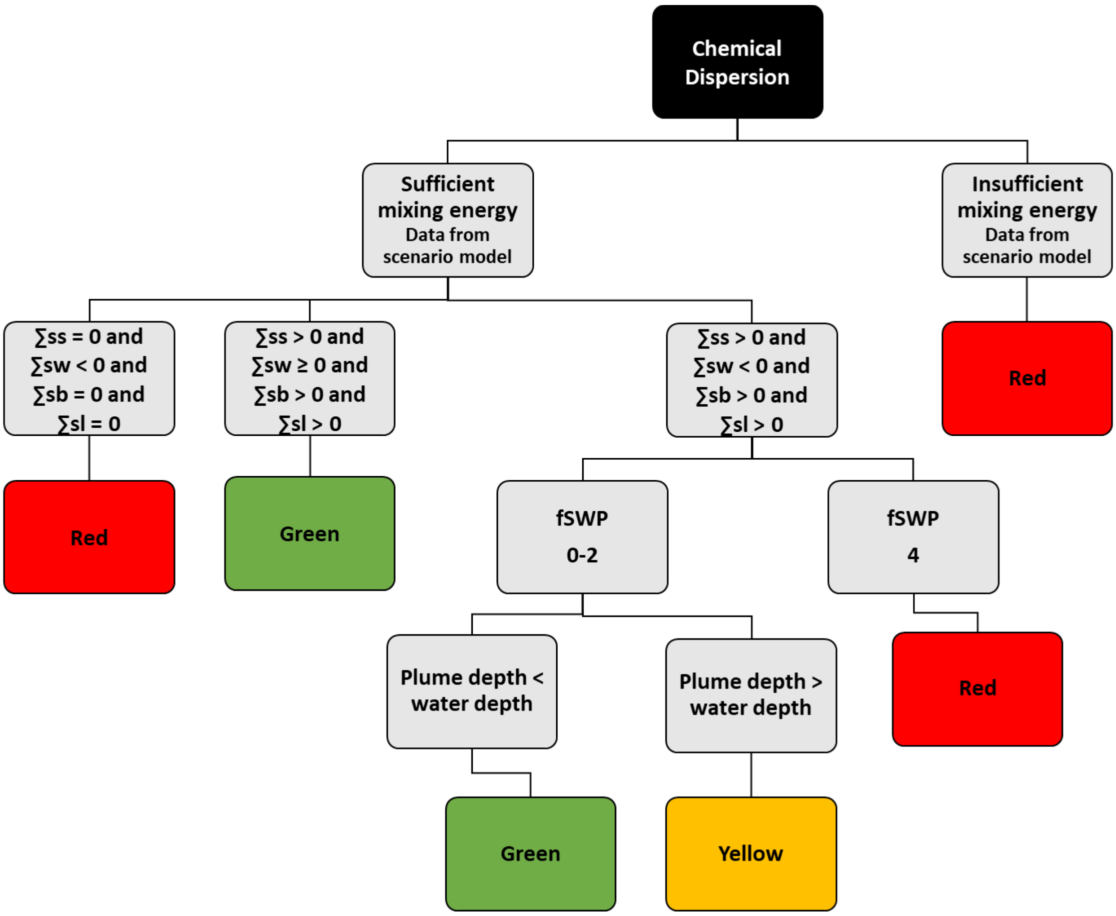
Ref. Ares(2018)6328945 - 10/12/2018

GRACE grant no 679266

Draft SNEBA tool

D5.8

WP5: Strategic Net Environmental Benefit Analysis (SNEBA)



Prepared under contract from the European Commission
Contract n° 679266
Research and Innovation Action
Innovation and Networks Executive Agency
Horizon 2020 BG-2014-2015/BG2015-2

Project acronym:	GRACE
Project full title:	Integrated oil spill response actions and environmental effects
Start of the project:	01 March 2016
Duration:	42 months
Project coordinator:	Finnish Environment Institute (SYKE)
Project website	http://www.grace-oil-project.eu

Deliverable title:	SNEBA tool report, draft
Deliverable n°:	D5.8
Nature of the deliverable:	Report
Dissemination level:	Public

WP responsible:	AU
Lead beneficiary:	AU

Due date of deliverable:	31.08.2018
Actual submission date:	30.11.2018

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

Executive Summary

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 (Do nothing)) for closed basins with extreme cold temperatures, based on relevant scenarios. The SNEBA tool development stands on the shoulders of the previous WP5 deliverables (D5.1 - D.5.7)

The SNEBA tool is developed to include and overarch the biological and technical knowledge obtained from the other WPs in GRACE. Furthermore, integrated operational assessments being based on knowledge / expertise on coastal protection and shoreline response will be developed by SSPA Sweden AB.

The beta version of the SNEBA tool was presented to relevant stakeholders at a workshop held in November 22, 2018 (see workshop report, Deliverable 5.9) to obtain feedback and optimize the tool including potential improvement of use. Hence, please note that the following SNEBA tool is a beta version and that it will be adjusted and amended before it will be ready to use. The final tool will be published in Deliverable 5.10 and in a scientific paper.

As part of the SNEBA work package (WP5) new information from the GRACE project will be compiled and presented in tables including data on biodegradation and ecotoxicological data as well as oil spill response and support equipment.

The SNEBA tool consists of a number of successive steps; compilation of data and information, calculations and assessments for score systems as well as decisions trees for each oil spill and dissemination of results. The steps are supported by information boxes with data / scoring tables.

1 Introduction

The main objective of the WP5 is to develop and launch a Strategic Net Environmental Benefit Analysis (SNEBA) tool for decision-making and planning. 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 (Do nothing)) 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 development stands on the shoulders of the previous WP5 deliverables (D5.1 - D.5.7)

The SNEBA tool is developed to include and overarch the biological and technical knowledge obtained from the previous WPs. Furthermore, integrated operational assessments being based on knowledge / expertise on coastal protection and shoreline response will be developed by SSPA Sweden AB.

The beta version of the SNEBA tool was presented to relevant stakeholders at a workshop held in November 22, 2018 (see workshop report, Deliverable 5.9) to obtain feedback and optimize the tool including potential improvement of use. Hence, please note that the following SNEBA tool is a beta version and it will not be ready to use before it has been adjusted and amended according to input from the stakeholder workshop as well as forthcoming meetings in January 2019 with representatives of the workshop participants.

1.1 New information for SNEBA and operational tools from GRACE project

To compile all information obtained and gathered in the GRACE project following table templates are circulated within the project partners.

The tables will hence list the products of the GRACE project in total and reveal what the project has accomplished with respect to new knowledge on oil spill environmental impact and response.

Biodegradation and Ecotoxicology

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

Oil spill response and support tools

Tool	Application	Results	Environmental implications	Publication/ authors/credit

2 Process for the SNEBA

The structure and process of the SNEBA is based on a number of descriptive boxes for gathering data, doing calculations and calculating scores (Table 2.1). The data and scores are finally used in the decision trees for each of the oil spill response methods. The process for the SNEBA is based on the five steps listed and described in further details below:

1) **Basic data and information**
   Collection and compilation of data and information as basis for the analysis
2) **Assessment**
   Processing of data and information for assessments
3) **Scores for the sNEBA analysis**
   Calculation of scores for analysis flow chart
4) **Analysis through decision trees**
   By decision trees for each oil spill response methods and for each season
5) **Interpretation and dissemination of analyses results**
   The outcome from the decision trees are discussed

2.1 Step 1 - Basic data and information

This is the first step in the SNEBA and includes collection and compilation of basic data and information for the calculations and score systems in Step 2) and 3), respectively.

The step includes nine boxes (Box 1.1 – 1.9) with descriptions and tables for collection data. A crucial part of Step 1) is also to have oil spill modelling simulations performed to obtain important data for the further process.

2.1.1 Step 1 information boxes

Box 1.1. Definition of assessment area, including examples of definitions to be used, natural limits/borders and examples of areas suitable for a SNEBA.

Box 1.2. Definition of oil spill scenarios including basic parameters for oil spill scenarios, selection of oil spill sites, oil types, size of oil spills, season and weather conditions as well as number of scenarios for covering the objectives of the SNEBA.

Box 1.3. Selection criteria for identification of species / organism groups of concern in the assessment area, including suggestions on using species already designated valuable ecosystem components (VECs), or characteristic of sensitive areas such as particular sensitive sea areas (PSSAs) or marine protected areas (MPAs). Species or organism groups must be selected for the four spatial compartments; sea surface, seawater, seabed, shoreline and for each season.

Box 1.4. Characterization of the assessment area's surroundings, including distance to cities / towns, animal congregation at sea or on land as well as prevailing wind direction and ice coverage. These parameters are of specific relevance to smoke spreading and soot deposition in connection with in situ burning.

Box 1.5. Characterization of the assessment area and water body, including sea surface area of the assessment area's waterbody, volume of waterbody, seabed area of the assessment area's waterbody, and shoreline length.

Box 1.6. Characterization of the oil type(s) selected for the oil spill scenarios, including crude oil types if the objective of the SNEBA is oil exploration / exploitation activities or shipping route for transportation of crude oil. In addition, fuel oil types should be included in case of shipping and hence credible fuel oil types should be included such as marine diesel and heavy fuel oil (HFO) types.

Box 1.7. Ecotoxicological data necessary for evaluating impact from untreated and treated oil on species / organism groups of concern, including toxicity of dissolved natural and chemical dispersed oil in seawater with respect to acute and chronic toxicity.

Also, effects of oil sheen or oil slick on seabird feather structure and water uptake are included in this box.

Box 1.8. Definitions of oil dispersion are given and includes natural dispersion caused by the weather and tidal energy in the system, chemical dispersion as obtained from applying of chemical dispersants and finally mechanical dispersion. Mechanical dispersion as a result from mechanical recovery operations' energy to the seawater system is only mentioned as it needs evaluation with respect to proportion in the future before it can be directly included in the calculations.

Box 1.9. Models for oil spill simulations are described including their output with relevance for SNEBA. This includes oil spill trajectory results, fate of oil with regard to the spatial compartments (sea surface, seawater, seabed, shoreline), naturally dispersed and evaporated oil fractions.

2.2 Step 2 - Assessments

This is the second step in the SNEBA and includes assessments and calculations based on the data compiled in the SNEBA tool's Step 1.

The step includes six boxes (Box 2.1 – 1.6) with descriptions, tables and calculations of which the calculations of oil polluted sea surface area, seawater volume, seabed area and length of shoreline are crucial for the further steps in the SNEBA.

2.2.1 Step 2 information boxes

Box 2.1. Assumptions and criteria behind calculation of sea surface area, seawater volume, seabed area and shoreline length polluted from oil spill simulation results used in Box 2.2.

Box 2.2. Calculations of sea surface, seawater, seabed and shoreline pollution, which include extent of pollution based on the assumptions from Box 2.1 (1.7) regarding oil sheen / slick thickness for damage of seabird feather structure and water volumes with oil concentrations above No Effect Concentration (NEC). The calculations for seabed and shoreline pollution is based on oil amount per m^2.

Box 2.3. Evaluation of oxygen conditions is important for assessing the potential environmental impact of chemical dispersion, as degradation of oil droplets by microorganisms is oxygen consuming.

Box 2.4. Evaluation of natural biodegradation potential includes identification of hydrocarbon degrading microorganisms as well as sufficient nutrients for the degradation process, which is important for assessing the potential environmental impact from chemical dispersion as oil spill response method.

Box 2.5. Description and estimation of the oil spill response technology efficiency includes descriptions of the three oil spill response methods, mechanical recovery, chemical dispersion and in situ burning. Furthermore, default values for efficiency of mechanical recovery is presented as although this method may have no environmental side effects, the efficiency may be very low.

Box 2.6. Assessment of pros and cons of the oil spill response technologies includes a description of the SNEBA conceptual framework and default considerations with respect to the net environmental benefit from the oil spill response methods with regard to species / organisms of concern associated with the different spatial compartments (sea surface, seawater, seabed, shoreline).

2.3 Step 3 - Scores / values for SNEBA

This is the third step in the SNEBA and includes score systems for scores to be used in the decision trees for mechanical recovery, chemical dispersants, in situ burning and do nothing (Step 4).

The step includes four boxes (Box 3.1 – 1.4) with descriptions and tables for data. A crucial part of Step 1) is to have oil spill modelling simulations performed to obtain important data for the further process.

2.3.1 Step 3 information boxes

Box 3.1. Net environmental benefit, NEB, score system, scores the impact on species individual, population, global population and cascade effects levels.

Box 3.2. Score system for soot pollution, SP, includes distance to inhabitation, animal congregations, wind direction and ice cover for protection against particles in smoke (soot) and soot deposition on ice, reducing the reflective effect and hence the albedo.

Box 3.3. Calculation of effective damage reduction, DaR, for mechanical recovery. From the net environmental benefit (NEB) score, the effective benefit for the species / organism groups at risk of an oil spill is scored by multiplying with the methods efficiency.

Box 3.4. Score system for pollution of sea surface, seawater, seabed and shoreline includes calculating the fractions of sea surface area, seawater volume, seabed area and shoreline length that are polluted by oil slick or dispersed oil in relation of the total areas / volume of the assessments area's waterbody.

2.4 Step 4 - Analyses through decision trees

The fourth step in the SNEBA includes following paths through decision trees for each oil spill response method to reach the SNEBA result and is based on the values and scores obtained in the proceeding steps of the SNEBA.

Please note that the decision tree paths have to be performed for each of the seasons relevant for the assessment area.

2.4.1 Chemical dispersion decision tree

First, it is assessed, on the basis of information from the oil spill scenario modelling, if there is sufficient mixing energy in the waterbody system for a dispersant operation to work as intended.

Then summed values for species / organism groups of concern is entered into the decision tree followed by the score for fraction of seawater oil polluted to assess the extent of the potential impact on organisms in the seawater column and if recruitment may compensate for the effects.

Finally, the dispersed oil plume depth is considered with respect to the seabed organisms.

