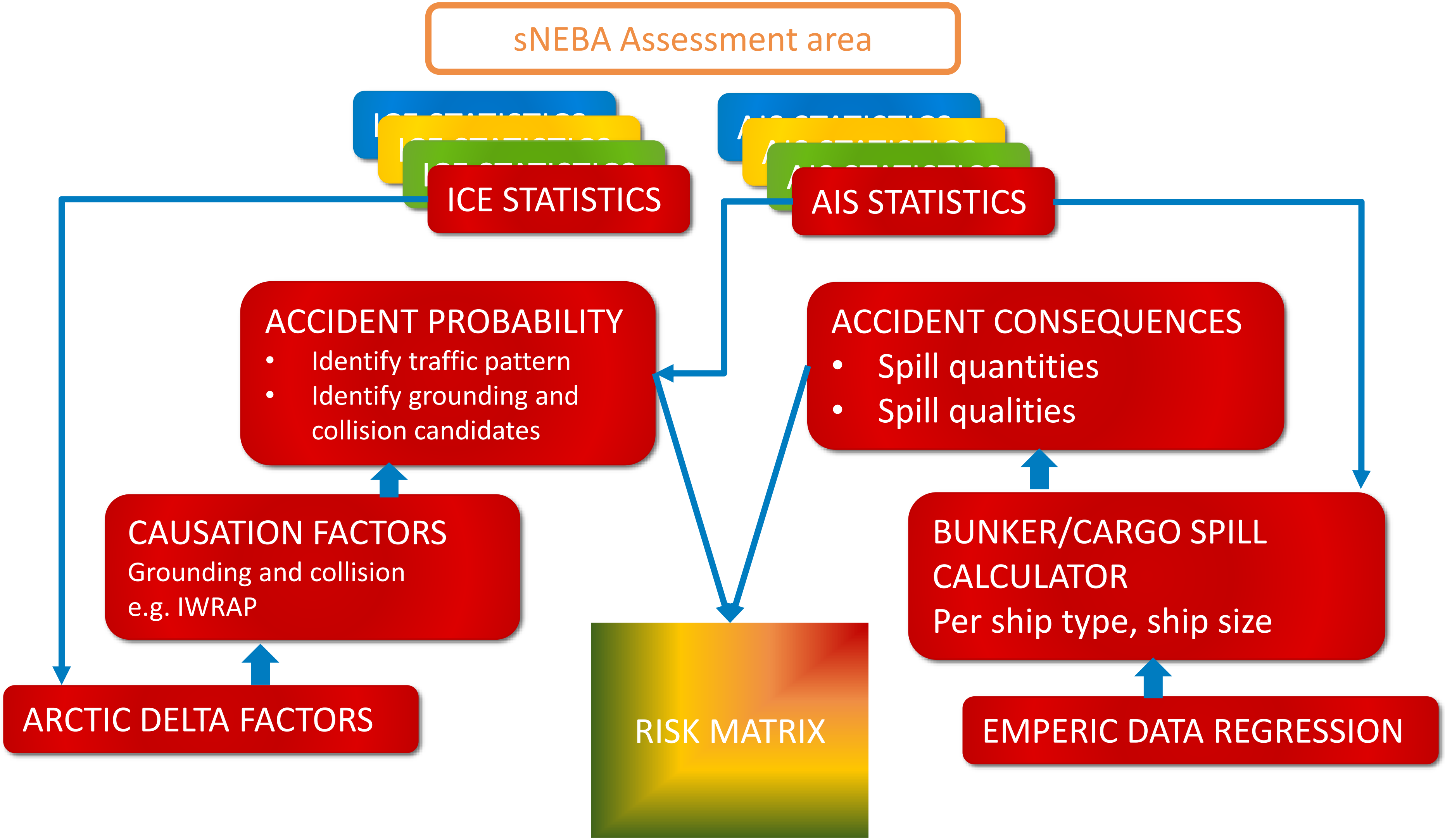


Input for quantification of ice influence and accident probability



The Safety and Operability Index (SOI) is developed from the data in the Arctic Risk Map. The SOI is based on risk influencing factors such as sea ice, visibility, temperature, distance from SAR resources etc, and gives an aggregated score for each Arctic region for factors that are identified to affect safety and operability in these regions, and also compared with a benchmark. The benchmark is chosen to be operations in the Norwegian Sea.

