USING NEBA AND ENVIRONMENTAL RISK METHODS FOR OIL SPILL RESPONSE PLANNING AND PREPAREDNESS

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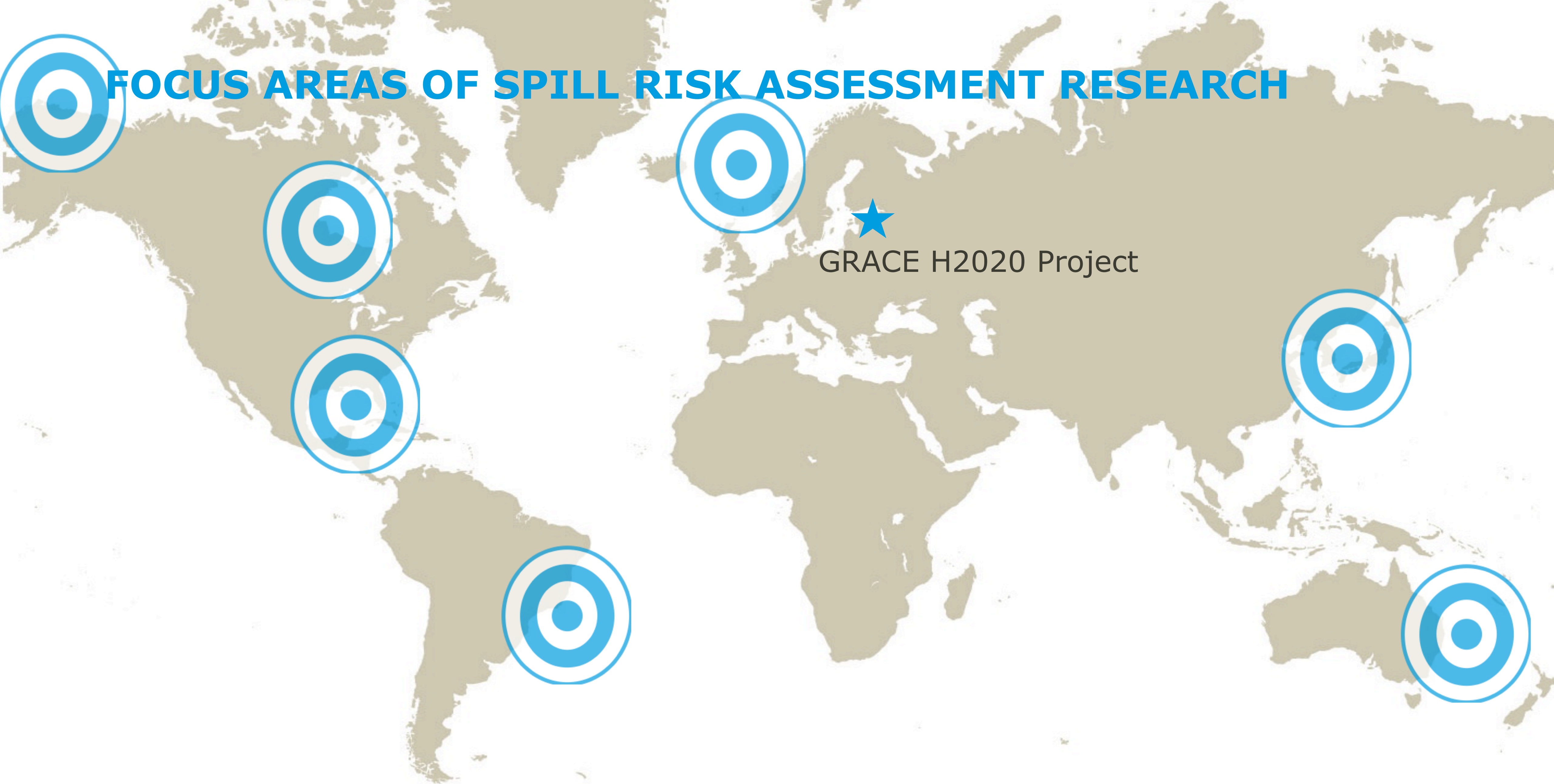
GRACE FINAL CONFERENCE
TALLINN, 23-24 MAY 2019

RAMBOLL

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

FOCUS AREAS OF SPILL RISK ASSESSMENT RESEARCH



HORIZON 2020 GRACE PROJECT

INTEGRATED OIL SPILL RESPONSE ACTIONS AND ENVIRONMENTAL EFFECTS

1 Oil spill detection, monitoring, fate and distribution

- Sensors for in situ oil spill detection (Harri Kankaanpää)
- FerryBox and SmartBuoy technologies (Siim Pärt et al.)
- Oil spill modeling (Urmas Raudsepp et al.)
- Remote sensing data tools (Tarmo Kõuts et al.)

2 Oil biodegradation and bioremediation

- Cold marine environments (Ossi Tonteri)
- Seawater and ice-water interface (Nga Dang)
- Marine microbial community responses (Jaak Truu)

3 Oil impacts on biota using biomarkers and ecorisk assessment

- Effects of oil contaminants in vivo (Denis Benito)
- Oil toxicity in mussels, copepods and zebrafish (Aino Ahvo)
- Effect-based toolbox for investigation and fingerprinting (Sarah Johann)
- Environmental effects and response actions (Thomas-Benjamin Seiler)