2.4.2 In situ burning decision tree

With respect to in situ burning, soot development and deposition is the first branch in the decision tree. If soot is considered a problem, and if the oil spill is comprehensive, and where many burns may be expected, health issues need to be addressed. If soot is not considered a problem, the net environmental benefit (NEB) scores and the fraction of sea surface area polluted must be evaluated in order to assess the overall benefit for the environment by in situ burning operations.

2.4.3 Mechanical recovery decision tree

Mechanical recovery is considered to have no environmental side effects, but the efficiency of oil recover may be relatively low.

Therefore, the decision tree includes assessments of the summed values for each spatial compartment, the net environmental benefit (NEB) as well as damage reduction (DaR).

Furthermore, the fraction of sea surface and shoreline length oil polluted is included in the decision tree.

2.4.4 "Do nothing" decision tree

"Do nothing" is not an oil spill response method, but a no-action which may be the result of difficult operational conditions or oil spill of smaller sizes that may evaporate or disperse naturally within too short time for action. In some situations though, it may include booming of the oil spill or spread of absorption pads. Thus, "do nothing" as such is never recommendable.

The decision tree, thus, includes size of oil spill, degree of natural evaporation, and the summed values for organisms on the sea surface and on shoreline.

2.5 Interpretation and dissemination of SNEBA results (Box 5.1)

The output of the decision trees is the colours of traffic lights, which means:

Green - the oil spill response method may be an option to obtain an overall environmental benefit

Yellow - expert judgement is necessary to assess if the oil spill response method, at the end of the day, may be an option to obtain an overall environmental benefit (or reduce harm).

Red - the oil spill response method may not be an option to obtain an overall environmental benefit.

The SNEBA results hence indicate which oil spill response methods that may be beneficial for the environment in the different seasons, but do not compare the methods.

The results must be followed by the considerations done when going through the decision tress, so that the final conclusion are not just green, yellow, or red, but also a narrative. This dissemination should prevent the results not to be over simplified.

2.6 Abbreviations (Box 6.1)

A list of abbreviation used in the SNEBA is provided.

Table 2.1. Steps in a Strategic Net Environmental Benefit Analysis, with links to information boxes, matrices and decision trees for collection and compilation of data, information and scores.

Step title	Box	Decision tree
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		
Assumptions and criteria behind calculations of polluted areas / volumes	2.1	
Calculation of sea surface, seawater, seabed and shoreline contamination	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 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 Pollution (SP) with respect to in situ burning (ISB) as oil spill response method; distance to inhabitation, biology of concern on land and reduced albedo effect from disposition on ice	3.2	
Score system for Damage Reduction (DaR)	3.3	
Score system for contamination of sea surface, seawater, seabed and shoreline	3.4	
4) Analysis – by decision trees for each oil spill response methods and for each of the four seasons (spring, summer, autumn and winter)		
Mechanical recovery		DECISION TREE MR
Chemical dispersion		DECISION TREE CD
In situ burning (ISB)		DECISION TREE ISB
Do nothing		DECISION TREE DN
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	
6) Abbreviations	6.1	

3 SNEBA tool

3.1 Step 1 - Basic data and information

BOX 1.1 – DEFINITION OF ASSESSMENT AREA

SNEBA is an tool for decision makers nationally or cross-borderly for oil spill response planning, capacity building or contingency development. Hence, the assessment area must be defined in accordance with the objectives of the analysis.

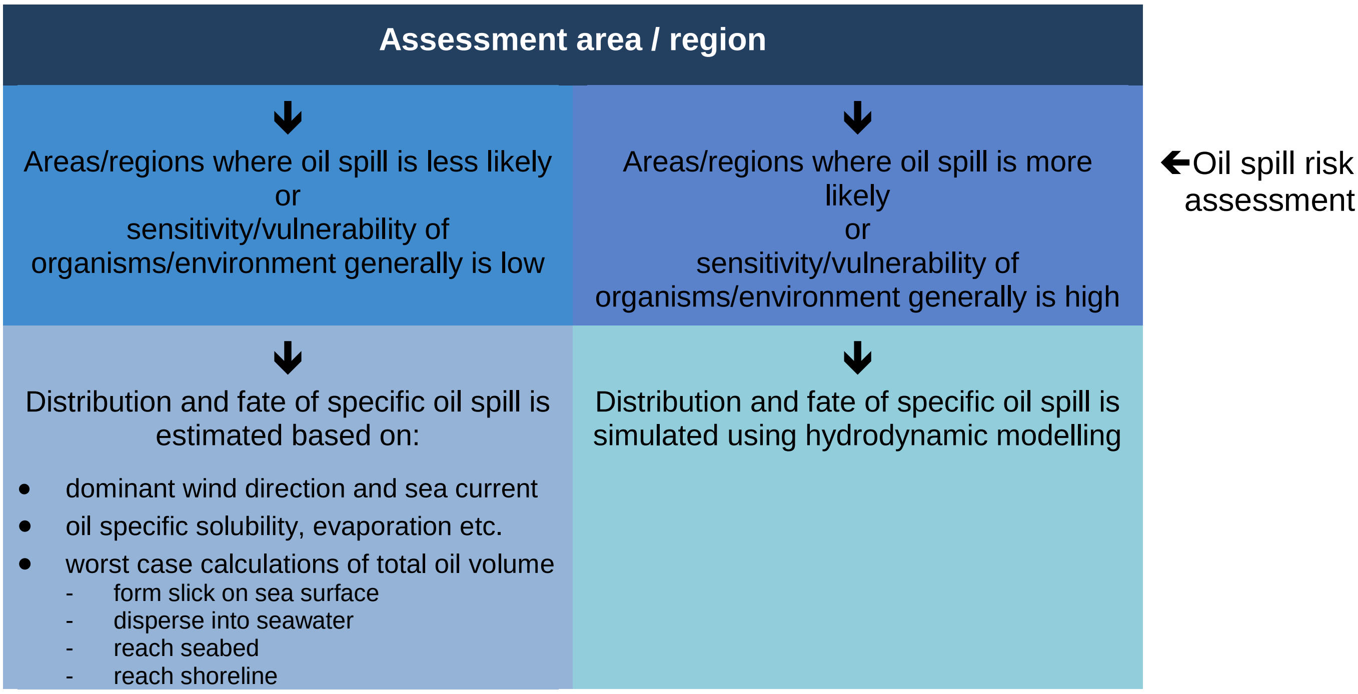
The area/region may possess natural limits, like in cases with enclosed seawater basins. Furthermore, if the area in question is defined in other respects, e.g., internationally within, e.g., Arctic Council, UN, considered a particular sensitive sea area (PSSA), or is designated important for wild life, etc., these borders may be respected and used for defining an assessment area.

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).

BOX 1.2 –DEFINITION OF OIL SPILL SCENARIOS

Aim of the oil spill scenarios is to understand the potential distribution, dispersion and fate of the spilled oil in the assessment areas/waterbody. Probability and size of oil pollution of the sea surface, the seawater, the seabed and the shoreline in the assessment area. In general, it is recommended that distribution, dispersion and fate of the oil in the environment is evaluated using hydrodynamic models that include sea currents, wind, bathymetry, density/salinity, weathering of the oil etc. 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:



The following basic parameters must be set for oil spill scenarios:

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

From the model simulations, the worst-case values are used for the further sNEBA process (BOX 2.2, Table 2.2.1).

1) Oil spill sites

Oil spill sites must be selected in order to cover the defined assessment sea area with respect heterogeneity in metocean data and biology.

2) Oil type

Oil types must be selected in order to cover realistic and/or actual activities in the assessment area. Each selected oil type must be characterized with respect to density, viscosity, and fraction of oil potential evaporated and soluble in water. In Table 1.2.1, default values are given for a suite of different oil types.

Table 1.2.1. Default characterization of a number of well-known oil types, including diesel, crude oils and heavy fuel oil types (HFOs).

Oil type	Density (kg/m3)	Viscosity (cP)	Fraction potential evaporate to air (%/hour)	Fraction potential soluble in seawater (%)
Crude oil -NAF				
Crude oil - ASPH				
Crude oil - xx				
IFO30				
IFO 180				

3) Size of oil spill

For worst-case scenarios from oil exploration/exploitation activities, blow-out oil volumes may be based on oil spill used in contingency planning of oil companies.

With regard to shipping, both transported oil volumes (crude oils) as well as fuel volumes should be considered. These volumes may be based on realistic carried volumes in the assessment area.

In Table 1.2.2, default oil spill sizes, rates and duration is given, which are based on oil cargo volumes and fuel oil volumes in Norway as well as oil spill modelling scenarios for oil exploration in Greenland. It should be noted that the largest oil spills in history, Macondo and Ictox were of volumes up to five times the volumes given as default. Hence, it must considered, if relevant, that the volumes/areas impacted by oil and toxic concentrations may be up to five times the modelled values.

Table 1.2.2. Default oil spill sizes, rates and duration.

	Oil tankers - cargo	Other vessels - fuel	Blow-out from offshore platforms
Volume			1000 MT
Rate			1000 MT/24 hours
Duration			28 days

4) Day and time of the year - seasons

For areas, with variating seasons, oil spill scenarios must cover all seasons or seasons of relevance. Seasons of relevance may be those seasons where there are activities from which an oil spill may occur. In ice-covered waters, oil exploration activities and shipping may potentially not be realistic, unless icebreakers are used.

5) Weather conditions

The weather conditions for the oil spill must be characteristic for the season including differences in wind and current. To achieve data for worst-case scenarios, model simulations must be run for a suite of weather conditions; calm and stormy weather, different wind directions, potential sea ice, etc.

6) Number of scenarios

An appropriate number of scenarios must be run for covering the heterogeneity of the area with respect to metocean data and biology at different time of the year.

BOX 1.3 – SELECTION CRITERIA FOR IDENTIFICATION OF SPECIES / ORGANISM GROUPS OF CONCERN IN THE ASSESSMENT AREA

For selection of species/organism groups of concern in the assessment area following criteria can be used:

- 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))
- Species considered sensitive to oil spill with regard to:
    - Sea surface (e.g., seabirds)
    - Pelagic species/organism groups (fish egg/fry, plankton, *Calanus* spp.)
    - Seabed (e.g., marine sponges, corals, benthic communities, seagrass beds)
    - Coast (Tidal communities, colonial seabirds)
- 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 (> 1 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.

BOX 1.4 - CHARACTERIZATION OF THE ASSESSMENT AREA'S SURROUNDINGS

To avoid impact from soot from in situ burning (ISB), distance to cities and residents (distance to inhabitation), wildlife and livestock (animal aggregations) must be determined in order to establish a safety zone.

Furthermore, as soot particles deposits on ice may reduce the reflective effect of ice, and hence lead to warming and melt of ice (reduced albedo effect), ice coverage for the assessment area per season must be estimated.

The distance between scenario sites and inhabitation / potential animal congregations may be obtained from measurements on digital maps or through a GIS (Geographic Information System) tool.

Prevailing wind direction may be obtained from metocean data used as input to the oil spill modelling simulations.

Table 1.4.1. Table for values of distance to inhabitation and animal aggregations from spill site, prevailing wind direction and ice coverage.

Distance from spill site to inhabitation (km)	Distance from spill site to animal aggregations (km)	Prevailing wind direction	Ice coverage (%)

BOX 1.5 – CHARACTERIZATION OF THE ASSESSMENT AREA AND WATER BODY

For the assessments and calculations included in the SNEBA, the assessment area must be a defined physical oceanographic unit with respect to estimations / calculations of relative impacted sea surface area, seawater volumes, seabed area and coastline from the oil spill scenarios (see Box 2.1).

Sea surface area of the waterbody of the assessment area (SSarea)

The sea surface area is used for calculation of the fraction of sea surface area polluted in relation to the entire sea surface area for the waterbody of the assessment area (see BOX 3.4).

The area of the assessment area may be defined by coastlines, depth/bathymetry, sill for fjords or other relevant borders.

The sea surface area of the assessment area (km^2) can be estimated by using digital maps (e.g., Google Earth) or through a GIS (Geographic Information System) tool.

Waterbody (WBvolume)

The waterbody volume of the assessment area is used for calculation of the fraction of seawater volume that is polluted with oil concentrations above "no effect" level toxicity for pelagic organisms in relation to the waterbody volume of the assessment area (see BOX 3.4).

Delimitation of (active) waterbody depth can be defined by, besides those already used for defining the assessment area, a termo- and/or halocline, or other hydrodynamic borders.

Seabed area of the waterbody of the assessment area (WBsba)

The seabed area is used for calculation of the fraction of seabed area polluted in relation to the entire seabed area of the waterbody in the assessment area (see BOX 3.4).

The seabed area of the assessment area (km^2) can be set as equal to sea surface area if seabed topography is not known. This will most likely be an underestimate of the seabed area, and hence lead to a conservative estimate of the fraction of the seabed potentially impacted from oil pollution.

Shoreline length
The shoreline length is used for calculation of the fraction of shoreline potential polluted by oil (see BOX 3.4).

Table 1.5.1. Characterization of the assessment area, physical parameters.

	Sea surface area (km^2)	**Water depth (m)**	**Seawater volume (km^3)**	**Seabed area (km^2)**	**Shoreline length (km)**
Min					
Max					
Mean					

Table 1.5.2. Characterization of waterbody. Physical and chemical parameters.

Season		**Depth of halocline/ thermocline (m)**	**Salinity (psu)**	**Oxygen levels in bottom water (mg/L)**	**Water temperature (°C)**
Spring	**Min.**				
	Max.				
Summer	**Min.**				
	Max.				
Autumn	**Min.**				
	Max.				
Winter	**Min.**				
	Max.				

BOX 1.6 – CHARACTERIZATION OF THE OIL TYPE(S) SELECTED FOR THE OIL SPILL SCENARIOS

Oil types selected for oil spill scenarios should include crude oil types if the objective of the SNEBA is oil exploration / exploitation activities or shipping route for transportation of crude oil. Fuel oil types should be included in case of shipping and hence credible fuel oil types for fuel should be included such as marine diesel and heavy fuel oil (HFO) types.

