Forum for Framtidas Oljevern 2021

MARINTMILJØ
Senter for oljevern og marint miljø

Shoreline Oil Spill Response Viability Analysis

Ed Owens, PhD

14 September 2021

Topics

- EPPR's Circumpolar Oil Spill Response Viability Analysis (COSRVA)
- COSRVA's Coastal-Nearshore Coverage
- Shoreline-COSRVA concept
- Shoreline Treatment
  - Feasibility Analysis Logic
    - Trade-Offs and Consequences
  - Operational Viability Analysis Logic
- Decision Support Tools and the Complexity of a Shoreline Response
- Next Steps

Circumpolar Spill Response Viability Analysis (COSRVA)

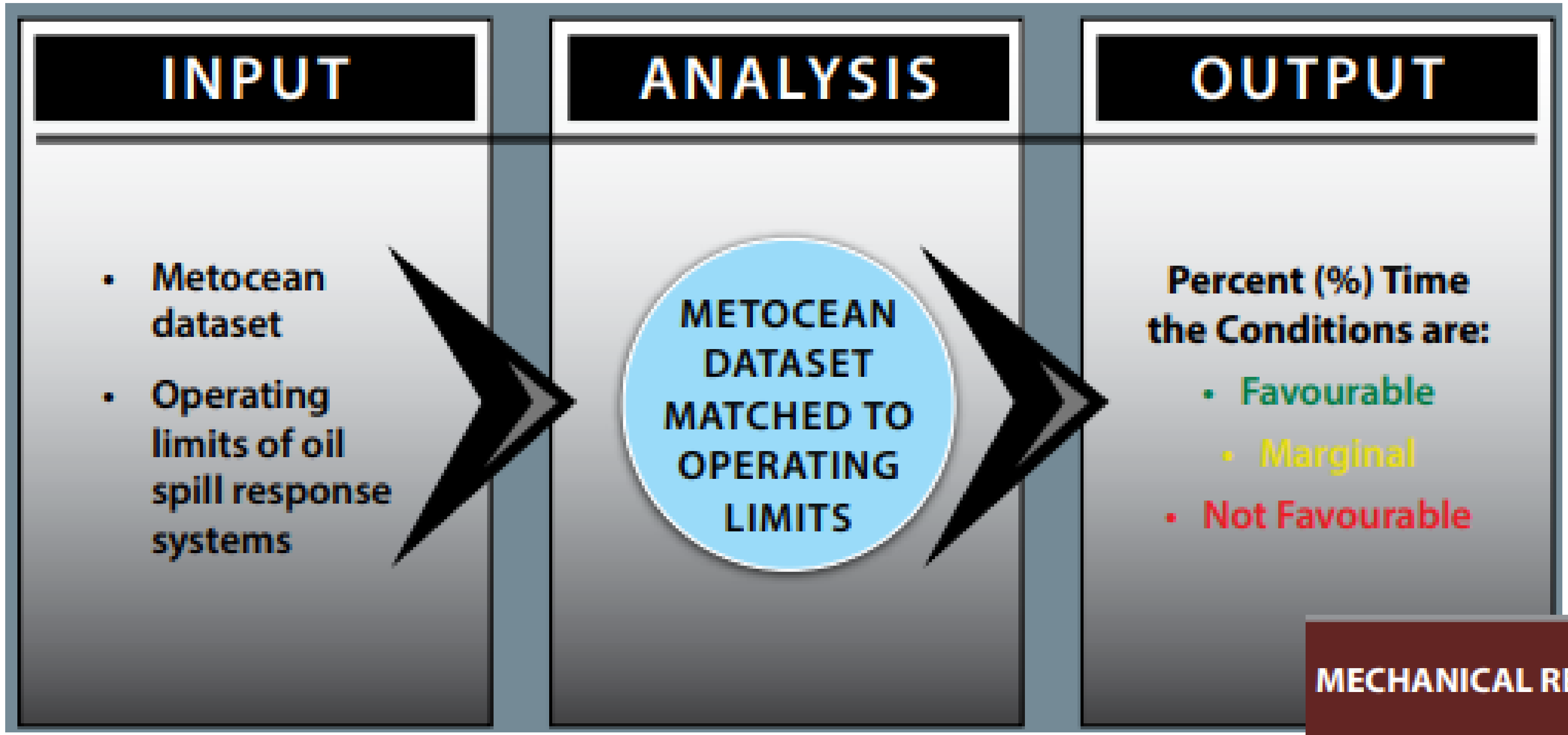
- A project of the Arctic Council EPPR cosponsored by Norway, Iceland, the United States and the Nordic Council of Ministers
- Analyses the viability of ten (10) marine response systems in terms of the environmental metocean (meteorological-oceanographic) operational limitations on each of system