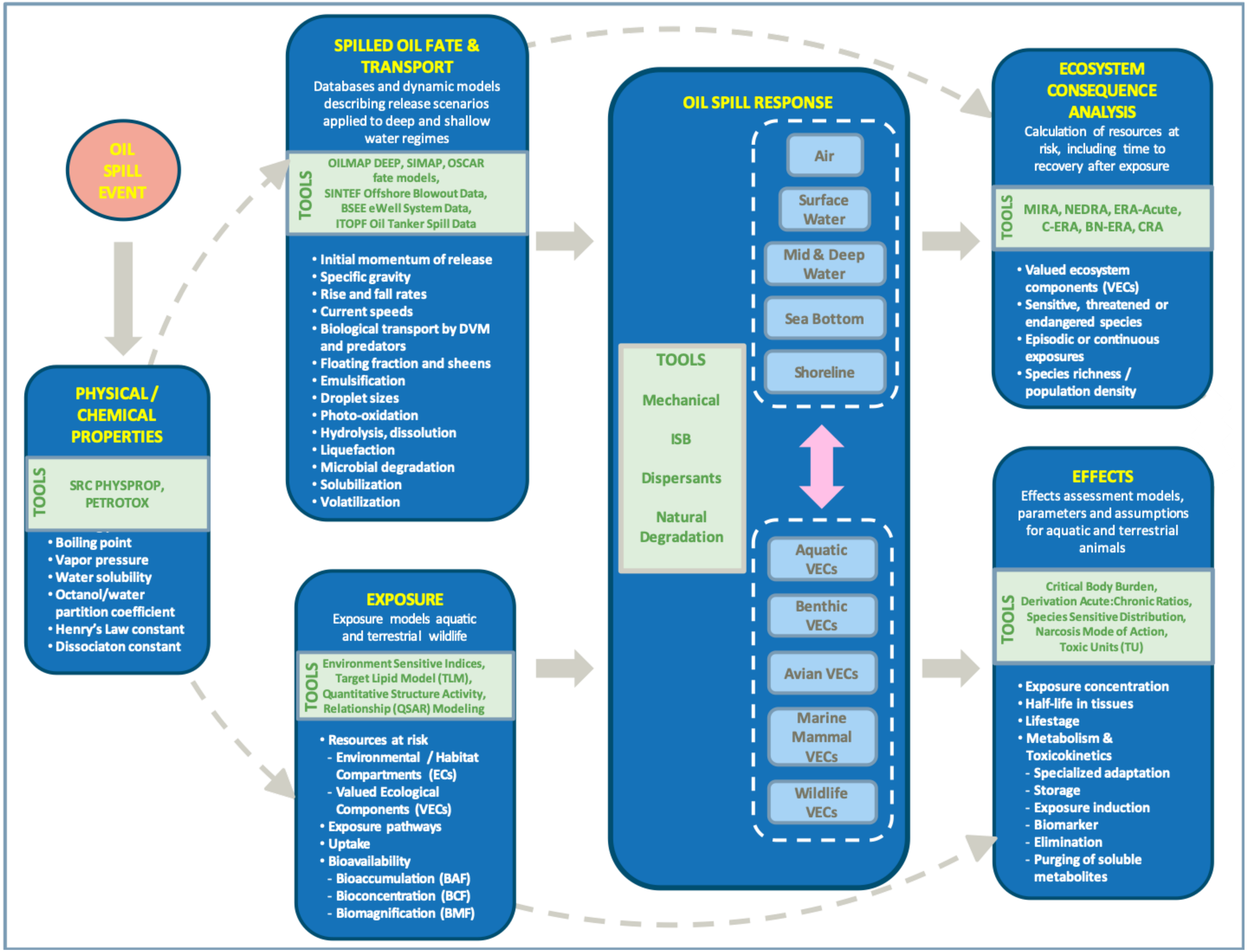
4 Responding to oil spills in coastal arctic waters

- Burning oil on ice (Christian Petrich)
- Mechanical removal of oil under ice (Rune Högström)
- In situ burning (Kim Gustavson et al.)

5 EOS

- I. Framework and decision trees (Susse Wegeberg et al.)
- II. Interactive component (Janne Fritt-Rasmussen et al.)
- III. Operational add-ons (Bjørn Forsman & Nelly Forsman)

OIL SPILL RESPONSE ASSESSMENT



Wenning et al. *Mar Environ Res* 141:289-304. (2018)