Characteristics of the oil types are inserted in Table 1.6.1.

Table 1.6.1. Oil types' physical characteristics.

Oil type/ Name	Density	Evaporation (%)	Viscosity	Fraction of the oil soluble in sea water

BOX 1.7 – ECOTOXICOLOGICAL DATA

Ecotoxicological data are necessary for evaluating impacts from untreated and treated oil on species / organism groups of concern, including toxicity of dissolved natural and chemical dispersed oil in seawater with respect to acute and chronic toxicity. The values for the median effective concentration (EC_{50}) and no effect concentration for the species or organism groups of concern are inserted in Table 1.7.1.

Effects of oil sheen or oil slick on sea surface on seabird feather structure and water uptake are included in table 1.7.2.

Default values obtained from literature are given for algae, crustaceans, mussels and fish. If more detailed information is available for the assessment area, these values should be used instead.

Table 1.7.1. Toxicity of dissolved, natural or chemical dispersed oil in seawater (acute toxicity/chronic toxicity).

Organism group	EC_{50} (mg THC/L)	No Effect Concentration (NEC) (mg THC/L)
Algae	10	4
Crustaceans	2	0,7
Mussels	2	1
Fish	12	2

Table 1.7.2. 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)

BOX 1.8 – DEFINITIONS OF OIL DISPERSION

Spilled oil at sea will usually stay on the sea surface as most oil types' density is less than seawater. For oil to disperse into the water column, energy in the system is needed to break the oil into smaller units (droplets), to be mixed with the seawater. Such energy may be provided naturally and mechanically. The dispersion process can be enhanced by using chemicals that break the oil into smaller droplets.

Natural dispersion

Natural dispersion of spilled oil into the sea is dependent of water mixing energy from currents, waves and tidal dynamics but also the physical characteristics of the oil types.

Oil broken into droplets of different sizes, and hence different buoyancies, will create a mixing layer. Laboratory experiments and theoretical calculations has estimated the depth of this mixing layer to be 1.5 times wave height (Tkalich & Chan 2002). Below the mixing layer, the oil concentration will decline gradually with water depth, but max. until 10 to 20 m's depth (Li et al. 2013).

Chemical dispersion

An oil slick can also be aided to disperse into the water column by adding chemicals (dispersants) that break the oil into smaller droplets. The oil droplets, however, is again dependent on mixing energy to disperse into the water column.

It is critical, that a sufficient degree of mixing energy and water exchange is available in the system for the oil to reach concentrations below toxic limits fast. In this way, the potential effects on pelagic organisms may be minimized and an overall environmental benefit from the dispersion operation can be obtained.

Mechanical dispersion (?)

Mechanical energy may be added to the system to enhance chemically dispersed oil, e.g., by thrusters. However, mechanical dispersion of oil may also be a result of the activities in connection with mechanical recovery of oil spill. The size of this (side?) effect, and potential environmental impact from the oil spill response activities, seems not to have been estimated.

BOX 1.9 – MODELS FOR OIL SPILL SIMULATIONS

Models for oil spill simulations may provide a wide range of information ranging from oil spill trajectory to chemical and physical fate of the oil, including change in density, viscosity, natural dispersion and fraction of oil soluble in seawater. This information is needed for later calculations of sea surface and seabed areas, seawater volumes and potential length of shoreline impacted by the oil spill.

An example of such a modelling tool, Seatrack Web, and the resulting data the simulations provide, are given below in Figure 1.9.1, 1.9.2 and 1.9.3. However, any other oil spill model may be used.

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 organisations. The model uses forecasted wind and current fields 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. The model handles a number of different oils, ranging from gasoline to asphalt. The Seatrack Web model includes state-of-the-art oil weathering algorithms for calculating evaporation, emulsification, density and viscosity of these oils over time. The results of a model simulation include oil trajectories, changes in the oil properties and the overall fate of the oil. Results of the model includes estimation of amount of the oil on sea surface, in seawater, on seabed and on shoreline over time, as well as values of evaporation, emulsification, density and viscosity of the oils. (http://www.helcom.fi/action-areas/response-to-spills/helcom-seatrackweb-and-oil-drift-modeling).

Oil spill trajectories

Seatrack Web model simulations includes drift/dispersion/fate of the oil in sea over time after the spill. The model will indicate if oil reach the seabed and/or shoreline. Note that in Figure 1.9.1-1.9.3, marine diesel will evaporate and naturally disperse before reaching the shoreline (Figure 1.9.1), while Statfjord crude oil (Figure 1.9.2) and the HFO IFO180 (Figure 1.9.3) reaches shoreline .

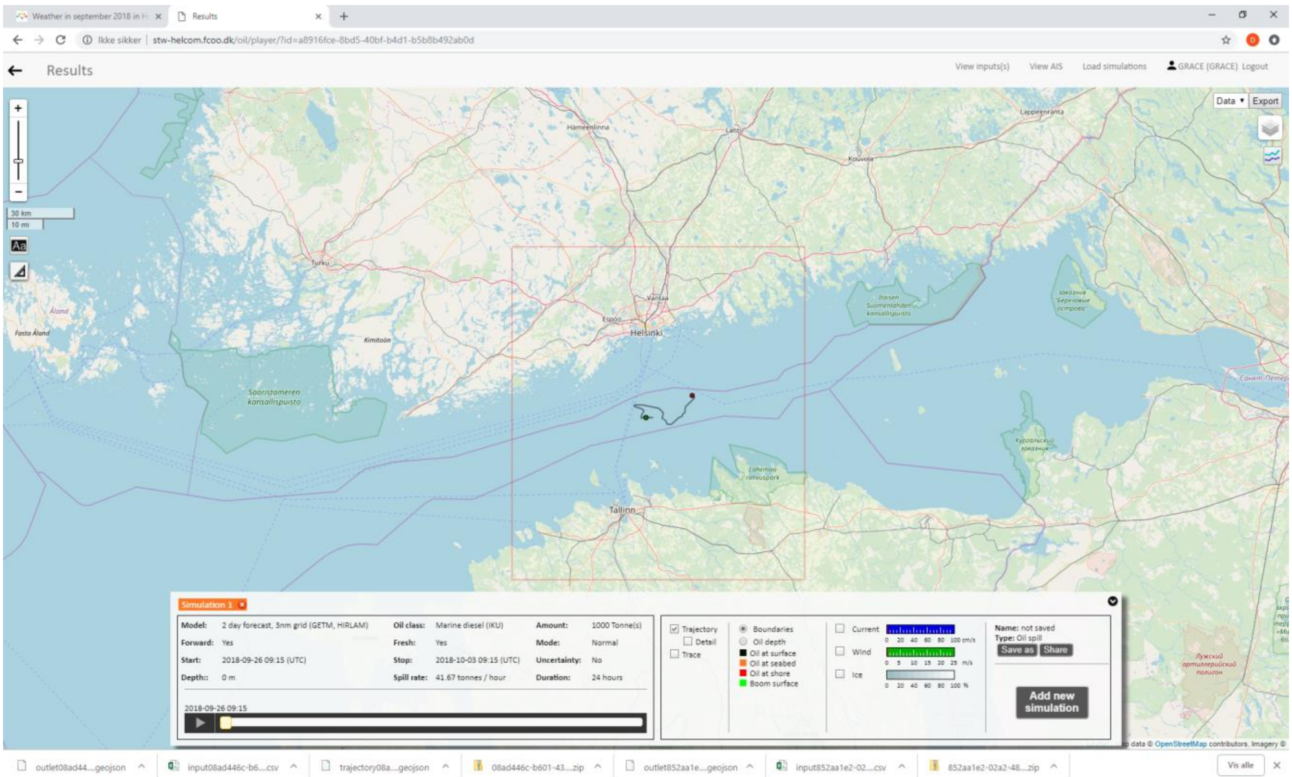


Figure 1.9.1. Seatrack Web: Simulation of drift/dispersion/fate of a spill of Marine diesel September 24-27, 2018.

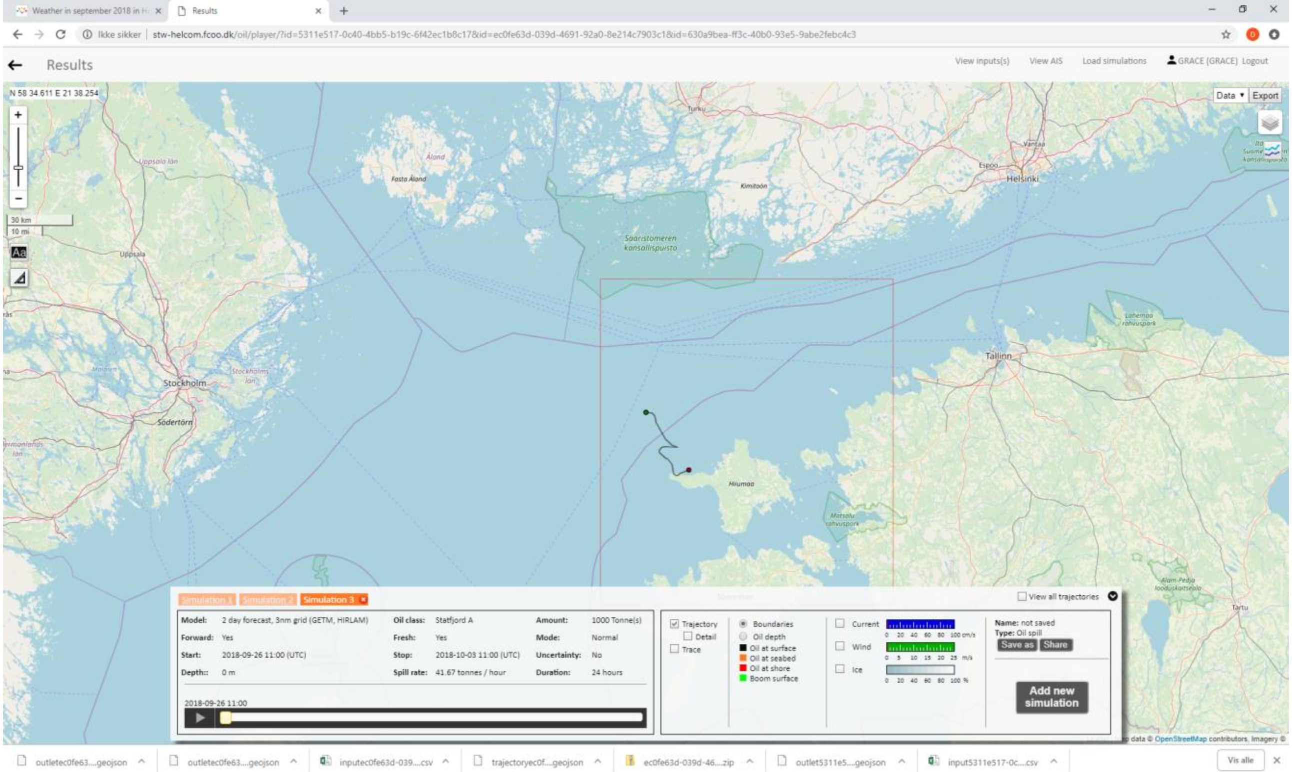


Figure 1.9.2. Seatrack Web: Simulation of drift/dispersion/fate of a spill of crude oil (Statfjord), September 24-27, 2018.

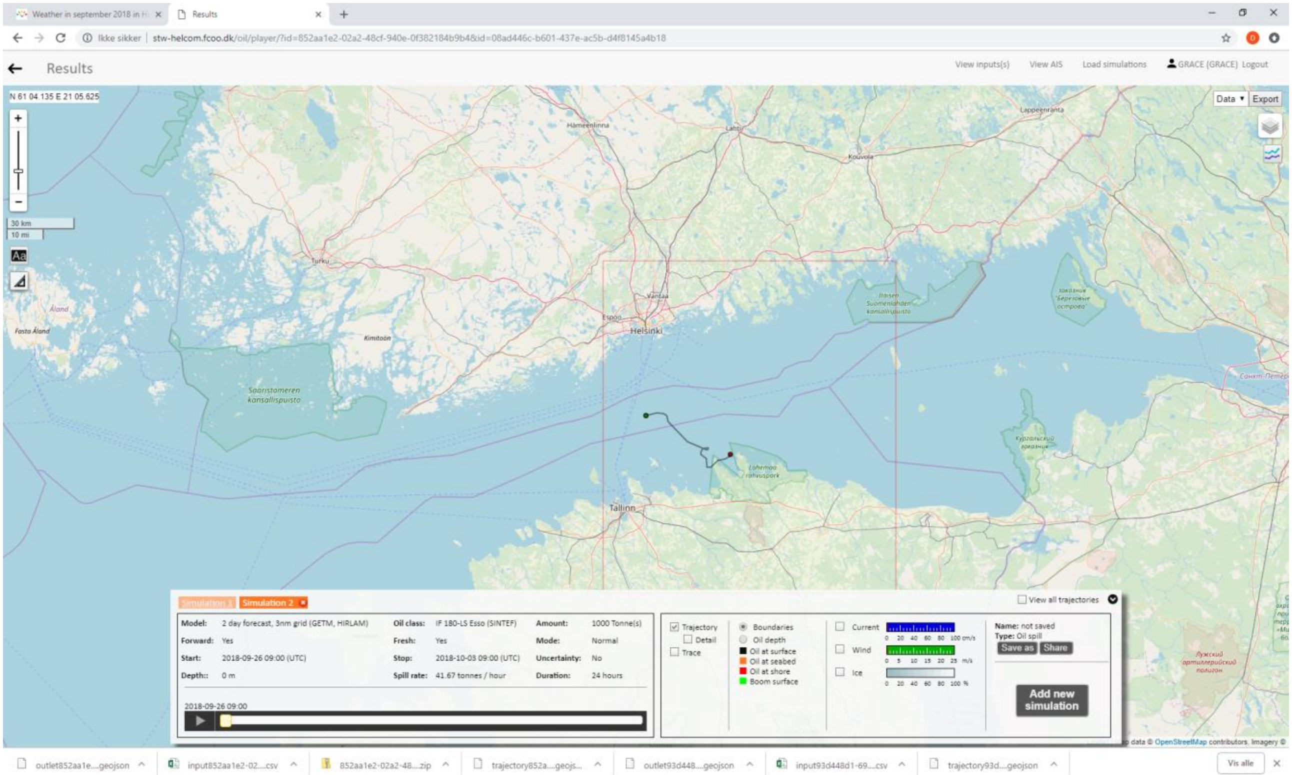


Figure 1.9.3. Seatrack Web: Simulation of drift/dispersion/fate of a spill of heavy fuel oil (IFO180), September 24-27, 2018.