KYSTVERKET
NORWEGIAN COASTAL ADMINISTRATION

DNV·GL

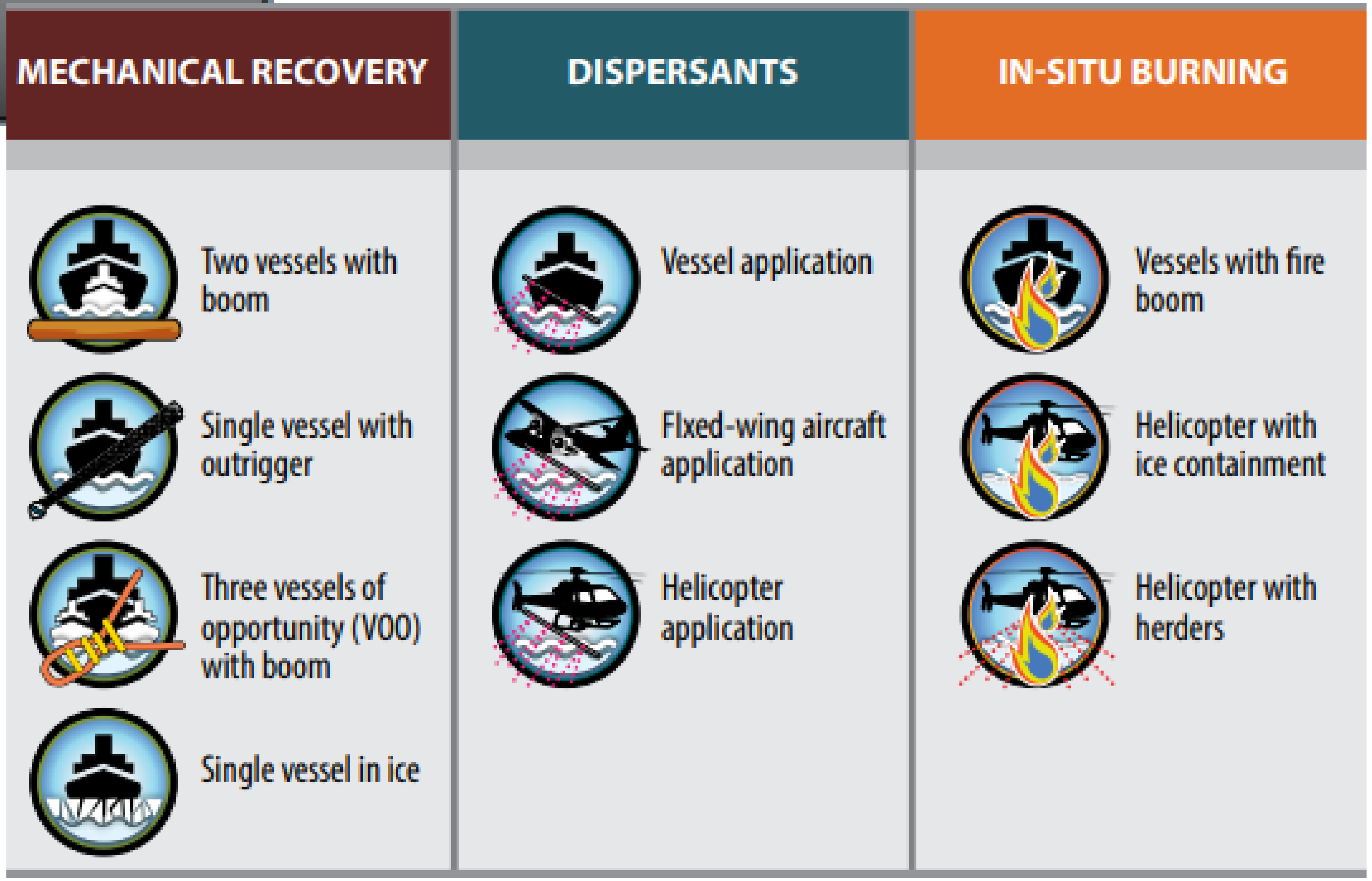
COSRVA

- An online tool
- A GIS-based web site that provides planners and decision makers with information on whether a marine response option is **Favourable**, **Marginal**, or **Not Favourable** in **TIME** (by month) and **SPACE** (by 25 km grid cells)