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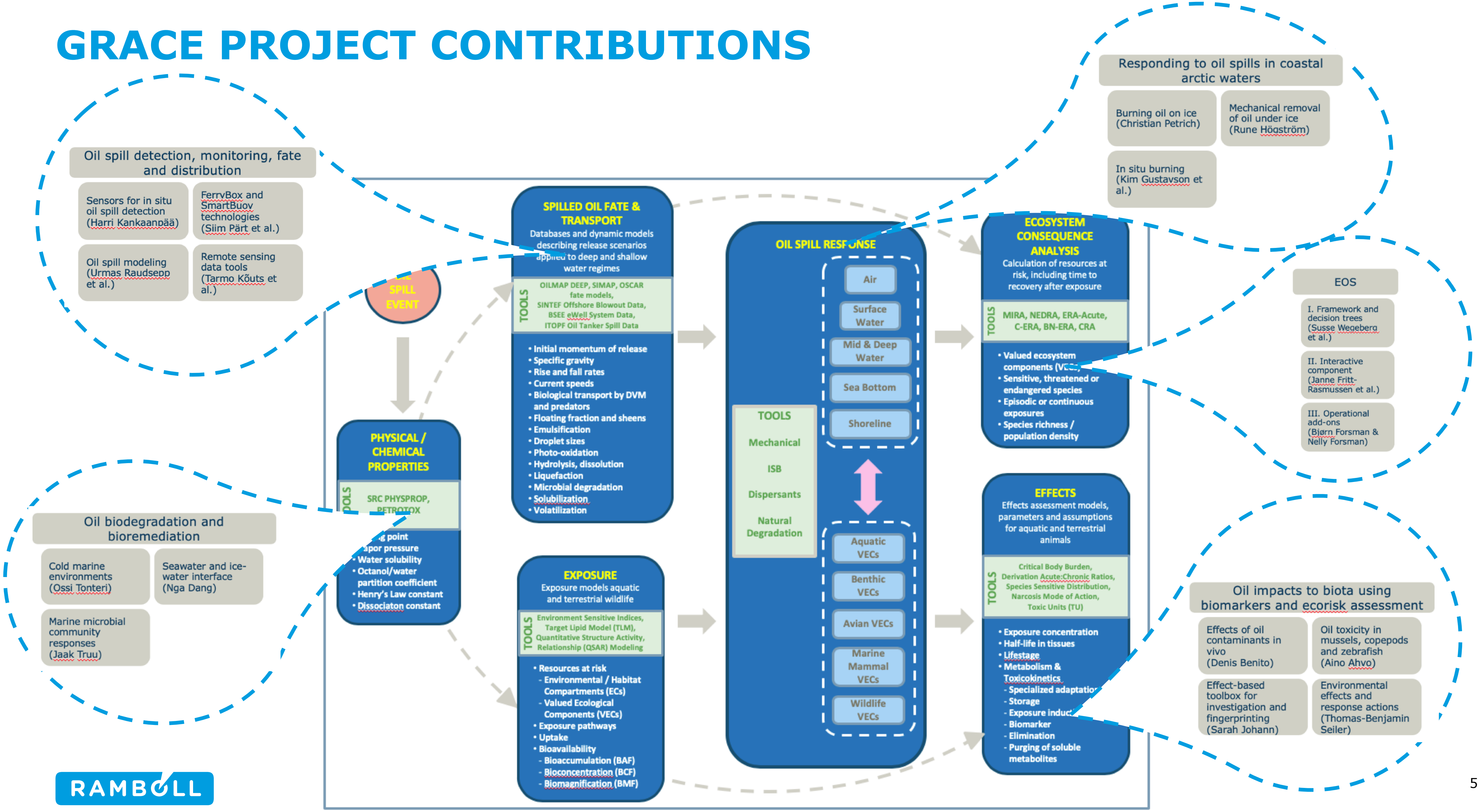
GRACE PROJECT CONTRIBUTIONS



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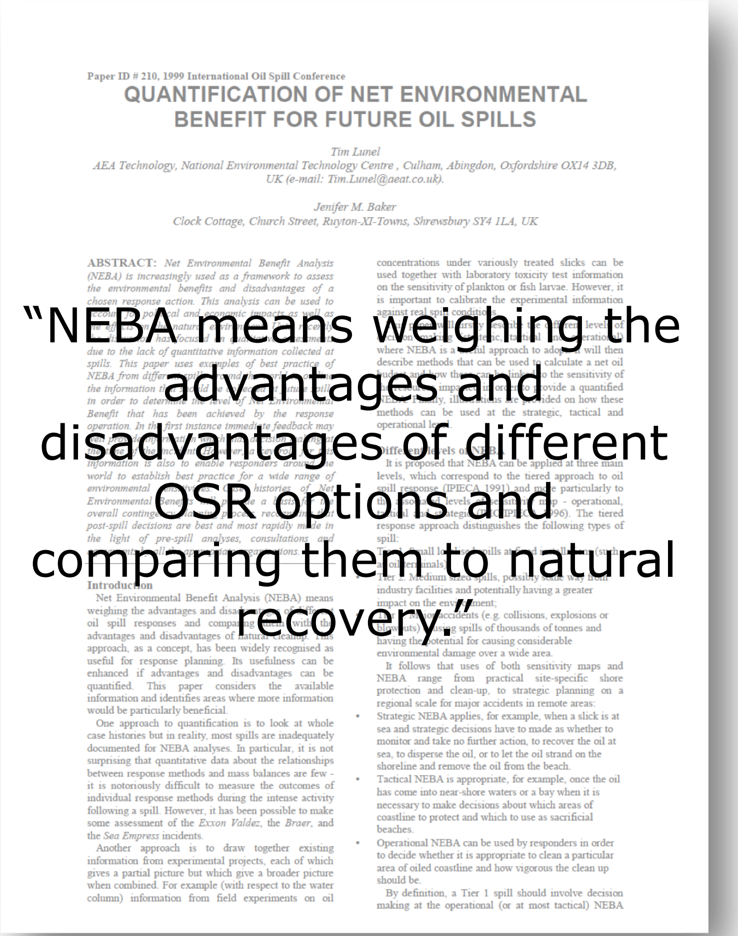
OIL SPILL RESPONSE DECISION-MAKING SHOULD CONTINUE TO EVOLVE



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

Lunel and Baker (1999)

- ✓ *Aim to minimize the net consequences of an oil spill on the environment*
- ✓ *Be mindful of the range of geographic areas, ecological habitats, and environmental/oceanographic and socio-economic conditions*
- ✓ *Consider protections for the broadest range of ecological receptors*
- ✓ *Refine assessments and strategies as knowledge expands*