Method for risk quantification



sNEBA Assessment area

ICE STATISTICS

AIS STATISTICS

ACCIDENT PROBABILITY
- Identify traffic pattern
- Identify grounding and collision candidates

ACCIDENT CONSEQUENCES
- Spill quantities
- Spill qualities

CAUSATION FACTORS
Grounding and collision
e.g. IWRAP

BUNKER/CARGO SPILL CALCULATOR
Per ship type, ship size

ARCTIC DELTA FACTORS

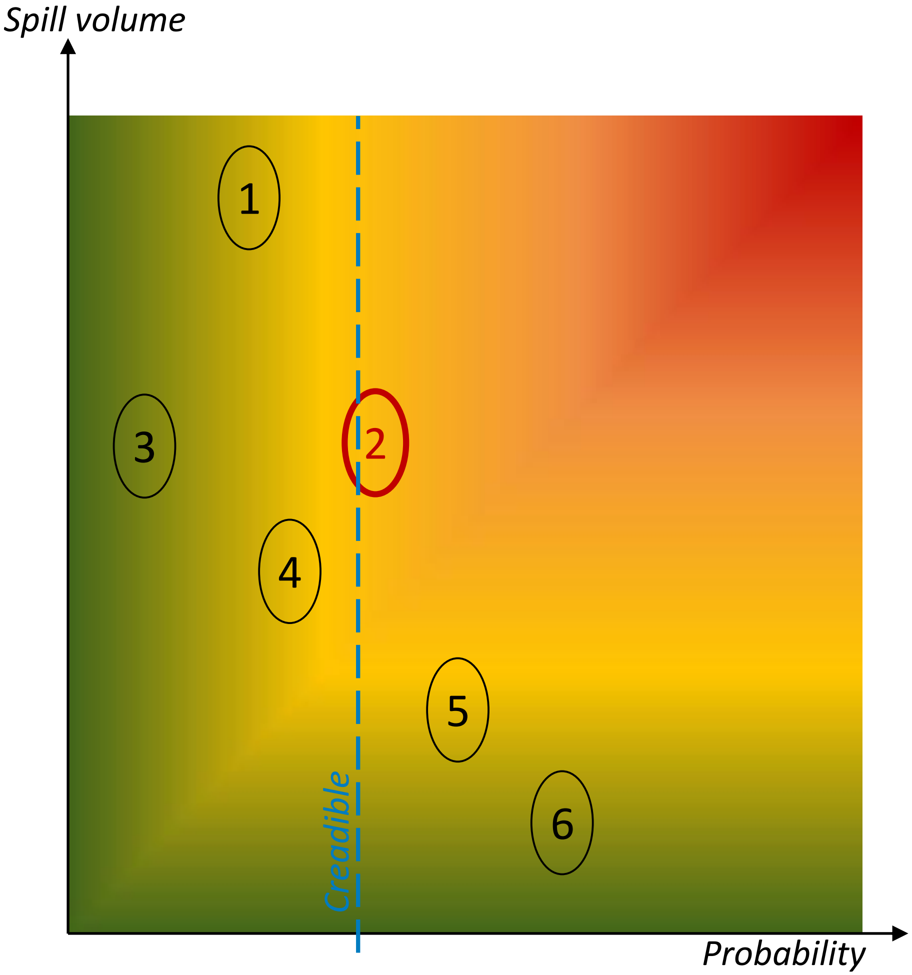
RISK MATRIX

EMPERIC DATA REGRESSION

Identification of worst creadible scenario

1. Large spill of crude oil from grounded tanker
2. Large spill of bunker fuel from grounded vessel
3. Collision and spill of crude oil
4. Collision and spill of bunker fuel
5. Spill from s-t-s cargo transfer
6. Spill from s-t-s bunker