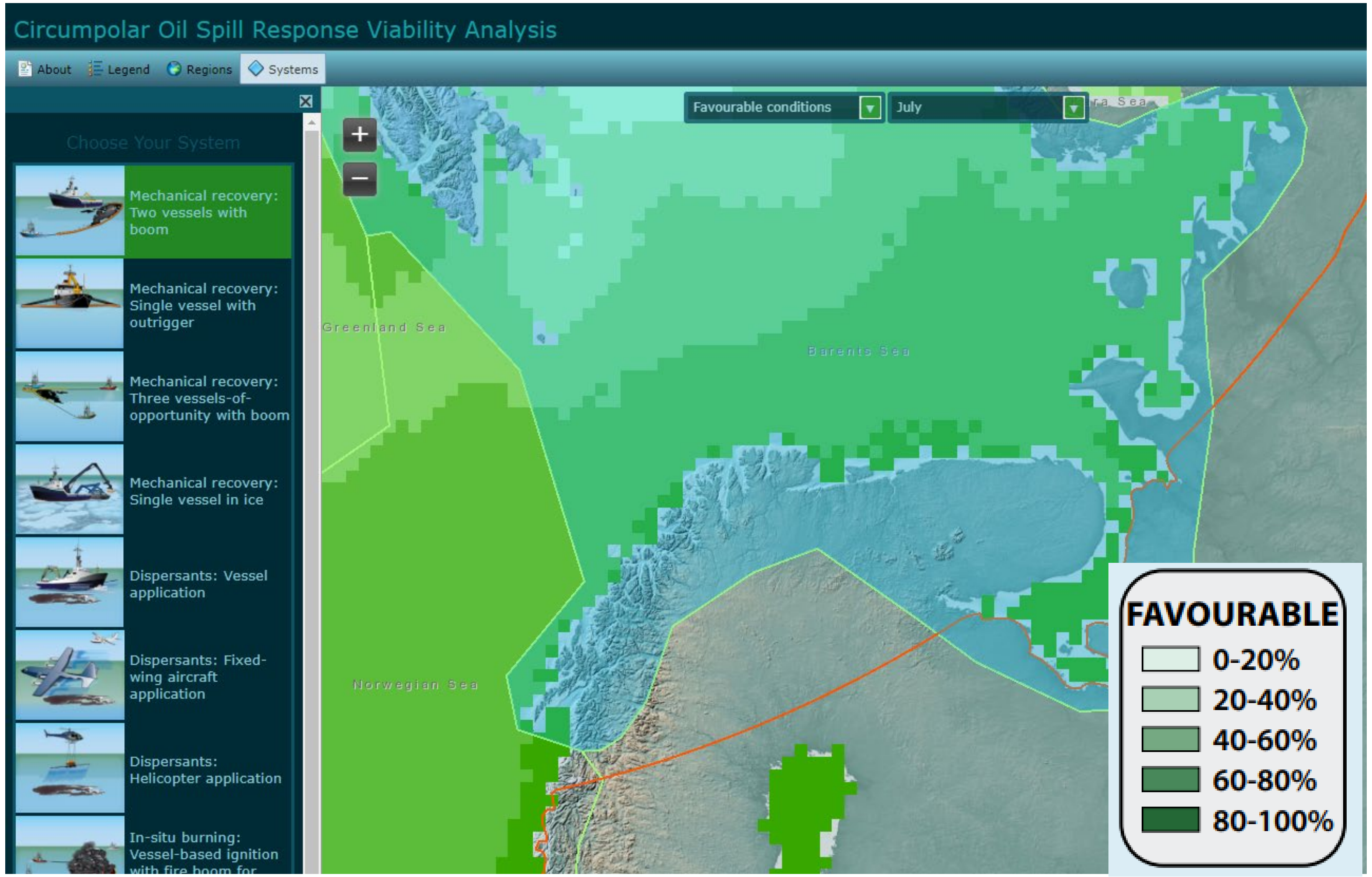
process

ten (10) marine response systems

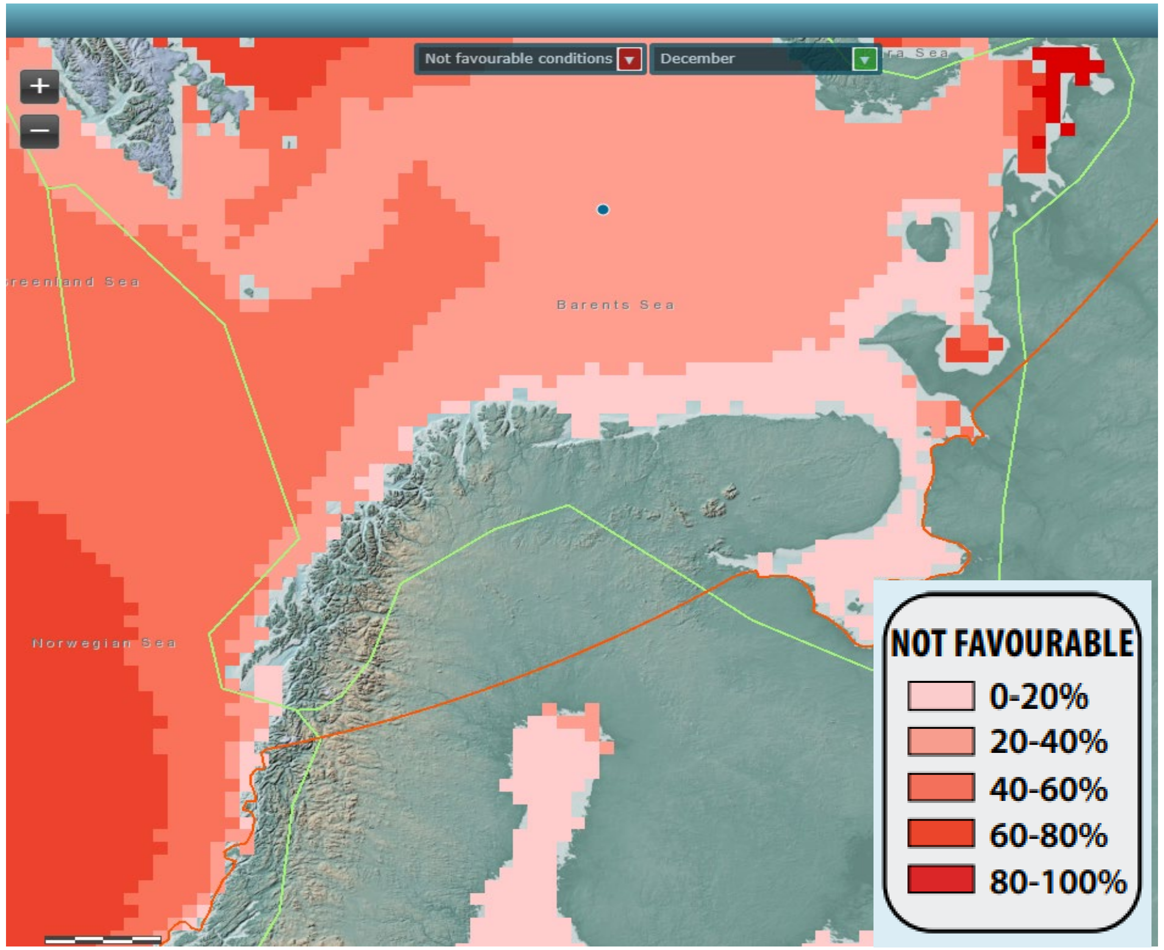