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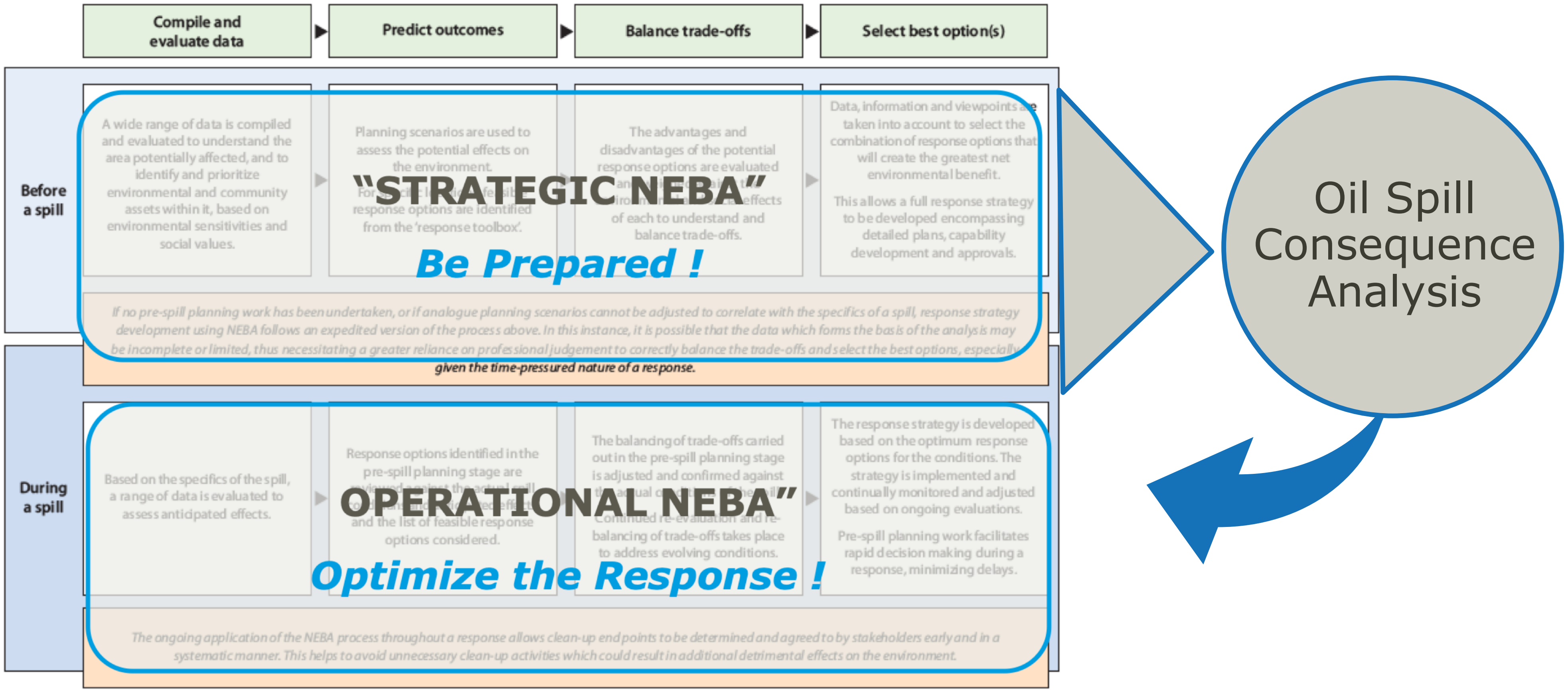
TWO RESPONSE STRATEGIES



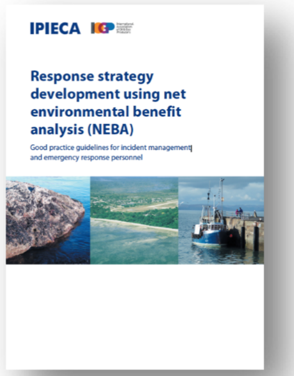
Resources at risk

Assessment inputs

Screening data

Stakeholder values

OSR technologies



IPIECA 2015

OIL SPILL RISK ASSESSMENT MUST BE RELEVANT TO ECOSYSTEMS / REGIONS

- 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)
- Alaska Oil Spill Risk Analysis, (NOAA, 2014)
- ISO31000 Oil Spill Risk Assessment Framework, (Neves et al. 2015)
- Oil Pollution Risk Assessment, (Lee and Jung, 2015)
- Risk Evaluation Method for Offshore Spills in China (Guo et al. 2015)
- 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)
- Guidelines on implementing spill impact mitigation assessment (SIMA), (IPIECA 2018)
- Spatial and Stochastic Oil Spill Risk Assessment, (Amir-Heidari et al. 2019)

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

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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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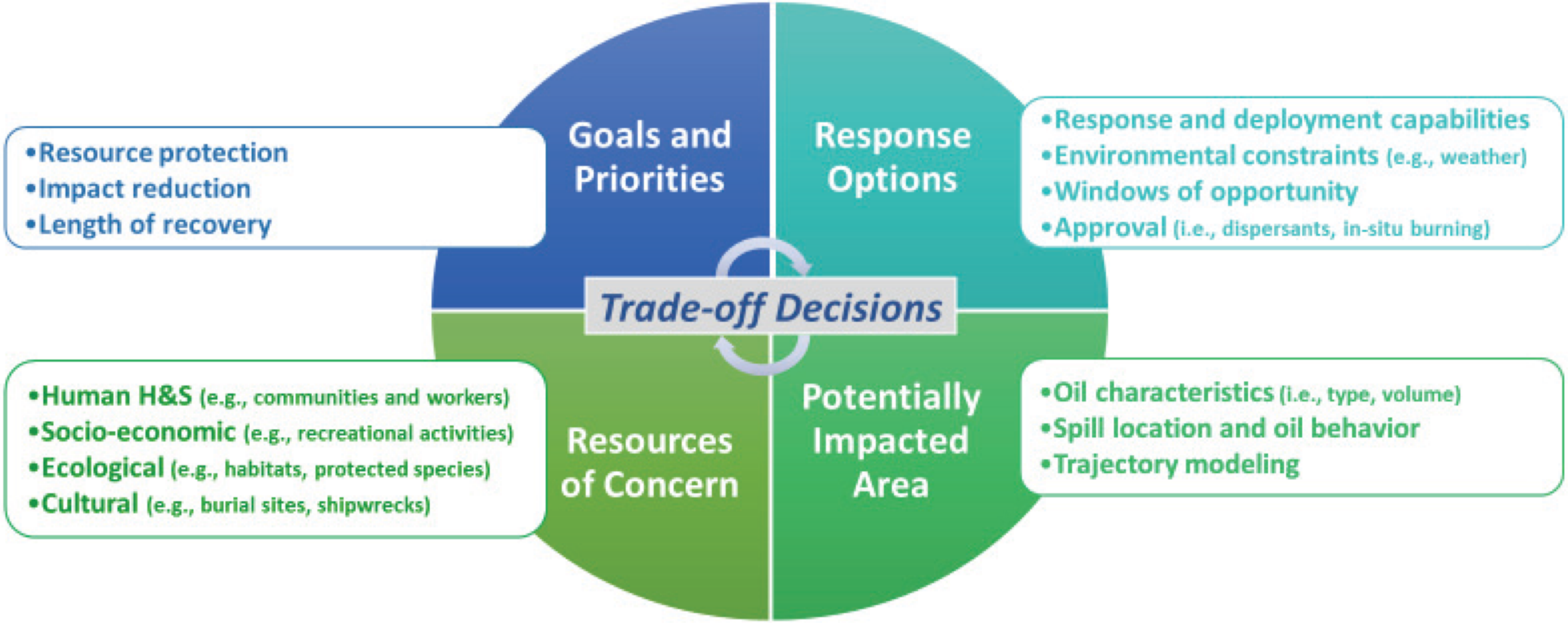
PREVENT CRUDE OIL & OIL PRODUCTS FROM REACHING SHORE