Seatrack Web model results

In Table 1.9.1 and 1.9.2 result from Seatrack Web modelling for spill of 1000 m^3 marine diesel, HFO or crude oil is shown.

Table 1.9.1. 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

Table1.9.2. 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 simulations

Other oil spill simulation models exists and which, if available, may be used to provide the necessary input data for the calculations in Step 2 and 3. Also, models with even more detailed results of, e.g., chemically dispersion of oil and fate of the plume etc., may be available. Such models could be provided by e.g. ClimateLab in Denmark and SINTEF in Norway (Figure 1.9.4 and 1.9.5)..

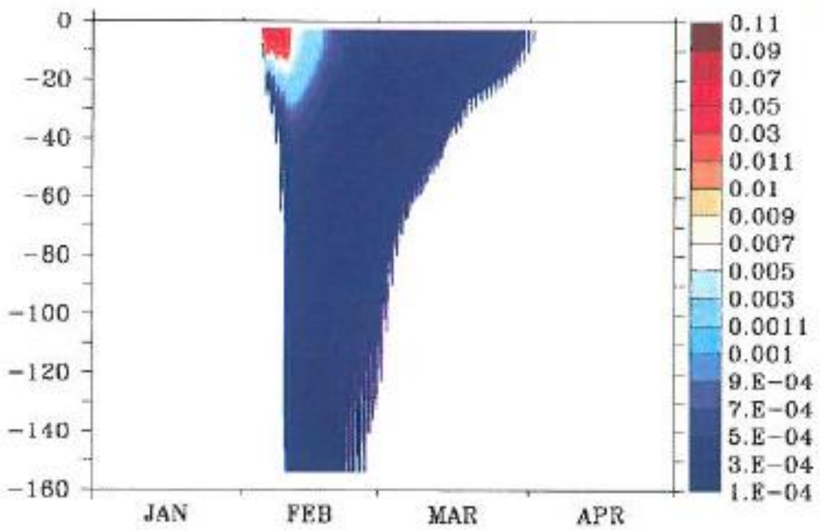


Figure 1.9.4. The vertical distribution of oil concentration with time, integrated over a period of 4 months, for simulated chemically dispersed oil. 6000 T oil released over 6 days. ClimateLab (2015).

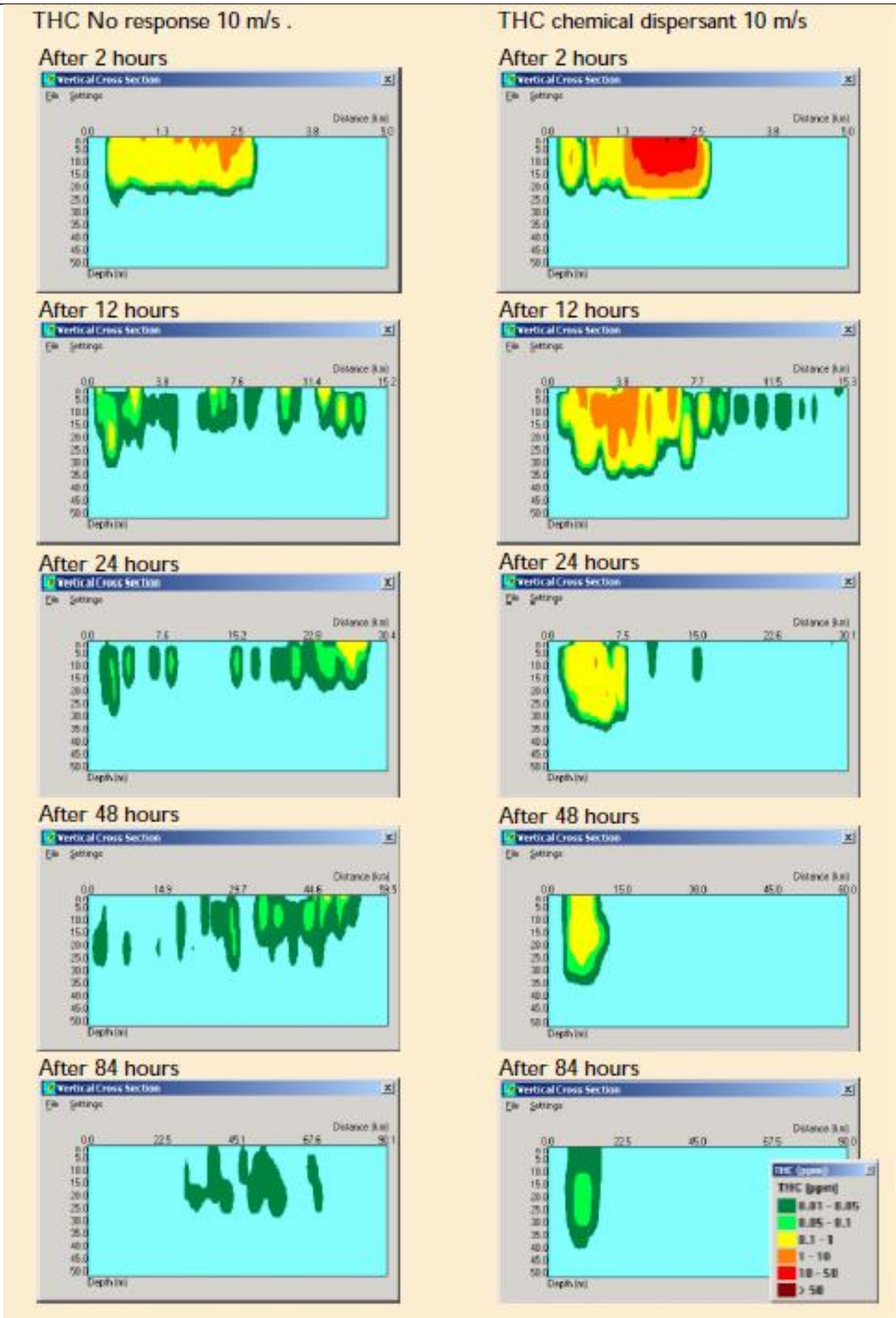


Figure 1.9.5. Naturally (left column) and chemically (right column) dispersed oil distribution and dilution with time. Oil on the surface is not shown in the figure. Fra Lewis & Daling (2001).

3.2 Step 2 - Assessments

BOX 2.1 – ASSUMPTIONS AND CRITERIA BEHIND CALCULATIONS OF POLLUTED AREAS / VOLUMES

In this box the assumptions and criteria behind calculations of polluted areas/volumes are given. For the calculations, see BOX 2.2.

The amount of oil used for further calculations of sea surface, seawater, seabed and shoreline oil pollution (BOX 2.2) is the resulting volumes after 3 days oil spill modelling simulation run. It is assumed that the window of opportunity for the oil spill methods under prevailing weather conditions will be open within this time interval. However, other time intervals of modelling could be used if it is considered more relevant for the specific SNEBA case. It is also assumed, as a rule of thumb, that 90% of the oil will cover 10% of the area and 10% of the oil will cover 90% of the area polluted. The slick thickness is set to:

- 10 % of the oil polluted area has an oil slick thickness of 30 mm
- 90 % of the oil polluted area has an oil slick thickness of 3 mm.

Sea surface pollution (SSP)
For calculating the potential sea surface area polluted with an oil slick of a thickness that may harm / change seabird feather structure, the threshold limit is set to 0.1 μm as default herein (Table 1.7.2). The 0.1 μm threshold value is based on literature values (see BOX 1.7).

3 μm oil sheen/slick thickness is considered the threshold value for risk of uptake of seawater in seabird feathers (Table 1.7.2) and also based on literature values (See BOX 1.7).

The calculations include 90 % of the polluted sea area with the 10 % of the surface oil amount, and which is considered to be homogenous distributed on the sea surface.

Seawater pollution (SWP)
The calculations of seawater pollution from dispersed oil include both naturally and chemically dispersed oil.

For calculating the potential volume of seawater polluted with oil concentrations above No Effect Concentration (NEC) or EC_{50} for acute and chronical toxic effects for pelagic organisms, 0.7 mg / L has been selected as default threshold value herein. The 0.7 mg/L threshold value is based on Crustaceans (Table 1.7.1) being most sensitive to oil pollution and having the lowest limit for no effect concentration (NEC). However, if more detailed and specific data are available for the assessment areas organism(s) of concern for each spatial compartment and season, these should be used for the calculations.

The amount of naturally dissolved and dispersed oil or only chemical dispersed oil in the seawater used in the calculations is oil spill model simulation results after 3 days run.

For calculating the area of sea surface that covers the seawater with these oil concentrations above NEC, the depth of the dispersed oil plume is set to 15 m as default herein. The 15 m depth limit is based on the rule of thumb, that the mixing layer of the sea is 1.5 times wave height, which results in max. depth of the mixing layer of 10-20 m (see also BOX 1.8).

If more detailed and specific model results are available for the depth of dispersed oil in the assessment area, these results should be used for the calculations.

Seabed pollution (SBP)
For calculating the potential area of seabed polluted by the oil volume reaching the seabed it is assumed that the seabed is polluted with 1 litre of oil per square meter seabed, corresponding to a deposition of 1 mm oil on the polluted seabed (French and Payne 2001).

The oil volume reaching the seabed is found from the oil spill simulations after 3 days of run.

Shoreline pollution (SLP)
For calculatiing the potential length of shoreline polluted, it is assumed that the shoreline is polluted with 1 litre of oil per meter shoreline (French and Payne 2001).

The oil volume reaching the shoreline is found from the oil spill simulations after 3 days of run.

BOX 2.2 - CALCULATIONS OF SEA SURFACE, SEAWATER, SEABED, AND SHORELINE POLLUTION

Based on the oil spill model simulations and the assumptions given in BOX 2.1 the sea surface, seawater, seabed and shoreline pollutions are calculated as described below.

The oil spill values used in the below calculations are worst case values, which are gathered from oil spill simulations of each oil type as presented in Table 1.9.1 and 1.9.2, and to be compiled in Table 2.2.1. The length of the scenarios is suggested to be 3 days as explained in BOX 2.1.

Table 2.2.1. Values from oil spill scenario model simulations. The worst-case values are gathered and used for the calculations below.

Scenario simulation results Oil type:	**Oil on sea surface (m^3)**	**Oil in seawater (m^3)**	**Oil on seabed (m^3)**	**Oil on shoreline (m^3)**	**Evaporated (%)**
Scenario 1					
Scenario 2					
Scenario…					
Worst-case scenario values					

Calculation of area with oil contamination on sea surface with a slick thickness that may damage seabird feather structure

Calculation for estimating the potential sea surface area that may be polluted to a level of damaging effect on seabird feather structure. 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. For the rationale behind these assessments, see BOX 2.1.

(1) Polluted area of sea surface (km^2) = oil on sea surface (m^3) $\times$ 0,1 µm / 0,000001 m / 1000000

Input to equation (1) can be obtained from Table 2.2.1.

The results from calculations of the area of sea surface polluted for the selected scenarios of relevance should be inserted in Table 2.2.2.

Table 2.2.2. Polluted area of sea surface calculated from the oil spill scenarios worst-case values and for different oil types.

	Oil on sea surface (m^3) (from Table 2.2.1)	**Least oil slick thickness that damage seabird feather structure (µm)**	**Area sea surface polluted (km^2)**
Oil type 1		0,1	
Oil type 2		0,1	
Oil type ...		0,1	

Calculation of polluted seawater volume

Calculating the potential polluted volume of seawater in concentrations above No Effect Concentration (NEC) for acute and chronic toxic effects should be completed for both dissolved and natural dispersed oil and for chemically dispersed oil only. It is assumed that the depth of the dispersed oil reaches 15 m (for the rationale behind this assessment, see BOX 2.1.), but more specific data obtained from oil spill modelling simulations may serve as more robust input.

Please note that volumes for both naturally dispersed oil and for chemically dispersed oil must be obtained for the decision trees for ”Do Nothing” and ”Dispersants”, respectively.

The length of the scenarios is suggested to be 3 days as explained in BOX 2.1.

(2) Polluted seawater volume at toxic concentrations (m^3) = naturally or chemically dispersed oil amount (m^3) / EC_{50} or NEC (0.7 mg/l) $\times$ 1000

(3) Sea surface area with polluted seawater down to 15 m (m^2) = naturally or chemically dispersed oil amount (m^3) / EC_{50} or NEC (0.7 mg/l) × 1000 / depth of dispersed plume (15 m)

Data for input to the equations (2) and (3) for natural dispersion can be obtained from Table 2.2.1, and input for chemically dispersed oil is the total amount of oil from the oil spill scenarios (e.g., 1000 T). Assuming that the chemical dispersion process is successful.

If the oil amount is given in tonnes, conversion to volume (m^3) must include the difference in density of the oil type. Conversion factor, as a rule of thumb, from tonne of oil to volume is 0.95 kg/m^3.

For the toxic effect concentration level, mg/l is converted to g/1000 l = g/m^3.

The values for naturally dispersed oil are inserted in Table 2.2.3, and for chemically dispersed oil in Table 2.2.4.

Table 2.2.3. Values for seawater volumes with dissolved or naturally dispersed oil concentrations above EC_{50} or No Effect (NEC) and sea area with seawater with toxic concentrations down to 15 m's depth from natural dispersion.