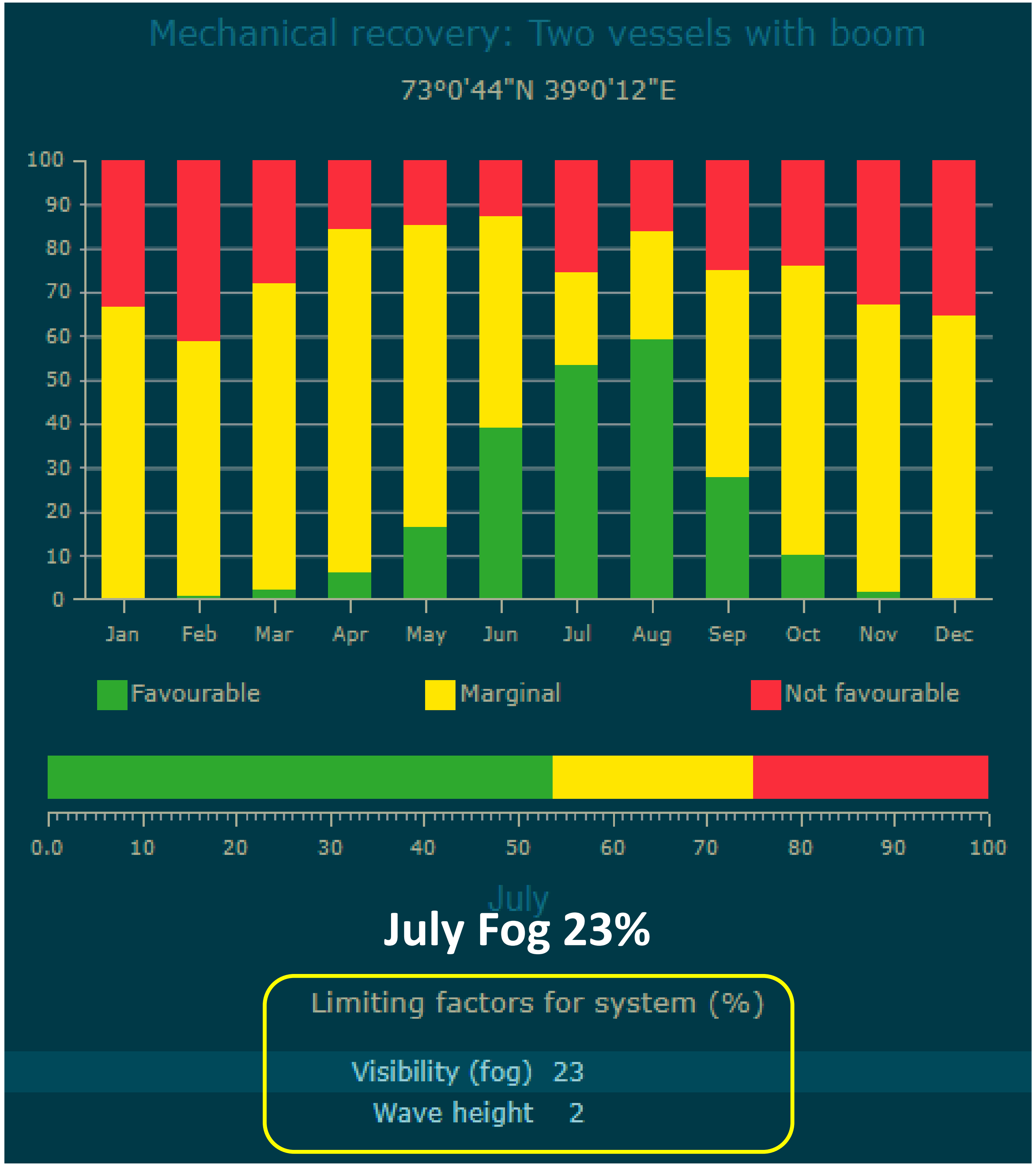
Barents Sea
Mechanical Recovery Two Vessels with Boom