TRADE OFFS ARE INEVITABLE



Decision-making for selecting optimal response options requires:

- Knowing what response options are available and feasible
- Understanding oil and spill behavior
- Understanding resources potentially affected by the spill and spill response activities

SPILL IMPACT MITIGATION ASSESSMENT (SIMA)

Predict Outcomes

1. Resource compartments

2. Relative impacts

3. Predict effectiveness and impact modification potential for spill response options

Balance Trade-offs

4. Impact modification factors

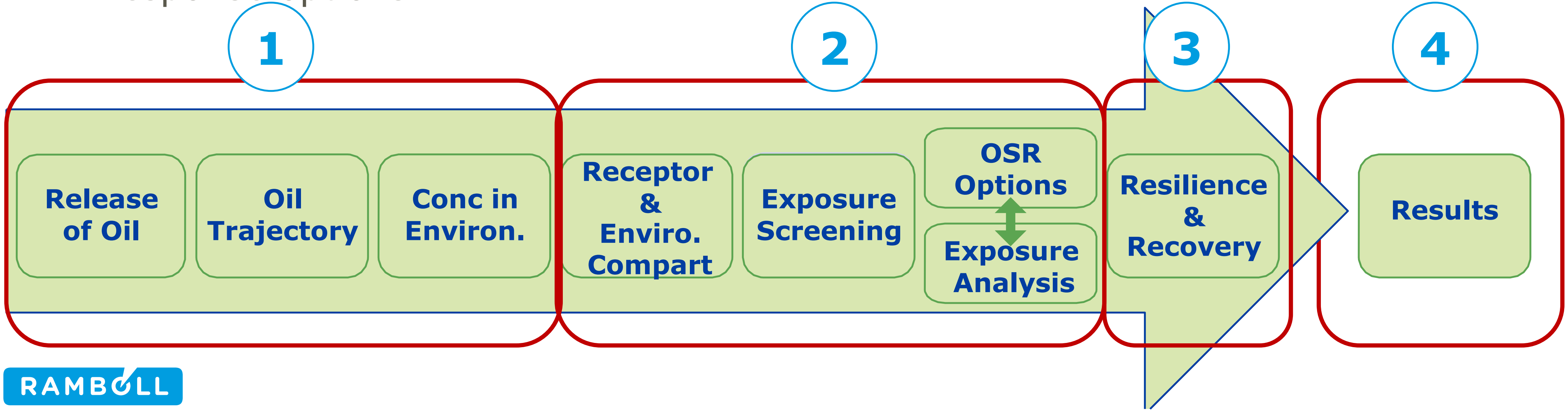
Resource compartments	No intervention	Potential relative impact (A)	Contain and recover: Impact modification factor (B1)	Contain and recover: Relative impact mitigation score (A x B1)	Surface dispersant: Impact modification factor (B2)	Surface dispersant: Relative impact mitigation score (A x B2)	Subsea dispersant – not feasible	In-situ burning: Impact modification factor (B4)	In-situ burning: Relative impact mitigation score (A x B4)	Shoreline booming: Impact modification factor (B5)	Shoreline booming: Relative impact mitigation score (A x B5)
Seabed	None	1	0		0			0		0	
Lower water column	None	1	0		0			0		0	
Upper water coloumn	Low	2	1		-2			0		0	
Water suface	Med	3	1		3			2		0	
Air	Med	3	1		2			-2		0	
Shorelines		3	1		3			2		1	
Saltmarsh	*High*	*4*	*1*		*3*			*2*		*1*	
Estuarine mudflats	*High*	*4*	*1*		*3*			*2*		*1*	
Sandy beaches	*Low*	*2*	*1*		*3*			*2*		*2*	
High value resources	Low	2	0		1			0		1	
Socio-economic		4	1		2			1		3	
Boat harbour	*Med*	*3*	*1*		*2*			*1*		*2*	
Water recreation	*High*	*4*	*1*		*2*			*1*		*3*	
Cultural	None	1	0		2			1		1	