	Dissolved or natural dispersed oil in seawater (m^3)	**Lowest EC_{50} or NEC for aquatic organisms (mg/l)**	**Seawater volume potentially polluted at a toxic level (m^3) from natural dispersion**	**Sea area with potential oil concentration above levels for toxic effects to 15 m's depth from natural dispersion**
Oil type 1		0,7		
Oil type 2		0,7		
Oil type ...		0,7		

Table 2.2.4. Values for seawater volumes with chemically dispersed oil concentrations above EC_{50} or No Effect (NEC) and sea area with seawater with toxic concentrations down to 15 m's depth from chemical dispersion.

	Chemically dispersed oil in seawater (m^3)	**Lowest EC_{50} or NEC for aquatic organisms (mg/l)**	**Seawater volume potentially polluted at a toxic level (m^3) from chemical dispersion**	**Sea area with potential oil concentration above levels for toxic effects to 15 m depth from chemical dispersion**
Oil type 1		0,7		
Oil type 2		0,7		
Oil type ...		0,7		

Calculation of polluted seabed area

Calculations for estimating the potential area of the seabed polluted by the oil that reaches the seabed is as described below. The length of the scenarios is suggested to be 3 days as explained in BOX 2.1. In the calculations it 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. For the rationale behind this assessment, see BOX 2.1.

(4) Area of potentially polluted seabed (m^2) = volume of oil on seabed (m^3) x 1000/1

(5) Area of potentially polluted seabed (km^2) = volume of oil on seabed (m^3) x 1000/1/1000000

Data for input to the equations (4) and (5) can be obtained from Table 2.2.1.

The values are inserted in Table 2.2.5.

Table 2.2.5. Values for seabed area (given as m^2 and km^2) potentially affected by oil contamination.

	Oil on seabed (m^3)	**Seabed area potentially affected (m^2)**	**Seabed area potentially affected (km^2)**
Oil type 1			
Oil type 2			
Oil type ...			

Calculation of distance of oil polluted shoreline

Calculations for estimating the potential length of coastline polluted by the oil in the sea surface is as described in the following. The length of the scenarios is suggested to be 3 days as explained in BOX 2.1. For the calculation of shoreline polluted, it is assumed that it is polluted with 1 litre of oil per square meter coast. For the rationale behind this assessment, see BOX 2.1.

(6) Length of potentially polluted shoreline (m) = volume of oil on shoreline (m^3) x 1000/1
(7) Length of potentially polluted seabed (km) = volume of oil on seabed (m^3) x 1000/1/1000

Data for input to the equations (6) and (7) can be obtained from Table 2.2.1.

The values are inserted in Table 2.2.6.

Table 2.2.6. Values for shoreline length (given as m and km) potentially affected by oil contamination.

	Oil Shoreline (m^3)	**Shoreline polluted (m)**	**Shoreline polluted (km)**
Oil type 1			
Oil type 2			
Oil type ...			

All values for contamination of sea surface, seawater, seabed and shoreline are gathered in Table 2.2.7.

In Table 2.2.7 all the values from Table 2.2.1-2.2.6 to be used in the score calculations and in the decision trees are compiled.

Table 2.2.7. Compilation of values for contamination of sea surface, seawater, seabed and shoreline.

Potential **area** of sea **surface** affected by oil spill (**m^2**)	SSa	
Potential **volume** of seawater affected by concentration of oil above EC50 or NEC (**m^3**) from dissolved and *naturally* dispersed oil	SWvn	
Potential **volume** of seawater affected by concentration of oil above EC50 or NEC (**m^3**) from *chemically* dispersed oil	SWvc	
Sea **area** with potential oil concentration above levels for toxic effects to **15 m** depth from dissolved and *natural dispersion* (**m^2**)		
Sea **area** with potential oil concentration above levels for toxic effects to **15** m depth from *chemical dispersion* (**m^2**)		
Potential **area** of **seabed** affected by the oil spill (**m^2**)	SBa	
Potential **area** of **seabed** affected by the oil spill (**km^2**)	SBa	
Potential **length** of shoreline polluted by the oil spill (**m**)	SLl	
Potential **length** of shoreline polluted by the oil spill (**km**)	SLl	

BOX 2.3 - EVALUATION OF OXYGEN CONDITIONS

When oil is dispersed into the water column, the oil plume is expected to dilute (BOX 1.8) and eventually degrade naturally.

Microbial degradation of naturally and chemically dispersed oil is oxygen consuming and if it leads to oxygen depletion it may harm pelagic, demersal and benthic organisms. Hazen et al. (2010) identified a plume of oil in app. 1 km depth after the Macondo blow-out in the Gulf of Mexico in 2010. This was based on a significant oxygen consumption revealed in vertical oxygen profiles of the waterbody (together with identification of an oil degrading microbial flora in the same depth).

Therefore, to obtain the expected biodegradation of dispersed oil without oxygen depletion in the waterbody, oxygen concentrations in the waterbody must be high enough to facilitate biodegradation of the potential volume of dispersed oil without becoming depleted.

The rate of biodegradation of oil may depend on several other factors, e.g., oil type, temperature (season, depth), nutritional conditions, stratification of water masses and presence of oil degrading microbial flora (see BOX 2.4) (Wegeberg et al. 2018, Vergeynst et al. (2018)).

If oxygen is naturally depleted in the bottom water during specific seasons, oxygen may also become depleted in another season from biodegradation of oil.

Hence, the fraction of seawater volume polluted with oil concentrations above “no effect” levels must be low (<5 (10)%), (Table 1.5.1), as the oxygen conditions are not considered to be sufficient to facilitate biodegradation of the potential dispersed oil without the environment becoming depleted. This situation is indicated as O_2 conditions = 0 (see BOX 3.4).

If oxygen conditions are expected to be sufficient to support natural degradation of dispersed oil also in the bottom water (Table 1.5.1), and which consumption is not considered to result in oxygen depleted conditions, a higher fraction of seawater volume with oil contamination may be accepted (<10(20)%). This is indicated as O_2 conditions > 0 (see BOX 3.4). Thus, O_2 conditions > 0, requires that oxygen is not depleted in the entire water body of the assessment area in any season.

BOX 2.4 - EVALUATION OF NATURAL BIODEGRADATION POTENTIAL

Rate of biodegradation of dispersed oil depend on presence of a microbial flora adapted to oil degradation among other factors such as oil type, oxygen conditions (see BOX 2.3), temperature (season, depth), nutritional conditions and stratification of water masses (Hazen et al. 2010, Vergeynst et al. (2018)).

If oil degrading microorganisms are present, and have the potential to instantly bloom in connection with a surplus of oil to the environment from, e.g., an oil dispersion operation, the potential for degradation of such an oil plume is much higher than if poor microbial adaptation to oil degradation is present (Hazen et al. 2010, Vergeynst et al. 2018).

Therefore, a higher fraction of seawater volume with oil contamination levels above “no effect” concentration for toxicity to pelagic organisms (see BOX 3.4) may be accepted (<20 (30) %) if also oxygen conditions are sufficient (see BOX 2.4 and BOX 3.4).

However, the presence of an oil degrading microbial flora must be well-known and documented for the waterbody of the assessment area for this higher fraction to be accepted. Like for the Gulf of Mexico, where natural seeps of oil sustain an natural oil degrading microbial flora (Hazen et al. 2010) as oppose to Greenland, where only a poor microbial adaption of oil degradation has been observed so far (Kristensen et al. 2015, Vergeynst et al. 2018).

Aerobic microbial degradation is only included here as anaerobic microbial degradation of oil is considered insignificant (Wegeberg et al. 2018).

Nutritional conditions, including N and P limitations should also be considered.

BOX 2.5 – DESCRIPTION AND ESTIMATION OF THE OIL SPILL RESPONSE TECHNOLOGY EFFICIENCY

Mechanical recovery

Mechanical recovery consist of a wide range of different physical methods all with the overall purpose of collecting and removing (skimming, pumping) the oil directly from the water surface. By this method, the oil is removed from the water surface and the side effects are expected to be the increased oil dispersion forced by the activity during the mechanical recovery, the activity itself and possible oil escaping from the containment.

The containment of the oil is typically completed by use of containment booms. In certain situation with pack ice in the range of 50-90 % the ice can function as the containment.

The removing of the oil from the surface is completed by use of some kind of skimmer system (brush, drum etc.) followed by pumping of the oil/oil-in-water emulsion to a storage tank on the response vessel.

The limitation of the method is the capacity of the booms, oil-water ration of the skimmer, storage capacity and vessel capacity etc. (e.g. see http://www.ipieca.org/resources/good-practice/at-sea-containment-and-recovery/ for more details).

The efficiency of the method varies a lot depending on the specific spill situation. However, often mechanical recovery for spill in open water is reported as less than 15 % of the oil volume and most often less than 5 % of the oil (EPPR 1998). In a recent report (**http://neba.arcticresponsetechnology.org/report/chapter-4/42/423/**) it is suggested to equate mechanical recovery with natural removal (do nothing) due to these low efficiencies.

IPIECA (http://www.ipieca.org/resources/good-practice/at-sea-containment-and-recovery/) suggest a recovery efficiency between 5 and 20 % of the oil initially spilled oil volume. The report base these numbers on three different oil spills:

- MV Erika, tanker spill, 1999. Approximately 6 % of the initially spilled oil
- Montara incident, well blow out, 2009. Approximately 10 % of the initially spilled oil
- Deepwater Horizon, the Macondo incident, well blowout, 2010. Approximately 4 % of the oil.

Some of these numbers are also affected by priority in response operation and weather conditions.

It is suggested to use 10 % as a measure for the mechanical recovery efficiency (Box 3.3).

Chemically dispersion

Dispersion is a process where the natural dispersion of oil into the water column is increased by application of a chemical dispersant. Various products exists, with different formulas adapted to different oil types, salinities, temperatures etc.

Thus, by this method the oil is removed from the surface. The side effects from chemical dispersants are related to the increased toxicity in the water column (typically the upper 10 m of the water column, IPIECA) from the oil and dispersant.

In the assessment of the dispersion efficiency, it is assumed that the selected chemical dispersant are able to disperse the oil and that the application is done within the window of opportunity of the dispersability of the oil.

In situ burning

In situ burning can be an effective measure in rapidly removing large quantities of oil from water surface. From field trials, it has been found that 80-95 % of the oil is burned and converted to primarily CO_2 and water. The rest, is converted into particulates (soot) and a residue (combustion products) that remain in the marine environment (might sink). In situ burning seems well suited to Arctic conditions and the presence of ice as the ice can keep the oil from reaching water (burning oil on ice) or limit the spreading of the oil on water (burning thick patches of oil on water contained among ice formations) (http://neba.arcticresponsetechnology.org/report/chapter-4/42/423/).

BOX 2.6 – ASSESSMENT OF ENVIRONMENTAL PROS AND CONS OF THE OIL SPILL RESPONSE TECHNOLOGIES

As part of the strategic net environmental benefit analysis, pros and cons of the oil spill response technologies included must be assessed for each spatial compartment and season. This include, as indicated in the SNEBA conceptual model (Figure 2.6.1), that all biological information regarding oil ecotoxicology and sensitivity as well as biodiversity, production and ecosystem should be included in the analysis.

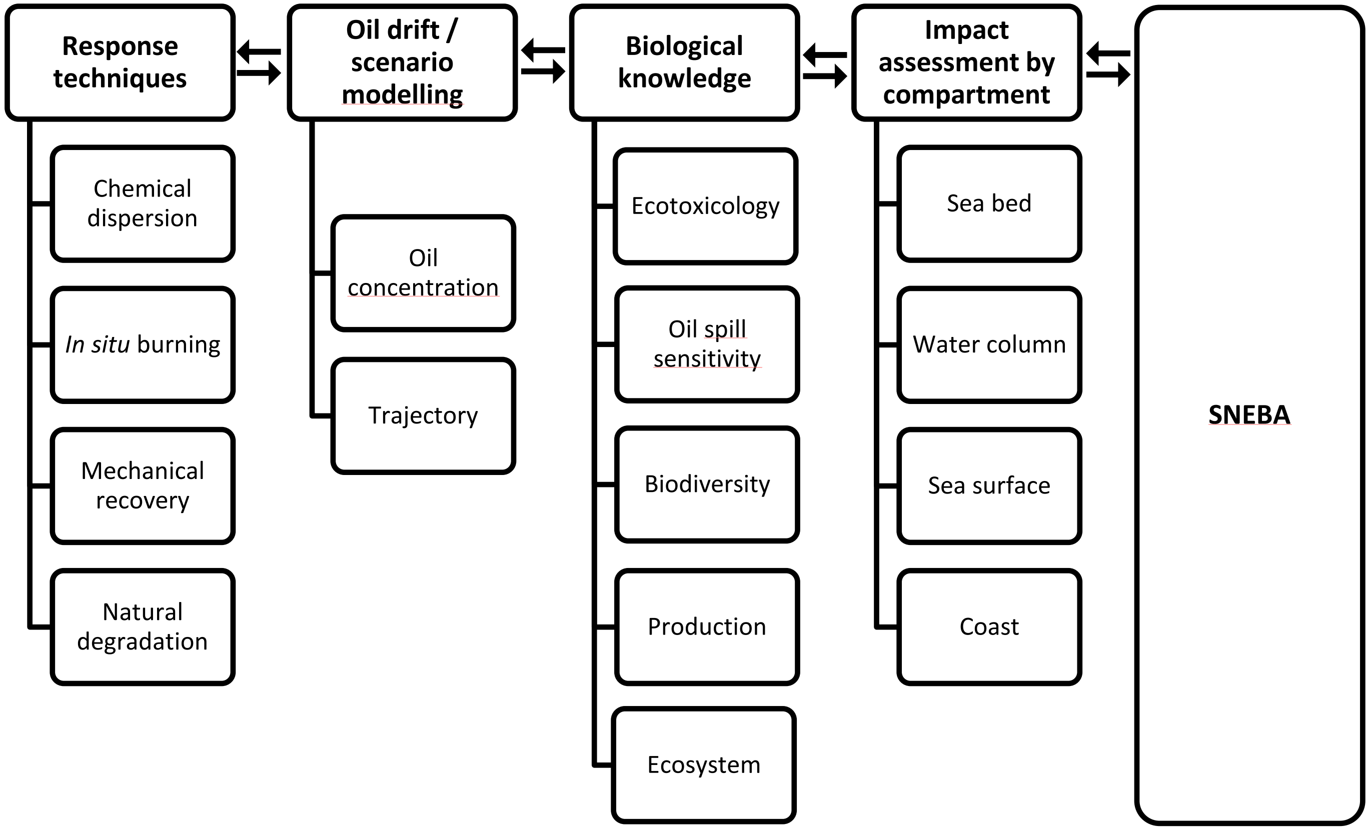


Figure 2.6.1. Conceptual model for the Strategic Net Environmental Benefit Analysis (SNEBA). For each oil spill response technique and based on oil spill scenarios for oil drift and oil concentration in seawater, pros and cons are assessed for each spatial compartment based on biological knowledge such as biodiversity, production (e.g., hot spots), ecosystem (cascade effects) as well as oil spill sensitivity and ecotoxicological data. All information feed into the SNEBA, which results indicate if the environment will benefit from a specific oil spill response method or not.