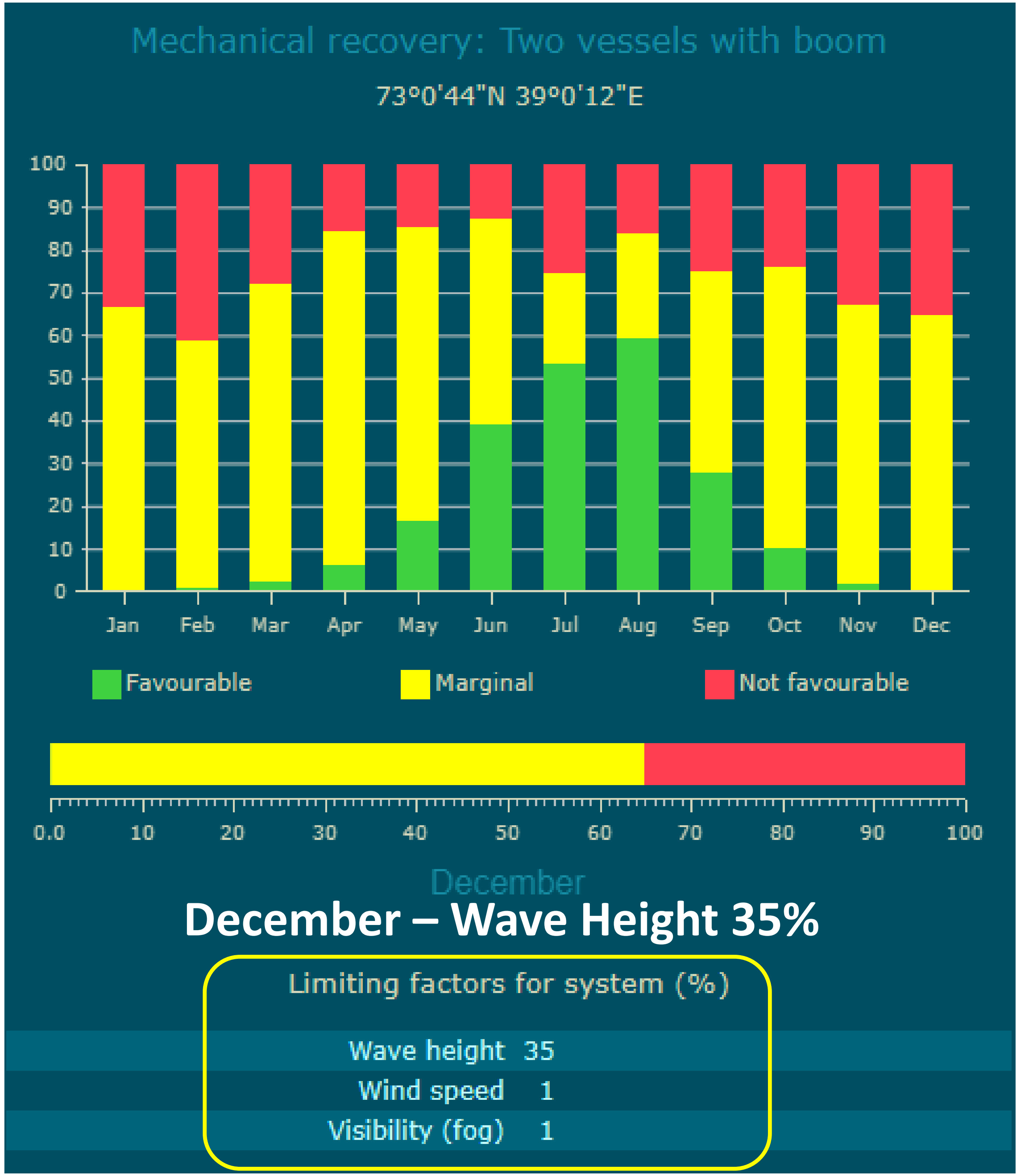
July – Favourable Conditions



December – Not Favourable Conditions




Mechanical recovery: Two vessels with boom
73°0'44"N 39°0'12"E
100
90
80
70
60
50
40
30
20
10
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Favourable
Marginal
Not favourable
0.0 10 20 30 40 50 60 70 80 90 100
July
July Fog 23%
Limiting factors for system (%)
Visibility (fog) 23
Wave height 2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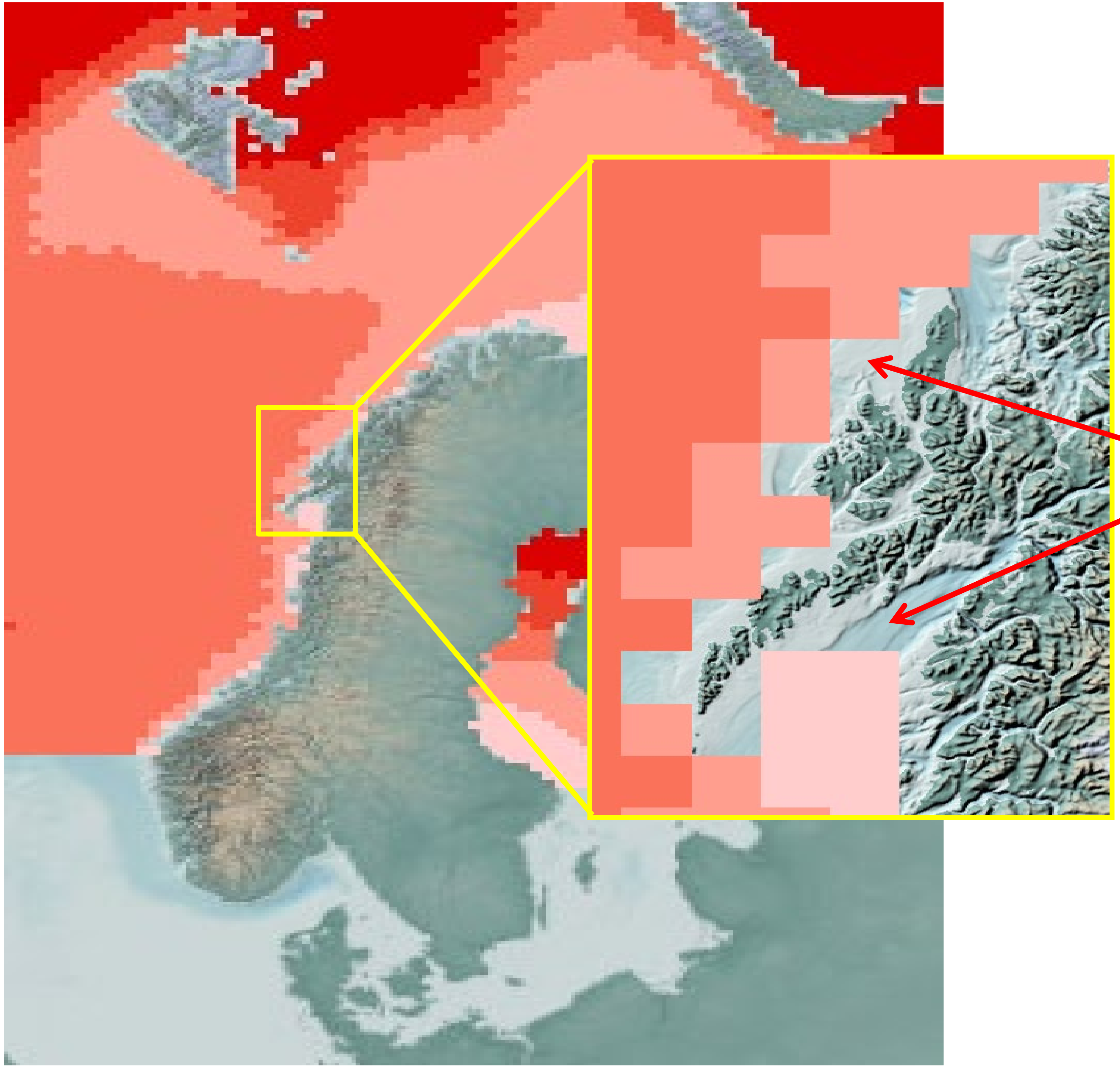
60
50
40
30
20
10
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Favourable
Marginal
Not favourable
0.0 10 20 30 40 50 60 70 80 90 100
December
December – Wave Height 35%
Limiting factors for system (%)
Wave height 35
Wind speed 1
Visibility (fog) 1