5. Total impact mitigation score and ranking of spill response options

Resource compartments	No intervention	Potential relative impact (A)	Contain and recover: Impact modification factor (B1)	Contain and recover: Relative impact mitigation score (A x B1)	Surface dispersant: Impact modification factor (B2)	Surface dispersant: Relative impact mitigation score (A x B2)	Subsea dispersant – not feasible	In-situ burning: Impact modification factor (B4)	In-situ burning: Relative impact mitigation score (A x B4)	Shoreline booming: Impact modification factor (B5)	Shoreline booming: Relative impact mitigation score (A x B5)
Seabed	None	1	0	0	0	0		0	0	0	0
Lower water column	None	1	0	0	0	0		0	0	0	0
Upper water coloumn	Low	2	1	2	-2	-4		0	0	0	0
Water suface	Med	3	1	3	3	9		2	6	0	0
Air	Med	3	1	3	2	6		-2	-6	0	0
Shorelines		3	1	3	3	9		2	6	1	3
Saltmarsh	*High*	*4*	*1*		*3*			*2*		*1*	
Estuarine mudflats	*High*	*4*	*1*		*3*			*2*		*1*	
Sandy beaches	*Low*	*2*	*1*		*3*			*2*		*2*	
High value resources	Low	2	0	0	1	2		0	0	1	2
Socio-economic		4	1	4	2	8		1	4	3	12
Boat harbour	*Med*	*3*	*1*		*2*			*1*		*2*	
Water recreation	*High*	*4*	*1*		*2*			*1*		*3*	
Cultural	None	1	0	0	2	2		1	1	1	1
				15		32			11		18
				3rd		1st			4th		2nd

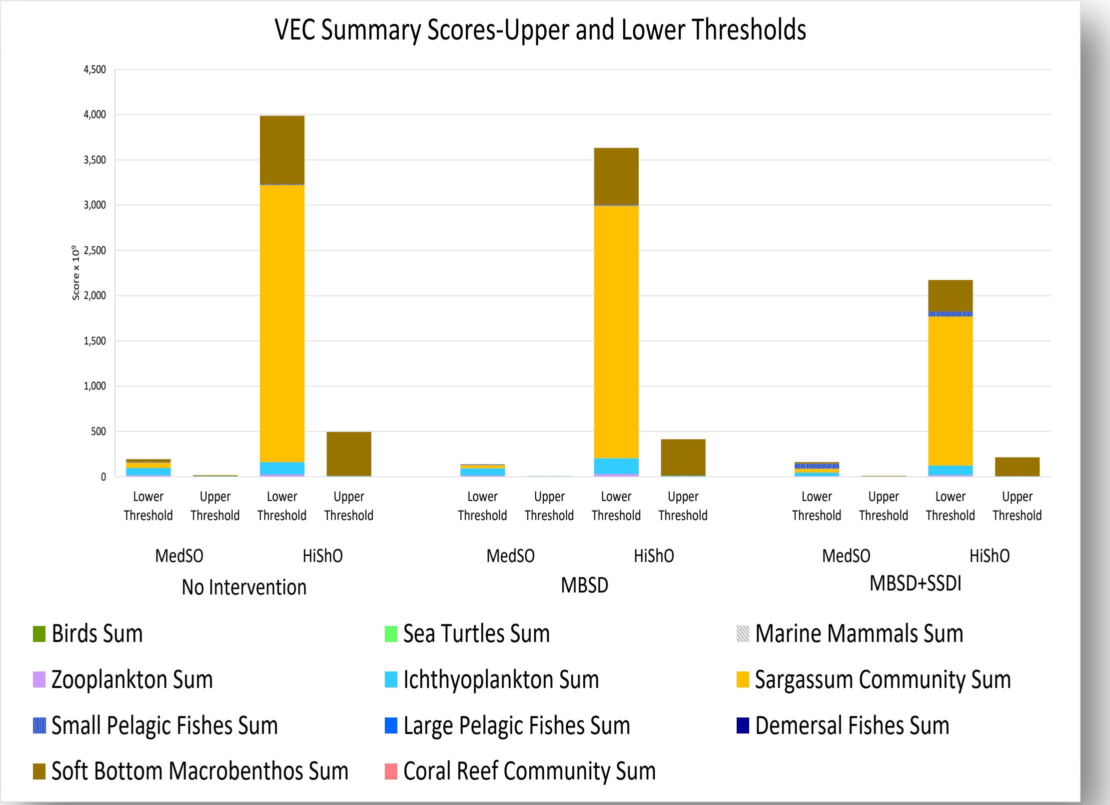
COMPARATIVE RESPONSE ASSESSMENT (CRA)