Default pros and cons of response technologies presented in Table 2.6.1-2.6.4 are based on references listed below. Please be aware that this information may be updated with time, and thus present-day literature should be consulted at all times.

Table 2.6.1. Default pros and cons of mechanical recovery as response method assessed from literature based on references in Wegeberg et al (2017).

		Sea surface (ss)		Seawater (sw)		Seabed (sb)		Shoreline (sl)	
		Pros	**Cons**	**Pros**	**Cons**	**Pros**	**Cons**	**Pros**	**Cons**
Mechanical recovery	Spring	Oil is removed from the environment	Smother and toxic effects from non-recovered oil	Oil is removed from the environment	Dispersion forced by mechanical activities	Oil is removed from the environment	In more shallow areas oil may reach seabed fauna from mechanical activities	Oil is removed from the environment	Low efficiency may allow oil to reach coast. Risk for effects on growth and reproduction
	Summer	Oil is removed from the environment	Smother and toxic effects from non-recovered oil	Oil is removed from the environment	Dispersion forced by mechanical activities	Oil is removed from the environment	In more shallow areas oil may reach seabed fauna from mechanical activities	Oil is removed from the environment	Low efficiency may allow oil to reach coast. Risk for effects on growth and reproduction
	Autumn	Oil is removed from the environment	Smother and toxic effects from non-recovered oil	Oil is removed from the environment	Dispersion forced by mechanical activities	Oil is removed from the environment	In more shallow areas oil may reach seabed fauna from mechanical activities	Oil is combated offshore	Low efficiency may allow oil to reach coast. Risk for effects on growth and reproduction
	Winter	Oil is removed from the environment	Smother and toxic effects from non-recovered oil	Oil is removed from the environment	Dispersion forced by mechanical activities	Oil is removed from the environment	In more shallow areas oil may reach seabed fauna from mechanical activities	Oil is combated offshore	Low efficiency may allow oil to reach coast. Risk for effects on growth and reproduction

Table 2.6.2. Default pros and cons of dispersants as response method assessed from literature based on references in Wegeberg et al (2017).

		Sea surface (ss)		Seawater (sw)		Seabed (sb)		Shoreline (sl)	
		Pros	Cons	Pros	Cons	Pros	Cons	Pros	Cons
Dispersion	Spring	Oil is removed from sea surface	Impact from dispersant on feather structure Increased combined effects on feather structure from oil+dispersant	Dilution below toxic concentrations. Potential increase of degradation rate	Oil is not removed from environment. Potential toxic oil concentrations. Chemicals are added to the effect of oil => cocktail effects of dispersant+oil. Uptake of oil droplets. O_2 consumption	Potential increase of degradation rate	In more shallow areas dispersed oil may reach the sea bed fauna in toxic concentrations	Oil is combated offshore	In more shallow areas dispersed oil may affect kelp and associated fauna
	Summer	Oil is removed from sea surface	Impact from dispersant on feather structure Increased combined effects on feather structure from oil+dispersant	Dilution below toxic concentrations Potential increase of degradations rate	Oil is not removed from environment Potential toxic oil concentrations Chemicals are added to the effect of oil + cocktail effects of dispersant+oil Uptake of oil droplets O_2 consumption	Potential increase of degradations rate	In more shallow areas dispersed oil may reach the sea bed fauna in toxic concentrations	Oil is combated offshore	In more shallow areas dispersed oil may affect kelp and associated fauna
	Autumn	Oil is removed from sea surface	Impact from dispersant on feather structure Increased combined effects on feather structure from oil+dispersant	Dilution below toxic concentrations Potential increase of degradations rate	Oil is not removed from environment Potential toxic oil concentrations Chemicals are added to the effect of oil + cocktail effects of dispersant+oil Uptake of oil droplets	Potential increase of degradations rate	In more shallow areas dispersed oil may reach the sea bed fauna in toxic concentrations		In more shallow areas dispersed oil may affect kelp and associated fauna
	Winter	Oil is removed from sea surface	Impact from dispersant on feather structure Increased combined effects on feather structure from oil+dispersant	Dilution below toxic concentrations Potential increase of degradations rate	Oil is not removed from environment Potential toxic oil concentrations Chemicals are added to the effect of oil + cocktail effects of dispersant+oil Uptake of oil droplets	Potential increase of degradations rate	In more shallow areas dispersed oil may reach the sea bed fauna in toxic concentrations		In more shallow areas dispersed oil may affect kelp and associated fauna

Table 2.6.3. Default pros and cons of in situ burning (ISB) as response method assessed from literature based on references in Wegeberg et al (2017).

		Sea surface (ss)		Seawater (sw)		Seabed (sb)		Shoreline (sl)	
		Pros	Cons	Pros	Cons	Pros	Cons	Pros	Cons
ISB	Spring	Oil is removed from sea surface Acute toxic volatile oil compounds are combusted	Smoke and soot deposition Burning residues Hazardous compounds; dioxin, PAHs	Acute toxic water soluble oil compounds are combusted	Residues (potentially sinking) and particles from combustion	Oil volume reduced and removed from the environment	Uptake of sinking residues and water surface deposited particles from combustion by, e.g., filtration Covering thallus surface may inhibit photosynthesis	Oil is removed from the environment	Floating residues may reach the coast and leak toxic compounds
	Summer	Oil is removed from sea surface Acute toxic volatile oil compounds are combusted	Smoke and soot deposition Burning residues Hazardous compounds; dioxin, PAHs	Acute toxic water soluble oil compounds are combusted	Sinking residues and particles from combustion	Oil volume reduced and removed from the environment	Uptake of sinking residues and water surface deposited particles from combustion by, e.g., filtration Covering thallus surface may inhibit photosynthesis	Oil is removed from the environment	Floating residues may reach the coast and leak toxic compounds
	Autumn	Oil is removed from sea surface Acute toxic volatile oil compounds are combusted	Smoke and soot deposition Burning residues Hazardous compounds; dioxin, PAHs	Acute toxic water soluble oil compounds are combusted	Sinking residues and particles from combustion	Oil volume reduced and removed from the environment	Uptake of sinking residues and water surface deposited particles from combustion by, e.g., filtration Covering thallus surface may inhibit photosynthesis	Oil is combated offshore	Floating residues may reach the coast and leak toxic compounds
	Winter	Oil is removed from sea surface Acute toxic volatile oil compounds are combusted	Smoke and soot deposition Burning residues Hazardous compounds; dioxin, PAHs	Acute toxic water soluble oil compounds are combusted	Sinking residues and particles from combustion	Oil volume reduced and removed from the environment	Uptake of sinking residues and water surface deposited particles from combustion by, e.g., filtration Covering thallus surface may inhibit photosynthesis	Oil is combated offshore	Floating residues may reach the coast and leak toxic compounds

Table 2.6.4. Default pros and cons of using no measures in case of an oil spill ("Do nothing") assessed from literature based on references in Wegeberg et al (2017).

		Sea surface (ss)		Seawater (sw)		Seabed (sb)		Shoreline (sl)	
		Pros	**Cons**	**Pros**	**Cons**	**Pros**	**Cons**	**Pros**	**Cons**
Do nothing	Spring	Some oil types may evaporate and/or naturally degrade relatively fast	Oil smother Toxic effects	Buoyant and surface drifting oil slick may not affect water column organisms	Toxic concentrations from natural dispersion	Buoyant and surface drifting oil slick may not affect seabed organisms	In more shallow areas untreated oil may smother seabed fauna		Smother and toxic effects on organisms
	Summer	Some oil types may evaporate and/or naturally degrade relatively fast	Oil smother Toxic effects	Buoyant and surface drifting oil slick may not affect water column organisms	Toxic concentrations from natural dispersion	Buoyant and surface drifting oil slick may not affect seabed organisms	In more shallow areas untreated oil may smother seabed flora and fauna		Smother and toxic effects on organisms
	Autumn	Some oil types may evaporate and/or naturally degrade relatively fast	Oil smother Toxic effects	Buoyant and surface drifting oil slick may not affect water column organisms	Toxic concentrations from natural dispersion	Buoyant and surface drifting oil slick may not affect seabed organisms	In more shallow areas untreated oil may smother seabed flora and fauna		Smother and toxic effects on organisms
	Winter	Some oil types may evaporate and/or naturally degrade relatively fast	Oil smother Toxic effects	Buoyant and surface drifting oil slick may not affect water column organisms	Toxic concentrations from natural dispersion	Buoyant and surface drifting oil slick may not affect seabed organisms	In more shallow areas untreated oil may smother seabed flora and fauna		Smother and toxic effects on organisms

3.3 Step 3- Scores / values for SNEBA

BOX 3.1 – NET ENVIRONMENTAL BENEFIT, NEB, - SCORE SYSTEM

Net Environmental Benefit, NEB, describes the net environmental benefit from the specific oil spill response method for each species/organism group of concern in a specific spatial compartment, sea surface, seawater, seabed, shoreline, per season. The NEB may be positive, null or negative.

The species or organism group of concern that will benefit or suffer the most from oil spill response on several levels from individual to global population / cascade effects, and hence may be considered the most vulnerable, will form the base for the assessment. The highest obtained numeric score (Table 3.1.1) will be used for calculating the NEB (Table 3.1.2), which again will go into the decision trees or for calculating the effective Damage Reduction (DaR, see Box 3.3). By choosing only one score (species, organism group), differences or bias due to different levels of knowledge or thoroughness with respect to number of species of concern selected or pooling of species into organism groups, can be neglected.

For the score, it has to be assessed if the oil spill response technology in question and for a specific season will impact the species of concern in a spatial compartment on individual, local and global population, and/or it is assessed if impact on the species organism group of concern will lead to ecosystem cascade effects.

Scoring criteria are as follows:

Impact on individual

If impact is on individual level only, this individual will be impacted but it is not likely that this will lead to impact on population level.

An example is impact from floating oil (doing nothing) on polar bear. It might impact a swimming individual, but will most likely not impact the population.

Score = 1

Impact on local population

If impact is on local population level, it means that the oil spill or response measure will affect not just an individual but a population of a species, e.g., rafting seabird species on sea surface or plankton (group of organisms) in the pelagic.

An example is impact from dispersed oil on capelin schools. This may impact that season's population, and potentially lead to cascade effects (see later), but will most likely not lead to global population effects as this fish species do not migrate long distances.

Score = 3

Impact on global population

If impact is on a global population level, it means that the oil spill or response measure will affect not just a local population of a species but also the global distribution of a migratory species.

An example is impact from drifting oil on eiders. This may impact the local population, but also on a more global level as the health of this highly migratory species populations in Greenland, Iceland and Canada are dependent on migrating birds from the other populations.

Score = 6

Impact on species leading to cascade effects

If impact on a local population leads to dissemination of the population and/or poor reproduction next year, and at the same time provide an important prey item in the food web, this impact may lead to reduction in energy transfer in the ecosystem and hence cascade effects. By including cascade effects, recovery of the ecosystem is implicitly weighed.

An example is impact from dispersed oil on *Calanus hyperboreus*, which is a pelagic copepod, but even though at a small size, prey item for species ranging from other planktonic organisms, fish, little auks and baleen whale species. Dispersed oil in toxic concentration may impact that season's population, but also potentially lead to cascade effects, but will most likely not lead to global population effects of that species.

Score = 5

The scoring system follows Table 3.1.1. The scoring must be repeated for each spatial compartment; sea surface, seawater, seabed and coast for each species/organism group of concern. The numerical maximal obtained total score for each oil spill response method, season and spatial compartment (Σss, Σsw, Σsb, Σsl) are inserted in Table 3.1.2.

Table 3.1.1. Scoring of environmental benefit for species / organism groups of concern for each oil spill response method and season.

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					
Mechanical recovery	Spring	Species 1					
		Species 2					
		Species …					
	Summer	Species 1					
		Species 2					
		Species …					
	Autumn	Species 1					
		Species 2					
		Species …					
	Winter	Species 1					
		Species 2					
		Species …					
Dispersion	Spring	Species 1					
		Species 2					
		Species …					
	Summer	Species 1					
		Species 2					
		Species …					
	Autumn	Species 1					
		Species 2					
		Species …					
	Winter	Species 1					
		Species 2					
		Species …					
In situ burning	Spring	Species 1					
		Species 2					
		Species …					
	Summer	Species 1					
		Species 2					
		Species 3…					
	Autumn	Species 1					

		Species 2					
		Species …					
	Winter	Species 1					
		Species 2					
		Species …					
Do nothing	Spring	Species 1					
		Species 2					
		Species …					
	Summer	Species 1					
		Species 2					
		Species …					
	Autumn	Species 1					
		Species 2					
		Species …					
	Winter	Species 1					
		Species 2					
		Species …					

Table 3.1.2 Total scores for Net Environmental Benefit (NEB) for each oil spill response method / season.