Circumpolar Oil Spill Response Viability Analysis

Online Portal

User Guide

KYSTVERKET

DNV·GL

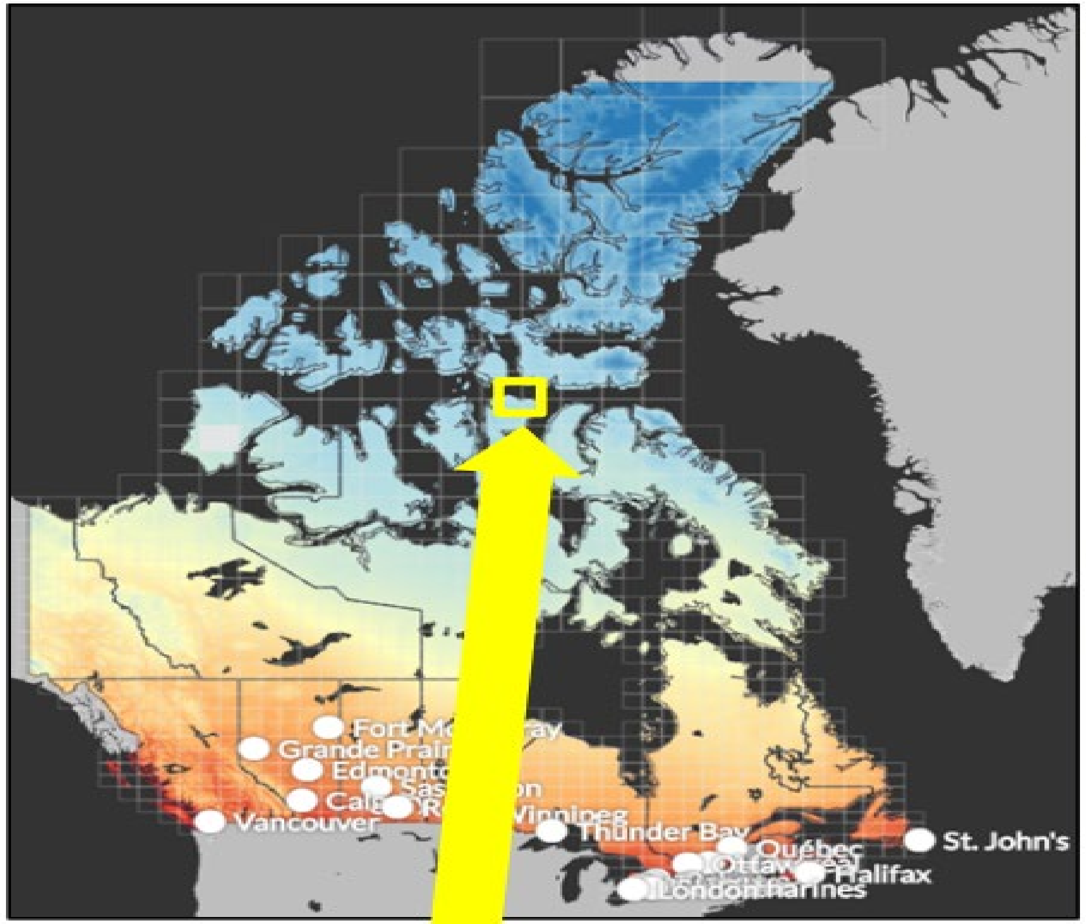
https://maps.dnvgl.com/cosrva

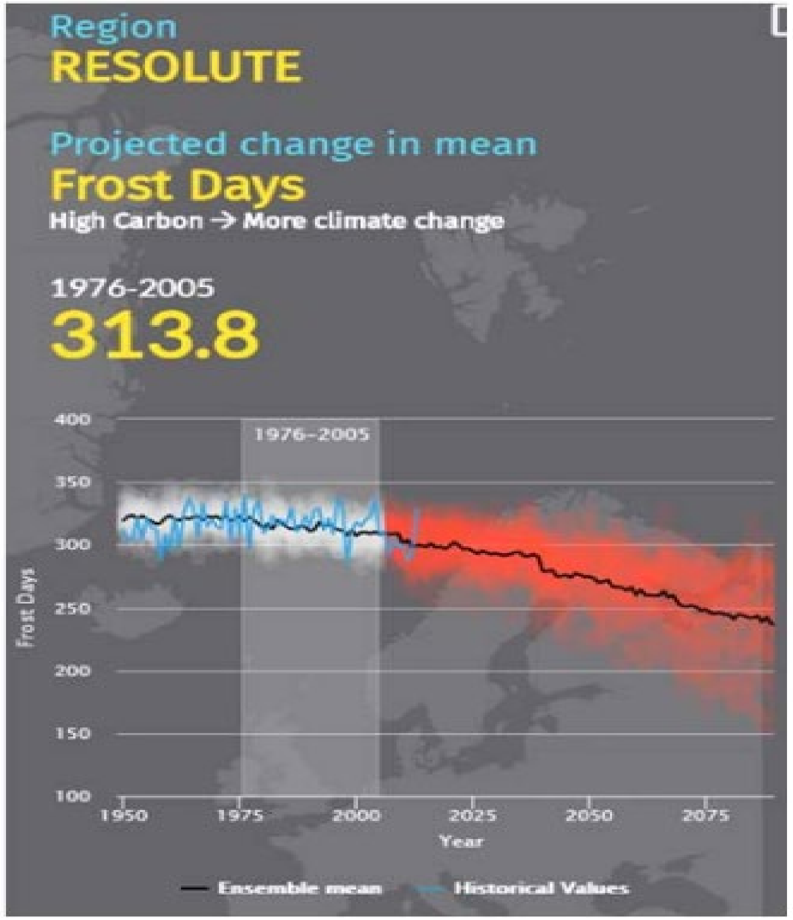
No COSRVA coverage if the center of the cell is <10 km from the shoreline

Add the "S" to COSRVA !

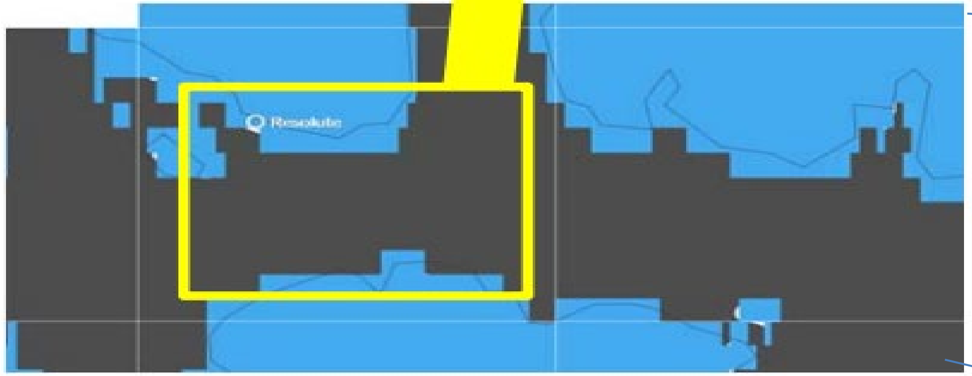
Current MPRI Shoreline Studies

- As part of the Canadian Oceans Protection Plan MPRI has funded a (Shoreline) Oil Translocation project that included the development of:
  - ***Shoreline Decision Support Tool*** (DST) concept
  - Demonstration DST input and output interfaces
  - Canadian oiled shorelines case studies data base
  - GIS data base for DST shoreline environmental data
  - Lab and meso-scale studies to support the shoreline oil weathering (Natural Translocation) modeling