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

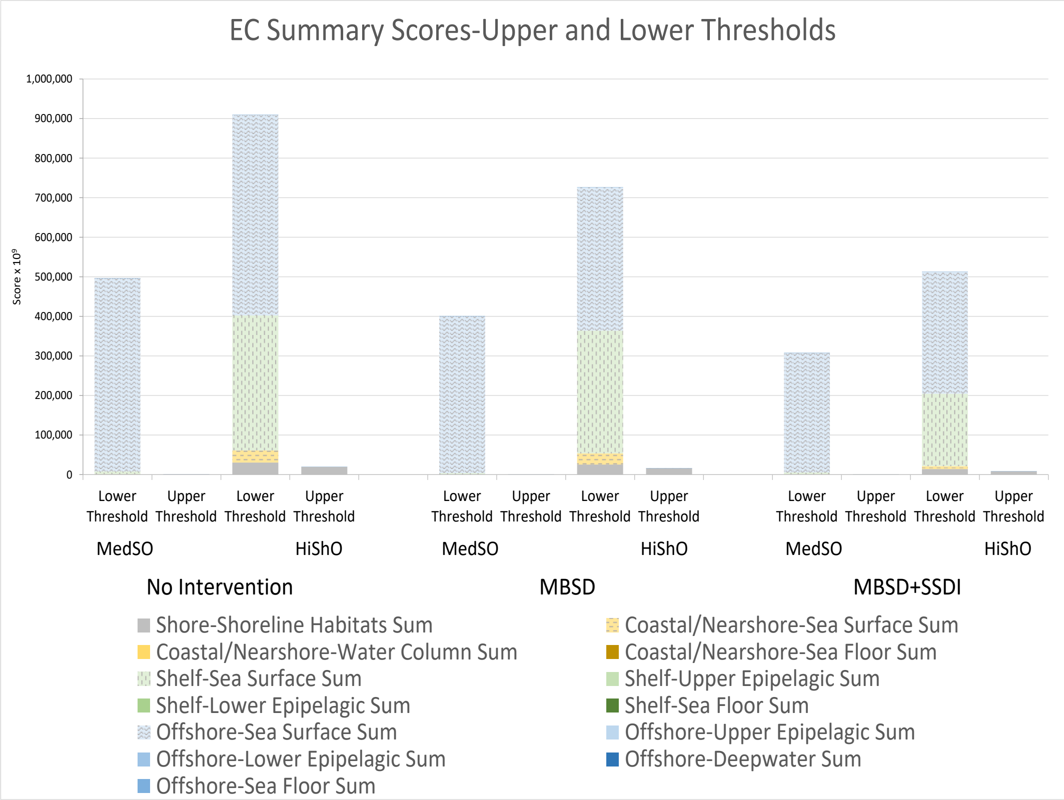


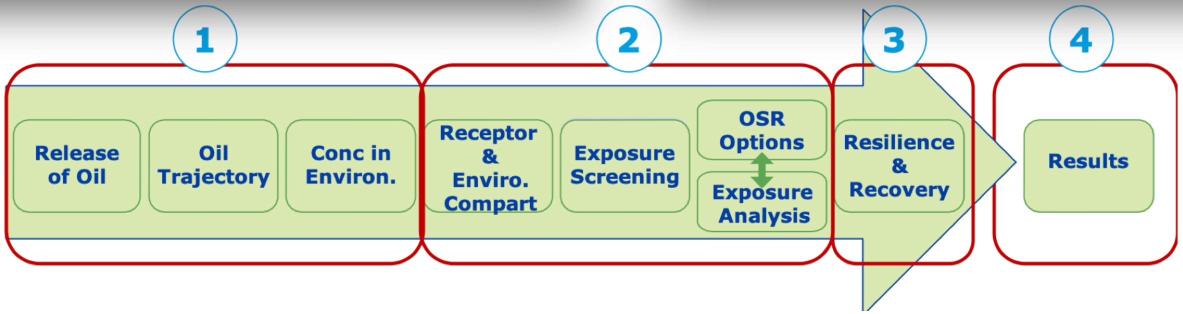
CRA RESULTS – ECOLOGICAL RECEPTORS

Ecological value



Habitat value





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ENVIRONMENT & OIL SPILL RESPONSE (EOS)

AARHUS UNIVERSITY

Integrated oil spill response actions and environmental effects
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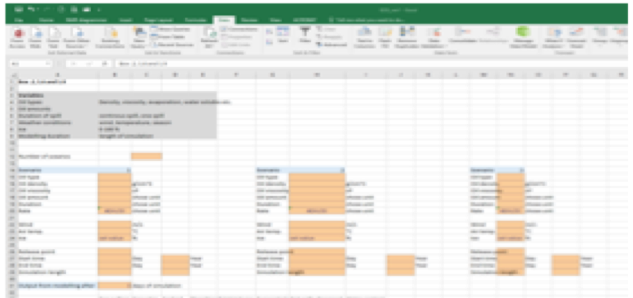
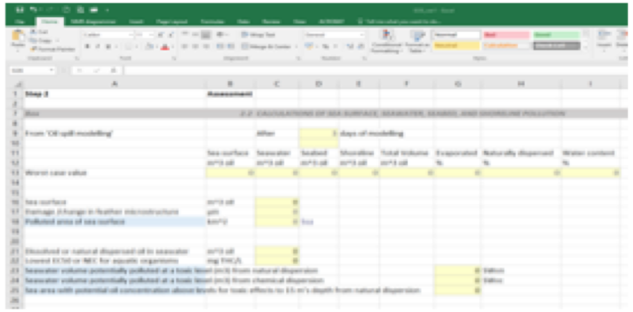
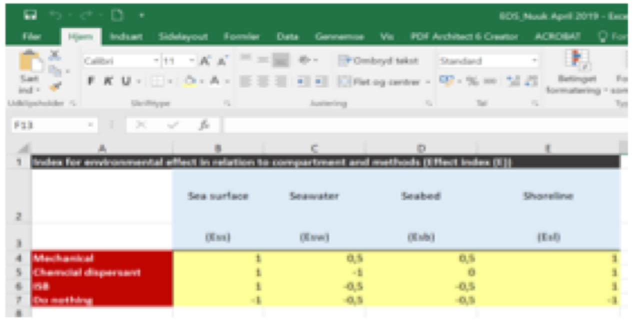
1) Baseline Information