	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					
	Summer					
	Autumn					
	Winter					
Dispersion	Spring					
	Summer					
	Autumn					
	Winter					
ISB	Spring					
	Summer					
	Autumn					
	Winter					
Do nothing	Spring					
	Summer					
	Autumn					
	Winter					

BOX 3.2 – SCORE SYSTEM FOR SOOT POLUTION - SP

Soot Pollution (SP) is a score to be used with respect to in situ burning (ISB) as oil spill response method due to the development of smoke as part of the burning. Therefore, this air pollution may lead to deposition of soot particles, and hence distance to inhabitation, distance to biology of concern on land and potential reduced albedo effect from soot deposition on ice, need to be taken into account.

SP thus describes the sum of scores for distance to land, inhabitation and potential animal congregations on land, e.g., herds of muskoxen or reindeer, or seabird colonies, as well as ice cover percentage.

Distance to inhabitation or animal congregations

The distances to inhabitation and/or animal congregations are based on reports from Alaska Regional Response Team (ARRT 2008).

The safety zone, i.e., the minimum distance to inhabited areas or animal congregations, is given as 3-4 miles (5-6.5 km) in downwind direction. This is based on standards for air pollution of the US Environmental Protection Agency (US EPA) and modelling of particle concentration in the smoke in wind direction. This distance also corresponds, with the indication of Potter & Buist (2008) of soot concentration being insignificant at sea surface in a distance of 3-6 km (2-4 nautical miles) from the ISB operation, as the smoke rise into the air due to the heat from the burning. See also Wegeberg et al. (2016) for further explanations.

Prevailing wind direction

If the wind direction do not lead the smoke plume towards inhabitation or animal congregations, ISB may be an option, despite being close to either inhabitation or congregations of animals.

Ice conditions

Ice cover is used as proxy for the potential reduction in albedo effect due to deposition of soot particles from the ISB operation smoke. The premise is:

- A higher degree of ice cover leads to potentially more deposition of soot particles on ice per sea area, and hence leads to potentially a higher degree of reduction in the albedo effect.

Threshold score

In the DECISION TREE ISB, the threshold value for soot pollution = 6.

The rationale behind this threshold score is:

To obtain the score of or below 6, either the distance to inhabitation / animal congregations is within an acceptable, however, not conservative length, or wind direction is away from inhabitation or congregations of animals.

Table 3.2. Score system for distance to inhabitation /animal congregations, prevailing wind direction and ice coverage.

	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

BOX 3.3 – DaR – CALCULATION OF EFFECTIVE DAMAGE REDUCTION FOR MECHANICAL RECOVERY

Explanation and rationale behind use of damage reduction and the algorithm.

Damage reduction is a measure of how the expected efficiency of mechanical recovery is affecting the calculated vulnerability for each compartment pr. season.

The damage reduction (DaR) is calculated as given in equation 8:

(8) Damage Reduction (DaR) = NEB $\times$ Efficiency (%)

Damage reduction is calculated with input from Table 3.1.2 and BOX 2.2.

Threshold score

In the DECISION TREE MR, the threshold value for DaR = 1.6.

The rationale behind this threshold score is:

To obtain a score higher than 1.6, a mechanical recovery of an oil spill is considered to be useful for an overall benefit to the environment, the numeric maximal scores for the species / organism of concern must be higher than 4 for all spatial compartments to obtain NEB > 16 at an efficiency % = 10. This implies, that even the efficiency of mechanical recovery may be considered limited, the species / organism group of concern, which otherwise may be impacted on the level of global population or cascade effects, is assessed to benefit from the operation.

The efficiency is by default set to 10 %, however if more specific/updated values are available these should be used.

Table 3.3. Values for DaR, which include multiplication of NEB with Efficiency (%) to obtain the effective damage reduction from the response method.

	NEB	Efficiency (%)	DaR NEB × Efficiency (%)
Spring			
Summer			
Autumn			
Winter			

BOX 3.4 – SCORE SYSTEM FOR POLLUTION OF SEA SURFACE, SEAWATER, SEABED AND SHORELINE

Score for oil polluted sea surface (SSP)

From the value of sea surface area polluted by oil at a thickness that may harm seabird feather structure and calculated from the oil spill scenarios (SSa) (Table 2.2.7), a fraction of sea surface area polluted in relation to the entire sea surface area for the waterbody of the assessment area (WBssa) (Table 1.1.1), can be obtained (9) and inserted in the score system in Table 3.4.1.

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

Table 3.4.1. Score system for evaluation of oil polluted sea surface area calculated from oil spill scenario data.

	<2 %	**2-10 %**	**>10 %**
fSSP	0	2	4
Fraction of oil polluted sea surface area (km²)	*Insert value*		
Score			

The score for evaluation of oil polluted sea surface will be used in decision tree for "Do Nothing" (DECISION TREE DN).

Score for oil seawater pollution for natural dispersed oil (SWPn) and chemically dispersed oil (SWPc)

From the value of seawater volume polluted with oil concentration above EC_{50} or no effect concentration (NEC) (SWv) (Table 2.2.7), calculated from the oil spill scenarios, and the volume of the waterbody of the assessment area (WBv) (Table 1.1.1), fraction of polluted water volume can be obtained (10).

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

The values are obtained for both naturally and chemically dispersed oil, and inserted in Table 3.4.2.

Table 3.4.2. Values for calculating the fraction of seawater polluted (fSWP) from values obtained from Table 2.2.7.

Naturally dispersed			**Chemically dispersed**		
SWvn	**WBv**	**fSWPn (%)**	**SWvc**	**WBv**	**fSWPc (%)**

The fraction of polluted water volume values (fSWPn and fSWPc) from Table 2.2.7, is used in the scoring system in Table 3.4.3 below.

If oxygen is depleted (in the bottom water) in the assessment area during specific seasons (1.5.1), $O_2 = 0$, the conservative scores in Table 3.4.3 is obtained.

If oxygen conditions are sufficient to support natural degradation of dispersed oil also in the bottom water (Table 1.5.1), and which USE is not considered to result in oxygen depleted conditions, a higher fraction of seawater volume with oil contamination may be accepted (Table 3.4.3).

To score in accordance with sufficient oxygen conditions ($O_2 > 0$), means that oxygen is not depleted in the entire water body of the assessment area in any season.

See also BOX 2.3

Furthermore, if oxygen conditions are in favour of natural degradation (O_2 conditions > 0), and a natural biodegradation potential is present, a higher fraction of seawater volume with oil contamination may be accepted (Table 3.4.3).

To score in accordance with natural biodegradation present, it must be known and documented, that such a potential exists in the assessment area.

See also BOX 2.4.

Table 3.4.3. Score system for evaluation of seawater fraction polluted.

O_2 conditions = 0	**<5 %**	**5-10 %**	**>10 %**
O_2 conditions > 0	**<10 %**	**10-20 %**	**>20 %**
O_2 conditions > 0 and Natural biodegradation potential present	**<15 %**	**15-30 %**	**>30 %**
Score	0	2	4
Seawater fraction oil polluted (fSWPn or fSWPc)	*Insert value*		
Score			

The score for evaluation of oil polluted sea volumes will be used in decision tree for "Dispersants" (DECISION TREE CD).

Score for oil pollution of seabed (SBC)

From the value of seabed area polluted with oil (SBa) (Table 2.2.7) calculated from the oil spill scenarios, and the seabed area of the waterbody of the assessment area (WBsba) (Table 1.1.1), fraction of polluted seabed can be calculated (equation 11) and inserted in the score system in Table 3.4.4.

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

Table 3.4.4. Score system for evaluation of oil polluted seabed area calculated from oil spill scenario data.

	<2 %	**2-10**	**>10**
fSBP	0	2	4
Fraction of oil polluted seabed area (km^2)	*Insert value*		
Score			

Score system for oil polluted shoreline (SLP)

From the value of shoreline length polluted by oil (Table 2.2.7) calculated from the oil spill scenarios, scores for shoreline pollution can be obtained by comparing the data with historical oil spill accidents' shoreline length impacted (Table 3.4.7)

< 4 km

This limit is based on the Norwegian oil spill from *Godafoss* from which it was assessed that environmental impacts were insignificant, and no remediation were initiated.

4-40 km

The upper limit of this interval is based on the Norwegian oil spills from *Server* and *Full City.*

Environmental impacts were observed from the *Server* spill; 40 km of shoreline were considered impacted and remediation were and the area was remediated.

However, there were no significant environmental impact from the *Full City* spill where 75 km were impacted and remediated.

There 40 km shoreline is considered a conservative value for shoreline length impacted but without significant environmental impacts.