Scenario 2 → Input for sNEBA



Oil in Ice Code

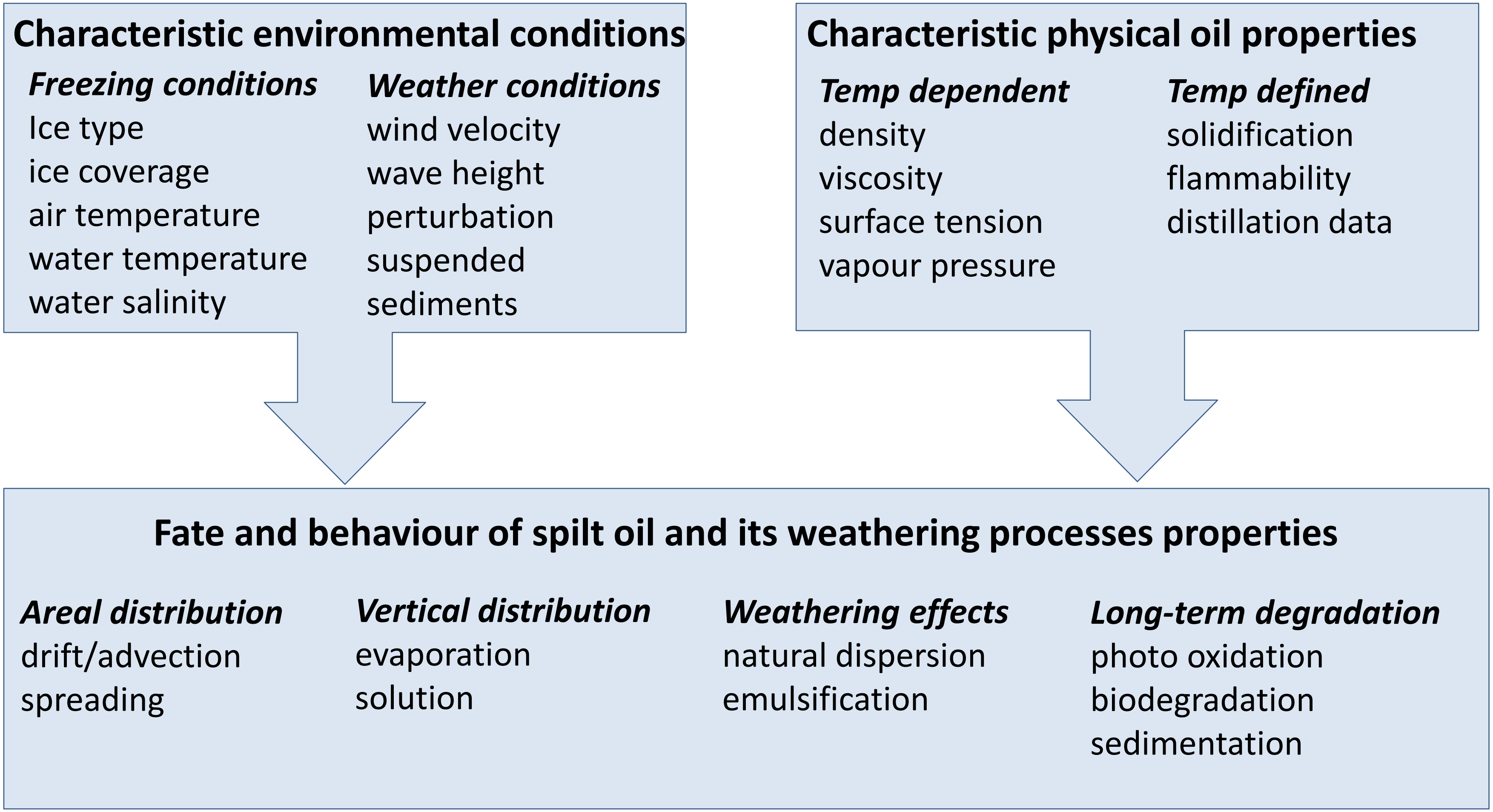
Background

A designated oil in ice code is needed, in order to facilitate communication, planning and efficient operations.

Aim

- A tool for facilitation of efficient communication between all professionals and stakeholders involved in oil spill issues related to sea ice.
- This group includes; planners and responders as well as researchers and environmental scientists evaluating potential consequences of oil spills and environmental risks associated with exploration of oil and gas in Arctic areas and increased shipping activities in ice-covered waters.
- The oil in ice code shall be simple and be based on established terminology.