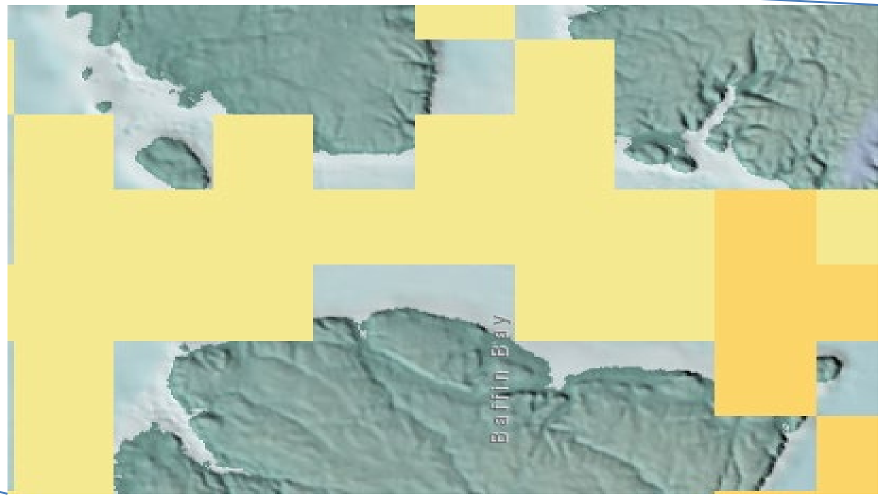




For the GIS component had already planned to use a grid cell basis with layered graphics



Consistent with the COSRVA cells approach



“Shoreline COSRVA”

- **Purpose:**
  - Add **shoreline (onshore) response viability** to the existing EPPR (offshore) marine response viability model
- **Presentation:**
  - Follow the **existing COSRVA grid cell presentation format** for consistency
- **New Data:**
  - ***No new metocean data required*** as would use existing (a) COSRVA environmental data and (b) the existing EPPR operational viability analysis

Existing COSVRA Metocean Data

Existing COSRVA Data	"SHORELINE COSRVA" Relevance
Wind speed (m/s)	✓✓
Significant wave height (m)	✓✓✓
Average wave period (s)	-
Sea Ice coverage (%)	✓✓✓
Air temperature (°C)	✓✓
Superstructure icing (cm/hr)	✓
Wind chill (w/m^2)	✓✓
Daylight/darkness	✓✓
Horizontal visibility (m)	✓✓
Cloud ceiling (m)	✓✓

Additional Data for a “Shoreline OSRVA”

S-COSRVA Category	“New” Data Availability
Wind direction (on-offshore quadrant)	probably same source as COSRVA
Shore-zone ice (Y/N)	easily derived from Frost data
Frost (Y/N)	existing Canada Atlas data base
Tidal Range (m)	can be easily extrapolated
Substrate type (14 categories)	existing ECCC categories
Oil Type (5 categories)	existing DST categories
Oil Loading (4 categories)	existing DST categories
Sediment fines availability (1-10 index)	existing - developed for MPRI study

Other Features

- ✓ Shoreline operational **viability analysis** already exists as text in the 2017 ***EPPR Field Guide for Oil Spill Response in Arctic Waters***
- ✓ Would use the same EPPR substrate type categories (this could vary from country to country depending on national data)
- ✓ Can use output from the ***EPPR Waste Management Calculator*** that was developed for Arctic shorelines
- ✓ 25 x 25 km grid would work well

Field Guide for Oil Spill Response in Arctic Waters

(Second Edition, 2017)

Table 5.14. Summary of efficiency factors for physical removal techniques

Technique or Device	Resource Requirements	Relative Cleanup Rate	Single or Multiple-Step	Waste Generation
9 manual removal	labour-intensive	slow	multiple	minimal
10 vacuum systems	labour-intensive	slow	multiple	moderate
11 grader/scraper	minimal labour support	very rapid	single/multiple	moderate
11 front-end loader	minimal labour support	rapid	single	high
11 bulldozer	minimal labour support	rapid	multiple	very high
11 backhoe	minimal labour support	medium	singl	
11 dragline/clamshell	minimal labour support	medium	singl	
11 beach cleaners	minimal labour support	slow-medium	varie	
12 vegetation cutting	labour-intensive	slow	multi	
13 passive sorbents	labour-intensive if used extensively with large amounts of oil	slow	mult	

Consequences

ARCTIC WATERS FIELD GUIDE

Table 4.1. Treatment Methods for Bedrock Shores

	Treatment Method	light oil	medium oil	heavy oil
1	natural recovery	○	○	
2	flooding	○	○	
3	low-pressure, ambient-water	○	○	◒
4	low-pressure, warm/hot-water		○	◒
5	high-pressure, ambient-water			◒
6	high-pressure, hot-water			◒
9	manual removal	◒	◒	◒
10	vacuum systems	○	○	◒
13	sorbents	◒	◒	
17	dispersants		◒	
18	shoreline cleaners		◒	

○ good ◒ fair (for small amounts of oil only)

Viability

	Bedrock	Manmade solids	Sand beaches	Mixed sediment	Pebble/Cobble beaches	Boulder beaches	Sand tidal flats	Mud tidal flats	Marshes	Peat	Low-lying inundated tundra	Tundra cliffs
Natural recovery	—	—	—	—	—	—	—	—	—	—	—	—
Flooding	●	●	●	●	●	●	●	●	●	●	●	●
Low-pressure, ambient wash	●	●	◒	◒	◒	●	○	○	●	●	●	●
Low-pressure, warm/hot wash	◒	●	○	◒	◒	◒	○	○	○	○	○	●
High-pressure, ambient wash	●	●	○	○	○	◒	○	○	○	○	○	○
High-pressure, warm/hot wash	◒	●	○	○	○	◒	○	○	○	○	○	○
Steam cleaning	◒	●	○	○	○	○	○	○	○	○	○	○
Sandblasting	○	◒	—	—	—	—	—	—	—	—	—	—
Manual removal	●	●	●	●	●	●	◒	○	○	○	○	●
Vacuums	●	●	●	●	●	●	◒	◒	◒	●	●	●
Mechanical removal	—	—	◒	◒	◒	◒	◒	○	○	◒	○	◒
Vegetation cutting	◒	●	—	—	—	◒	—	○	○	—	◒	—
Passive sorbents	●	●	●	●	●	●	●	●	●	●	●	●
Mixing	—	—	◒	◒	◒	—	◒	○	○	○	○	●
Sediment relocation	—	—	◒	◒	◒	—	○	○	○	○	○	●
Burning	●	●	◒	◒	◒	◒	○	○	◒	○	○	—
Dispersants	●	●	●	●	●	●	—	—	○	○	○	●
Shoreline cleaners	●	●	●	●	●	●	—	—	◒	—	—	●
Solidifiers	●	●	●	●	●	●	◒	◒	◒	●	●	●
Bioremediation	●	●	●	●	●	●	●	●	●	○	●	●