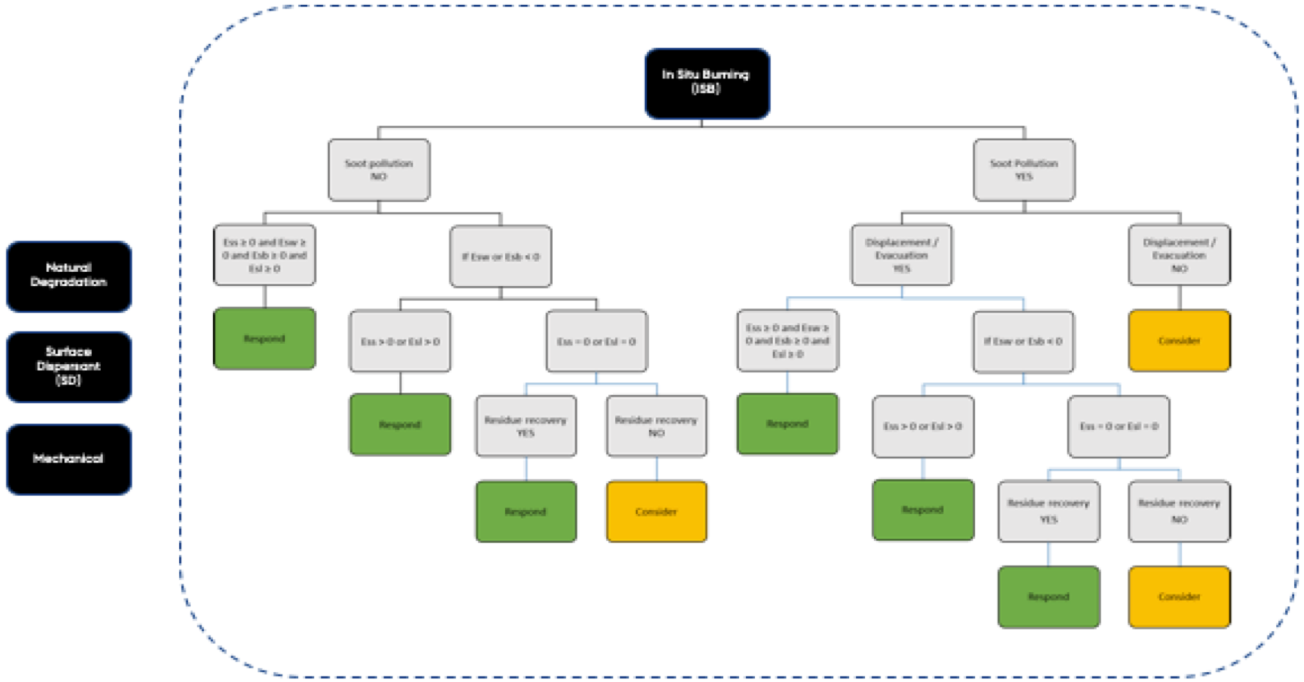
2) Assessment Calculations



3) Index / Scores



4) Decision Trees



THE 4-STEP FRAMEWORK IS THE FOUNDATION FOR FURTHER RESEARCH AND SPILL RESPONSE

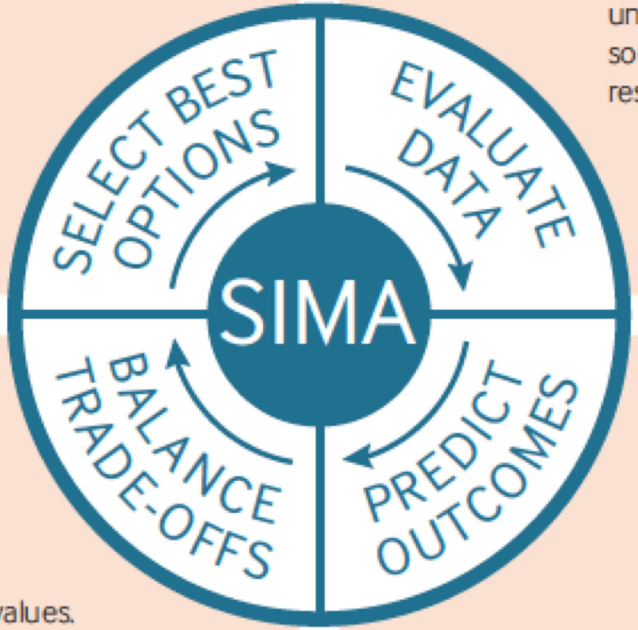
Stage 4: Select best options

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.

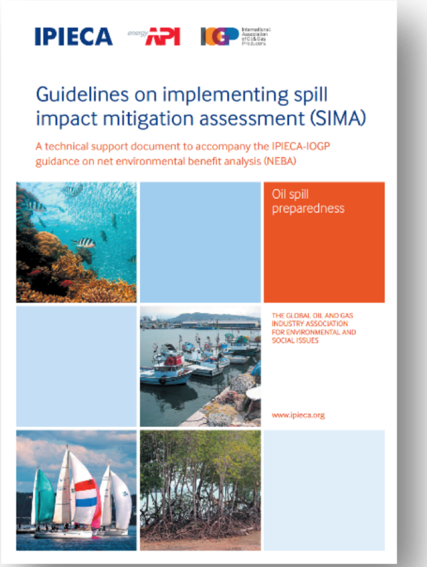


Stage 3: Balance trade-offs

- 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.



IPIECA 2017

FUTURE WORK

1. Incorporate ecosystem service approach

- Model important physical and biological systems to track the consequence of an oil spill on the local ecosystem services (e.g., fish populations)

2. Continued research on microbial communities and oil biodegradation

- Microbial community composition dictates oil biodegradation pathways, how fast the oil is degraded, which compounds in the oil are degraded, and what oil daughter products might result that could affect bioavailability and toxicity of hydrocarbons

3. Communicate the OSR toolbox in terms meaningful to decision makers

- Focus on knowledge exchange that increase the relevance of the science and technology generated from scientific research, and attract the attention of decision makers who are grappling with the same concerns about oil spill consequences and appropriate responses

4. Don’t stop with GRACE accomplishments… there is much more to learn !

THANK YOU

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2016-2019

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