Ice and oil properties and their influence on oil spill behavior in icy water



Characteristic environmental conditions

Freezing conditions
- Ice type
- ice coverage
- air temperature
- water temperature
- water salinity

Weather conditions
- wind velocity
- wave height
- perturbation
- suspended sediments

Characteristic physical oil properties

Temp dependent
- density
- viscosity
- surface tension
- vapour pressure

Temp defined
- solidification
- flammability
- distillation data

Fate and behaviour of spilt oil and its weathering processes properties

Areal distribution
- drift/advection
- spreading

Vertical distribution
- evaporation
- solution

Weathering effects
- natural dispersion
- emulsification

Long-term degradation
- photo oxidation
- biodegradation
- sedimentation

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Oil in Ice Code – Selected parameters

The oil in ice code includes the following characteristic ice and oil parameters:

- Ice type
- Sea ice concentration
- Temperature
- Ice dynamics
- Oil classification

Oil in Ice Code –Selected parameters

The oil in ice code includes the following characteristic ice and oil parameters and classes:

- **Ice type**
- Sea ice concentration
- Temperature
- Ice dynamics
- Oil classification

0 = Ice free

1 = Slush < 2 cm

2 = Small brash < 40 cm

3 = Brash < 2m

4 = Floes < 6 m

5 = Large floes/pack ice ≥ 6 m

6 = Fast ice

Affects both how the oil interacts with the ice and what type of vessel and oil spill recovery equipment that is needed

Oil in Ice Code –Selected parameters

The oil in ice code includes the following characteristic ice and oil parameters and classes:

- Ice type
- **Sea ice concentration**
- Temperature
- Ice dynamics
- Oil classification

0 = ice free
1 ≤ 1/10 concentration (areal coverage)
2 ≤ 2/10
3 ≤ 3/10
4 ≤ 4/10
5 ≤ 5/10
6 ≤ 6/10
7 ≤ 7/10
8 ≤ 8/10
9 ≤ 9/10
10 > 9/10, including ridged pack ice
≥ 10/10

The sea ice concentration has a direct impact on drift and weathering characteristics and thus the choice of oil recovery method

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GRACE

Oil in Ice Code – Selected parameters

The oil in ice code includes the following characteristic ice and oil parameters and classes:

- Ice type
- Sea ice concentration
- **Temperature**
- Ice dynamics
- Oil classification

-	Freezing, temperatures below the freezing point of the water
0	Temperatures around the freezing point of the water
+	Melting, no risk of ice formation, above freezing point

Essential external factor which influences all the processes that changes the oil properties and behaviour in water and in ice. Temperature is also important with respect to ice formation and development.

Oil in Ice Code – Selected parameters

The oil in ice code includes the following characteristic ice and oil parameters and classes:

- Ice type
- Sea ice concentration
- Temperature
- **Ice dynamics**
- Oil classification

Affected by wind, current and waves. In addition, localisation and surrounding geographic affects the movements. The movements affects the choice of response technique.