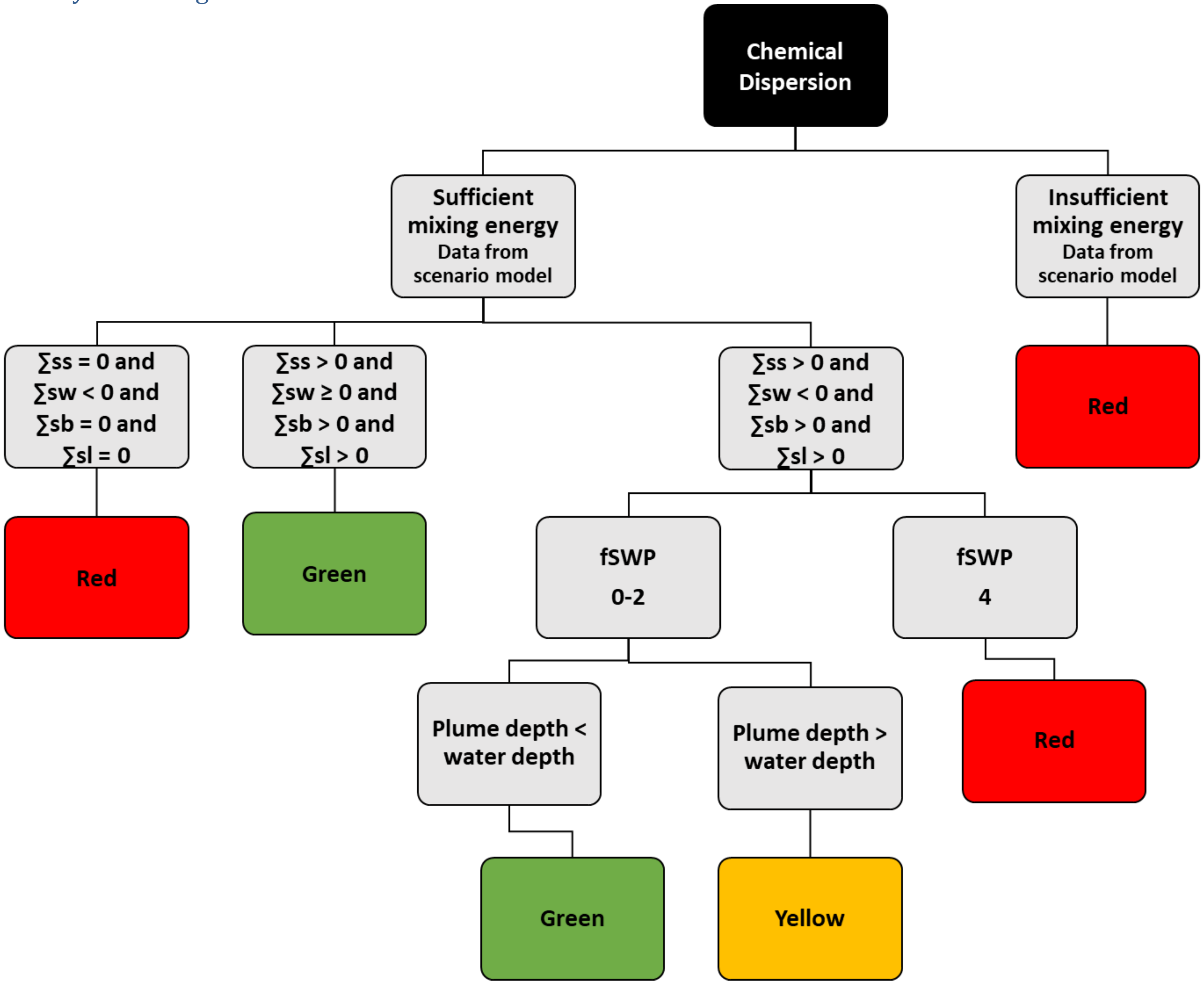
> 40 km

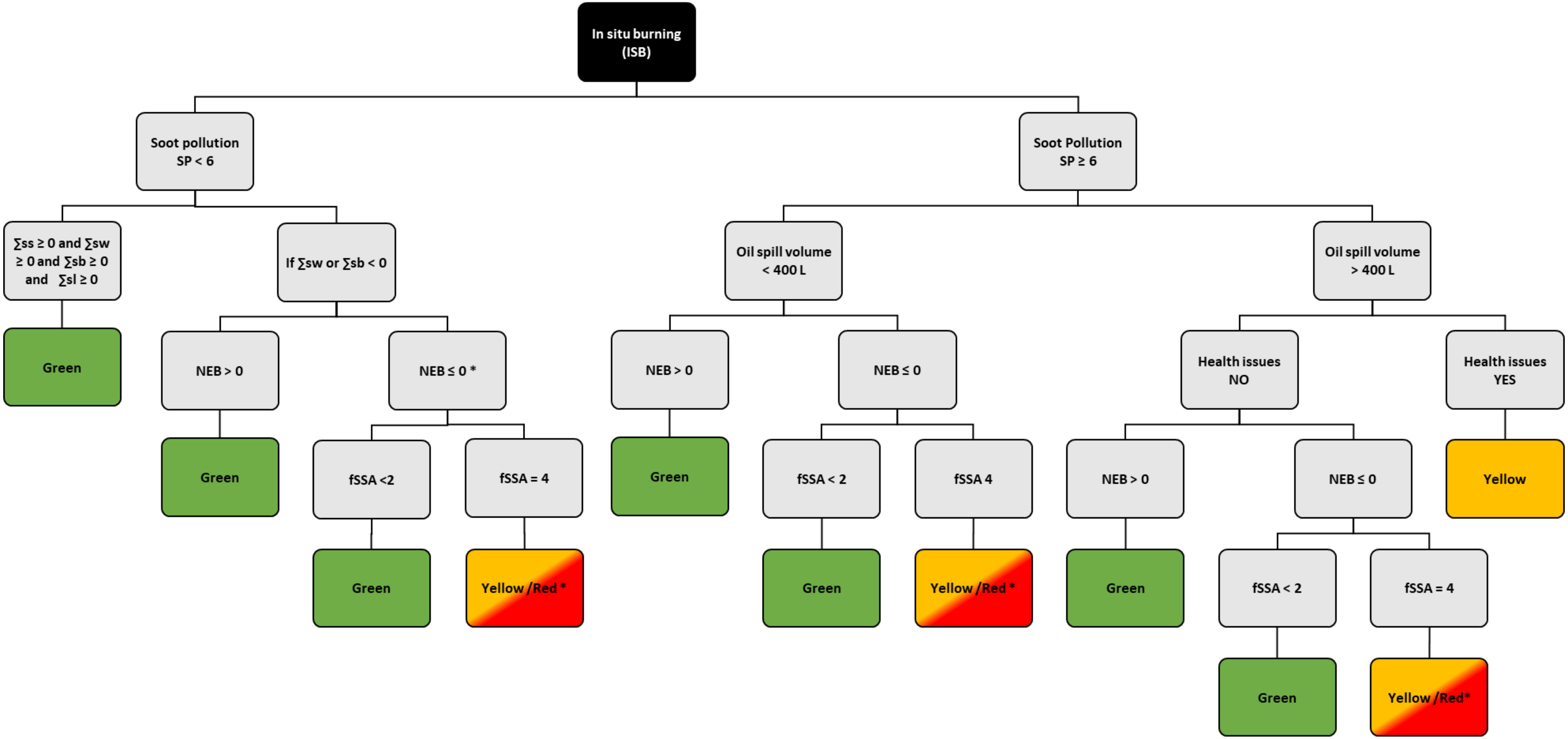
For more than 40 km of impacted shoreline, the oil spill is according large and significant environmental impacts must be expected. In the case with the *Exxon Valdez* oil spill, 300 km of shoreline were heavily or moderately impacted.

Table 3.4.7. Score system for evaluation of shoreline length impacted.

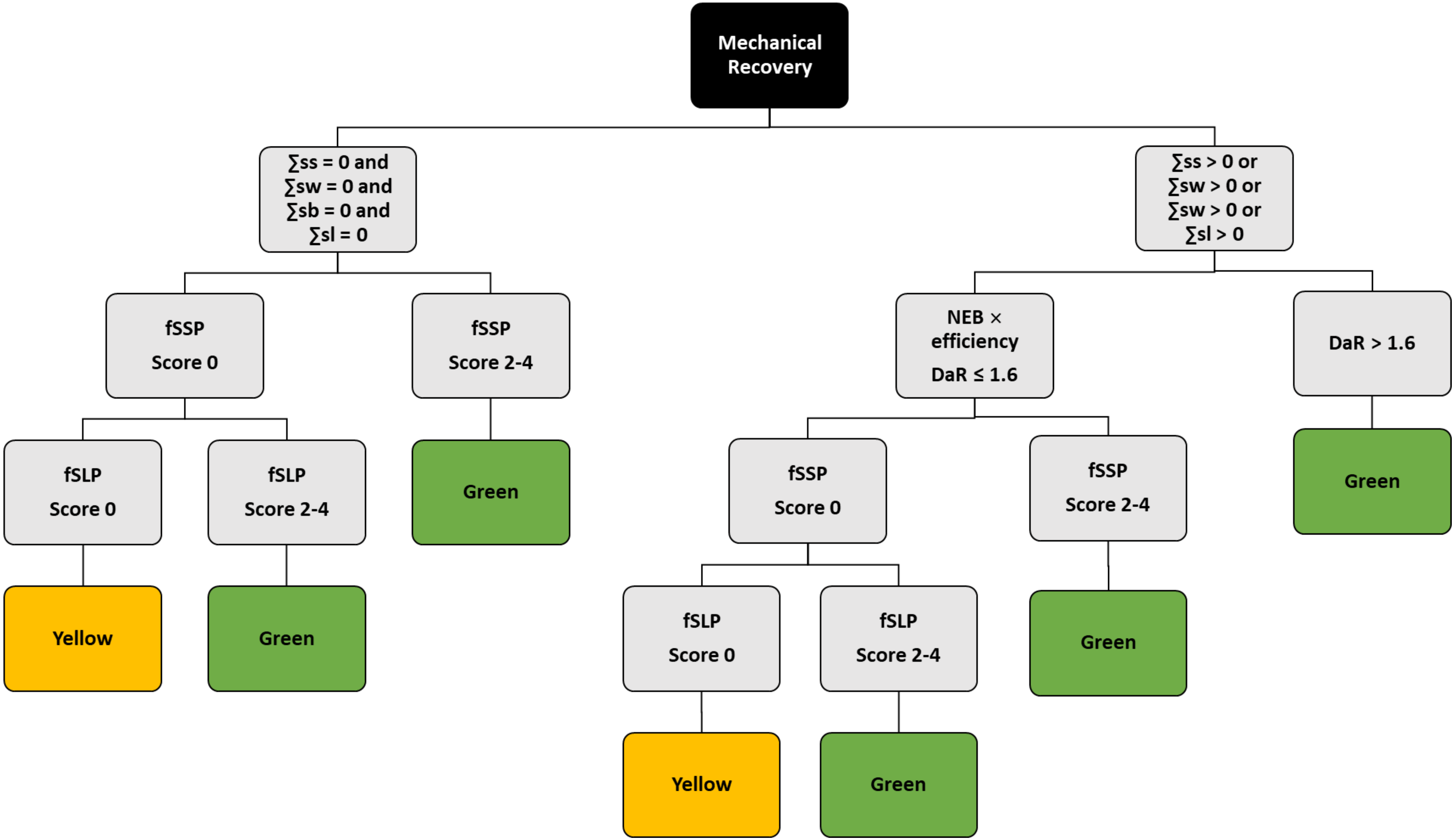
	< 4 km	**4-40**	**> 40 km**
SLP	0	2	4
Shoreline length polluted from scenarios (km)	*Insert value*		
Score			

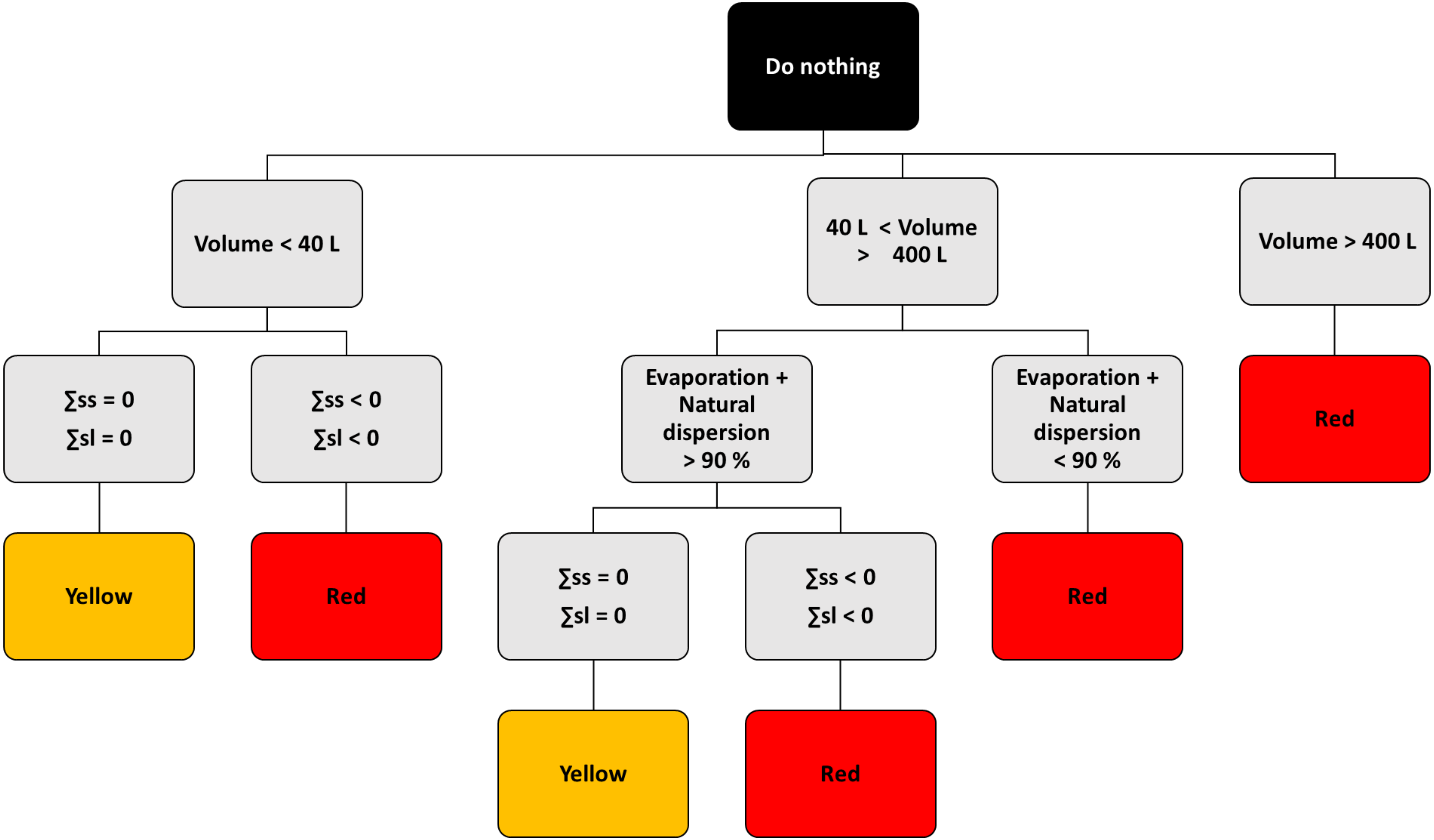
3.4 Analyses through decision trees





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


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 > 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
Yellow
Green


Do nothing
Volume < 40 L
40 L < Volume > 400 L
Volume > 400 L
∑ss = 0
∑sl = 0
∑ss < 0
∑sl < 0
Evaporation + Natural dispersion > 90 %
Evaporation + Natural dispersion < 90 %
Red
Yellow
Red
∑ss = 0
∑sl = 0
∑ss < 0
∑sl < 0
Red
Yellow
Red

3.5 Interpretation and dissemination of results

BOX 5.1 – INTERPRETATION AND DISSIMINATION OF THE SNEBA

From the decision trees, the final result for each oil spill response method for each season is obtained. The results are presented with colours from traffic light:

Green

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

It is important to emphasize that the SNEBA results indicate which oil spill response methods that may be **beneficial** for the environment in the different seasons. However, the SNEBA results **do not compare** the oil spill response methods in order to select the best option. Often more than one oil spill response methods may be optimal from an operational point of view. Please consult appropriate information for operational assessment.

The SNEBA is a planning tool, and thus a desktop analysis for environmentally assessing and preparing of oil spill combating potential, strategy and capacity building. The SNEBA results form base for a faster and more robust response in case of oil spill. It will constitute a decision-making tool on a scientific basis that synthesizes available relevant knowledge and advance the qualified framework on which a national oil spill strategy can be based. The SNEBA results can also be used to establish cross-border and trans-boundary co-operation and agreements.

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

3.6 Abbreviations

BOX 6.1 – ABBREVIATIONS

Σss	Total score for species/organism group of concern each oil spill response method and season for sea surface
Σsw	Total score for species/organism group of concern each oil spill response method and season for seawater
Σsb	Total score for species/organism group of concern each oil spill response method and season for seabed
Σsl	Total score for species/organism group of concern each oil spill response method and season for shoreline
DaR	Damage Reduction (%)
DECISION TREE MR	sNEBA decision tree for mechanical recovery.
DECISION TREE CD	sNEBA decision tree for chemical dispersants
DECISION TREE ISB	sNEBA decision tree for in situ burning
DECISION TREE DN	sNEBA decision tree for "Do nothing"
fSBP	Fraction of oil polluted seabed area compared to seabed area of the waterbody in the assessment area
fSSP	Fraction of oil polluted sea surface area compared to sea surface area of the waterbody in the assessment area
fSWP	Fraction of oil polluted seawater volume compared to seawater volume of the waterbody in the assessment area
NEB	Bet Environmental Benefit
NEC	No Effect Concentration
SB	Seabed
SL	Shoreline
SS	Sea surface
SW	seawater
SBa	Potential area of seabed affected by the oil spill (m^2)
SBa	Potential area of seabed affected by the oil spill (km^2)
SBP	Seabed pollution
SLl	Potential length of shoreline polluted by the oil spill (m)
SLl	Potential length of shoreline polluted by the oil spill (km)
SLP	Shoreline pollution
SIMA	Spill Impact Mitigation Analysis
SNEBA	Strategic Net Environmental Benefit Analysis
SP	Soot pollution
SSa	Potential area of sea surface affected by oil spill (m^2)
SSP	Sea surface pollution
SWP	Seawater pollution
SWvn	Potential volume of seawater affected by concentration of oil above EC50 or NEC (m^3) from naturally dispersed oil
SWvc	Potential volume of seawater affected by concentration of oil above EC50 or NEC (m^3) from chemically dispersed oil
WBsba	Seabed area of the water body of the assessment area
WBssa	Sea surface area of waterbody of the assessment area
WBv	Waterbody volume