0 – Calm

1 – Moderate ice movements

2 – Severe ice movements

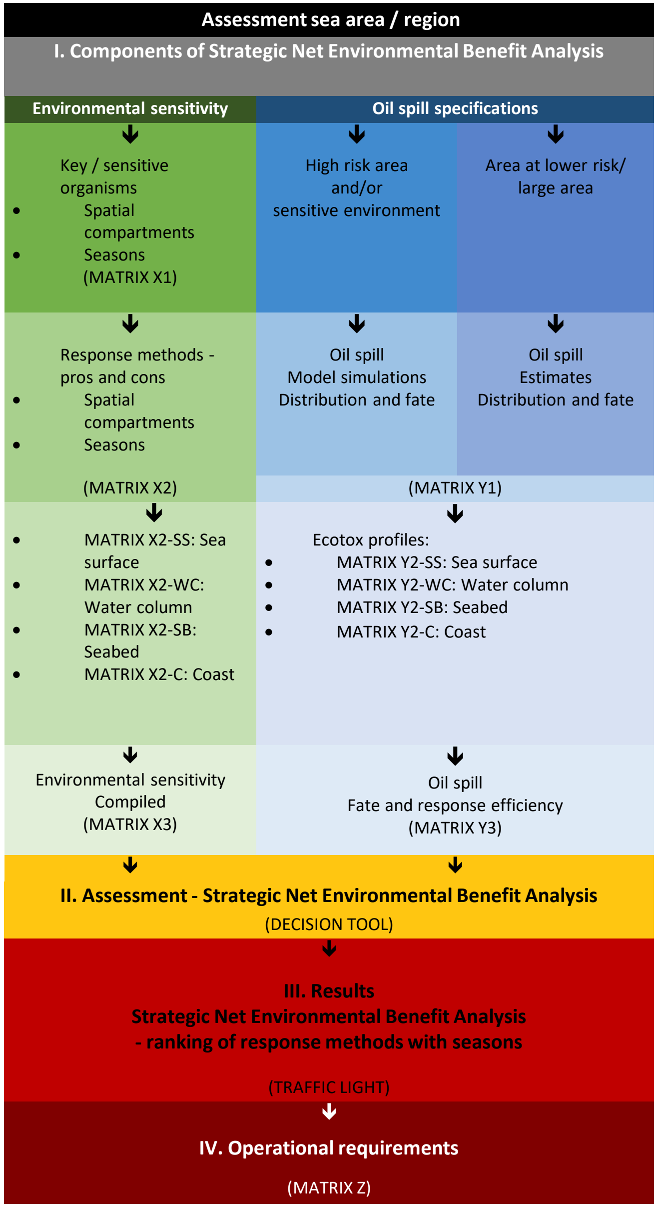
Oil in Ice Code – Selected parameters

The oil in ice code includes the following characteristic ice and oil parameters and classes:

- Ice type
- Sea ice concentration
- Temperature
- Ice dynamic
- **Oil classification**

FE	Floater/evaporator
FED	Floater/evaporator/dissolver
F	Floater
FD	Floater/dissolver

An important stage in choosing an appropriate response strategy for an oil spill is to predict the behaviour of the substance spilt at sea.



Assessment sea area / region

I. Components of Strategic Net Environmental Benefit Analysis

Environmental sensitivity

Key / sensitive organisms
- Spatial compartments
- Seasons

(MATRIX X1)

Response methods - pros and cons
- Spatial compartments
- Seasons

(MATRIX X2)

- MATRIX X2-SS: Sea surface
- MATRIX X2-WC: Water column
- MATRIX X2-SB: Seabed
- MATRIX X2-C: Coast

Environmental sensitivity
Compiled
(MATRIX X3)

Oil spill specifications

High risk area and/or sensitive environment

Area at lower risk/ large area

Oil spill
Model simulations
Distribution and fate

Oil spill
Estimates
Distribution and fate

(MATRIX Y1)

Ecotox profiles:
- MATRIX Y2-SS: Sea surface
- MATRIX Y2-WC: Water column
- MATRIX Y2-SB: Seabed
- MATRIX Y2-C: Coast

Oil spill
Fate and response efficiency
(MATRIX Y3)

II. Assessment - Strategic Net Environmental Benefit Analysis
(DECISION TOOL)

III. Results
Strategic Net Environmental Benefit Analysis
- ranking of response methods with seasons

(TRAFFIC LIGHT)

IV. Operational requirements

(MATRIX Z)

Matrix Z; Operational requirements provides an add-on to the sNEBA traffic light output; *shall we?*

Given a *specific area* and *specific design oil spill* (quantity and type), the sNEBA matrices will give traffic light indications/ranking for each of the 4 oil spill response methods; mechanical recovery, dispersion, in-situ burning (ISB) and do nothing.

The knowledge database Z on operational requirements will provide answers to the subsequent question; ***can we?***

MATRIX Z1

For each of the 4 OSR methods, MATRIX Z1 defines **general operational requirements** in terms of time, weather windows and ice conditions and identifies **needs for specific resource logistics** in terms of equipment, personnel and vehicles. In addition, the operational requirements vary depending on oil type. Matrix Z1 primarily refers to conditions in spatial compartments Sea surface 1 and Coast 4

Oil spill response method	**Operational window**			**Resource logistics**		
	Time window	**Weather window**	**Ice conditions**	**Equipment**	**Personnel**	**Transport**
Mechanical recovery	Medium 8-72 h	Moderate 0-9 m/s	<1/10	Booms, skimmers, storage	Intense	Dedicated vessels
Dispersion	Very short 2-8 h	Wide for airborne application	< 5/10	Dispersants, spraying equipment	Non intensive	Aircraft, boats
ISB	Short 6-24 h	Calm stable	0 – 8/10	Fire boom, herders, igniters	Non intensive	Boats
Do nothing	Long 0 - years	Only option for severe weather	0-10/10	monitoring	No urgent needs, but may call for intensive beach cleaning	Only for monitoring

MATRIX Z2

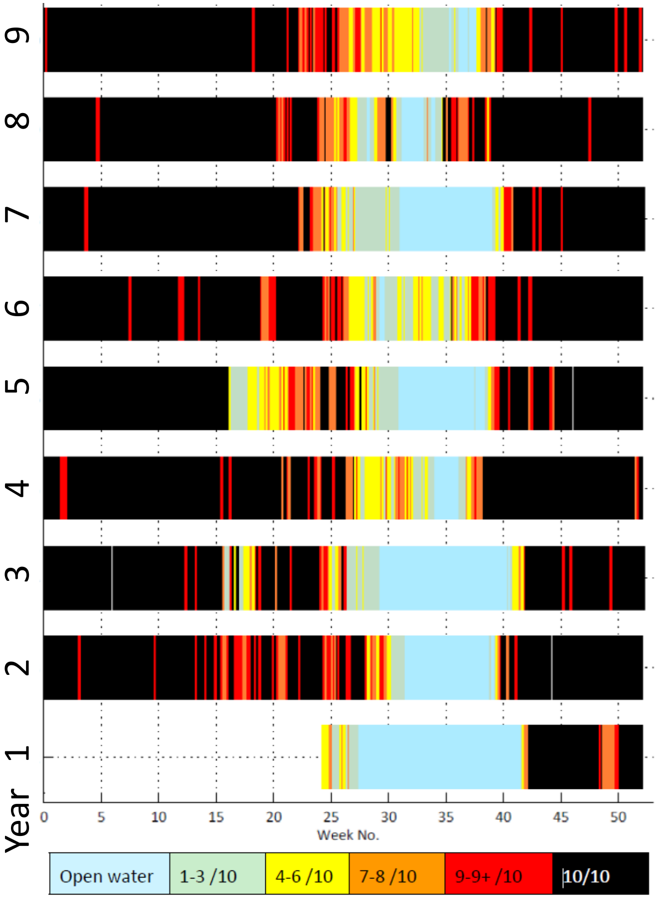
The variables defining weather and ice conditions cannot be accurately specified in absolute figures for a specific area and season, but may rather be described in terms of probability figures. Therefore, Matrix Z2 is outlined to calculate the **operational probability** for each OSR method and each season for a **specific oil spill scenario**.

Oil spill response method	Season	Operational window			Resource logistics						
		Oil specific time window	Probability weather window	Probability suitable ice conditions	Equipment		Personnel		Transport		Operational probability
		hours	p_{Ww}	p_{Ic}	Available E_{av}	Needed E_{ne}	Available P_{av}	Needed P_{ne}	Available T_{av}	Needed T_{ne}	$P(op) = p_{ww} \times p_{Ic} \times \frac{E_{av}}{E_{ne}} \times \frac{P_{av}}{P_{ne}} \times \frac{T_{av}}{T_{ne}}$
Mechanical recovery	Spring										
	Summer										
	Autumn										
	Winter										
Dispersion	Spring										
	Summer										
	Autumn										
	Winter										
ISB	Spring										
	Summer										
	Autumn										
	Winter										
Do nothing	Spring										
	Summer										
	Autumn										
	Winter										

Probability of suitable ice conditions

Example on how metocean/ice statistics can be utilised to estimate credible operational window for spill response operations in ice infested areas and harsh weather conditions

Registered ice concentration at a site off Greenland per week during 9 years



Combined with NOAA egg code statistics on ice type, floe size, thickness + wind from ECMWF, an ice severity index is defined (1-10). The operational window for each RT is also defined by the in ice severity index. Assessment of statistics graphically defines expected operational season duration at a given probability confidence level.