○ good (low potential impact) ◒ fair (medium potential impact) ● poor (high potential impact)

SHORELINE TREATMENT LOGIC

- **Feasibility Analysis** (*completed*)
  - Operationally practical, appropriate, and reasonable, and environmentally acceptable?
  - **YES**, a technique is an option

    \- or **NO**, it is not applicable because impractical, incompatible, inappropriate, or a safety concern
- **Operational Viability Analysis** (*text written – analysis not yet started*)
  - Environmental (metocean) viability of the feasible options?
  - **YES**, but only in certain operating conditions

    \- or **NO**, because of environmental or access constraints

SHORELINE TREATMENT LOGIC

1. FEASIBILITY ANALYSIS

Based on:

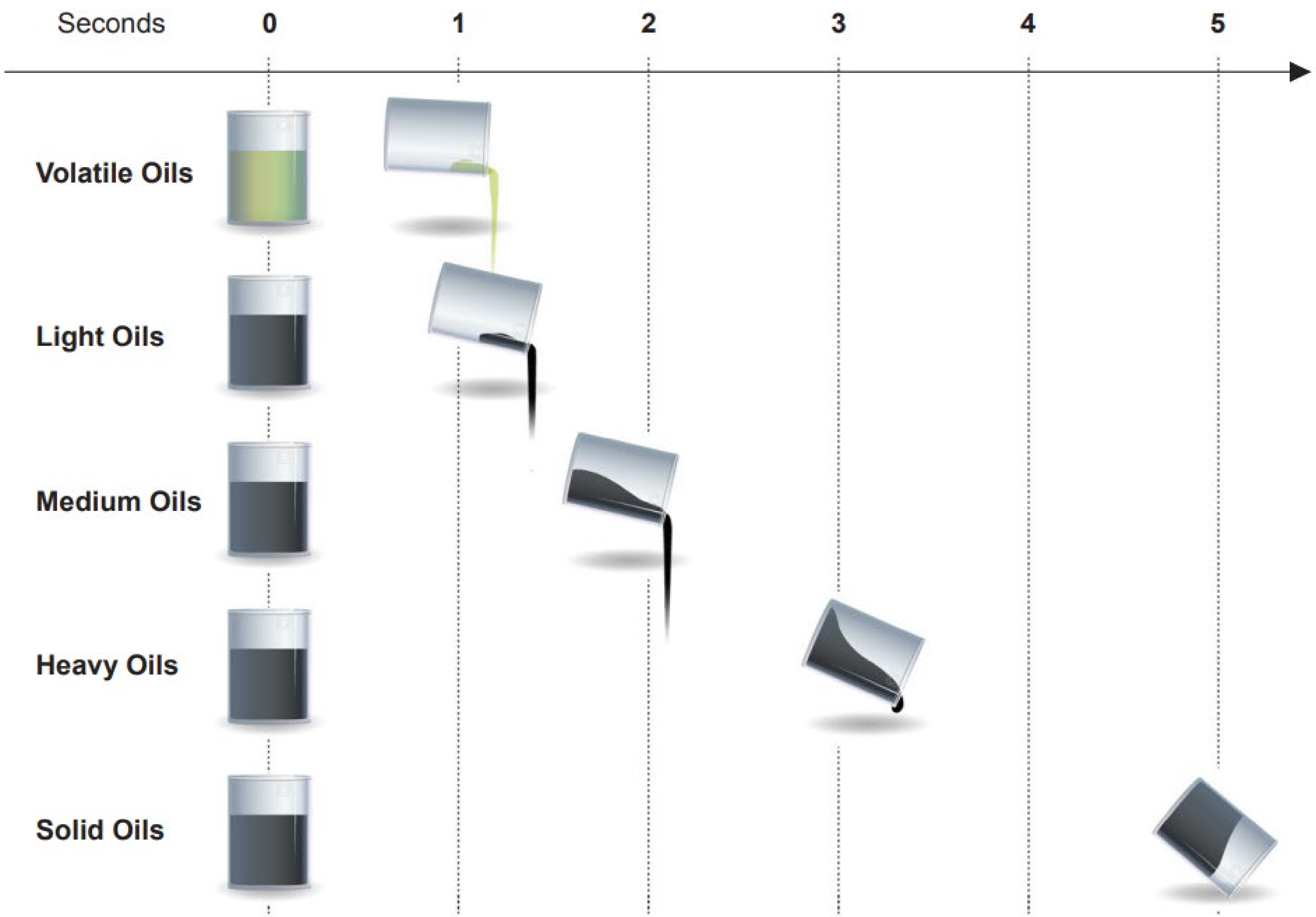
- 5 oil types
- 15 shoreline types
- 21 shoreline treatment options

FEASIBILITY ANALYSIS	
FEASIBLE OPTION	✓
NOT APPLICABLE	→
FEASIBLE SMALL AMOUNTS	x

Primary "NOT APPLICABLE" Reason *		
environmentally inappropriate	E	feasible but inappropriate or unacceptable
operationally incompatible	I	incompatible - not technically feasible
operationally impractical	O	impractical - technically feasible but of little/no value
safety	S	everything manual for Volatile oils

** more than one reason may apply for a given shore type/treatment option*

5 Oil Types



Seconds
0
1
2
3
4
5
Volatile Oils
Light Oils
Medium Oils
Heavy Oils
Solid Oils

Basic Shoreline Types

Impermeable

- *Bedrock*
- *Ice - Glaciers*
- *Man-Made Solid*

Permeable

- *Mud Tidal Flat*
- *Sand Tidal Flat*
- *Sand Beach*
- *Mixed-Sediment Beach*
- *Mixed-Coarse Sediment Flat*
- *Pebble-Cobble Beach*
- *Boulder Beach*
- *Snow*

Permeable Vegetated Shores

- *Salt Marshes (grasses)*

ARCTIC

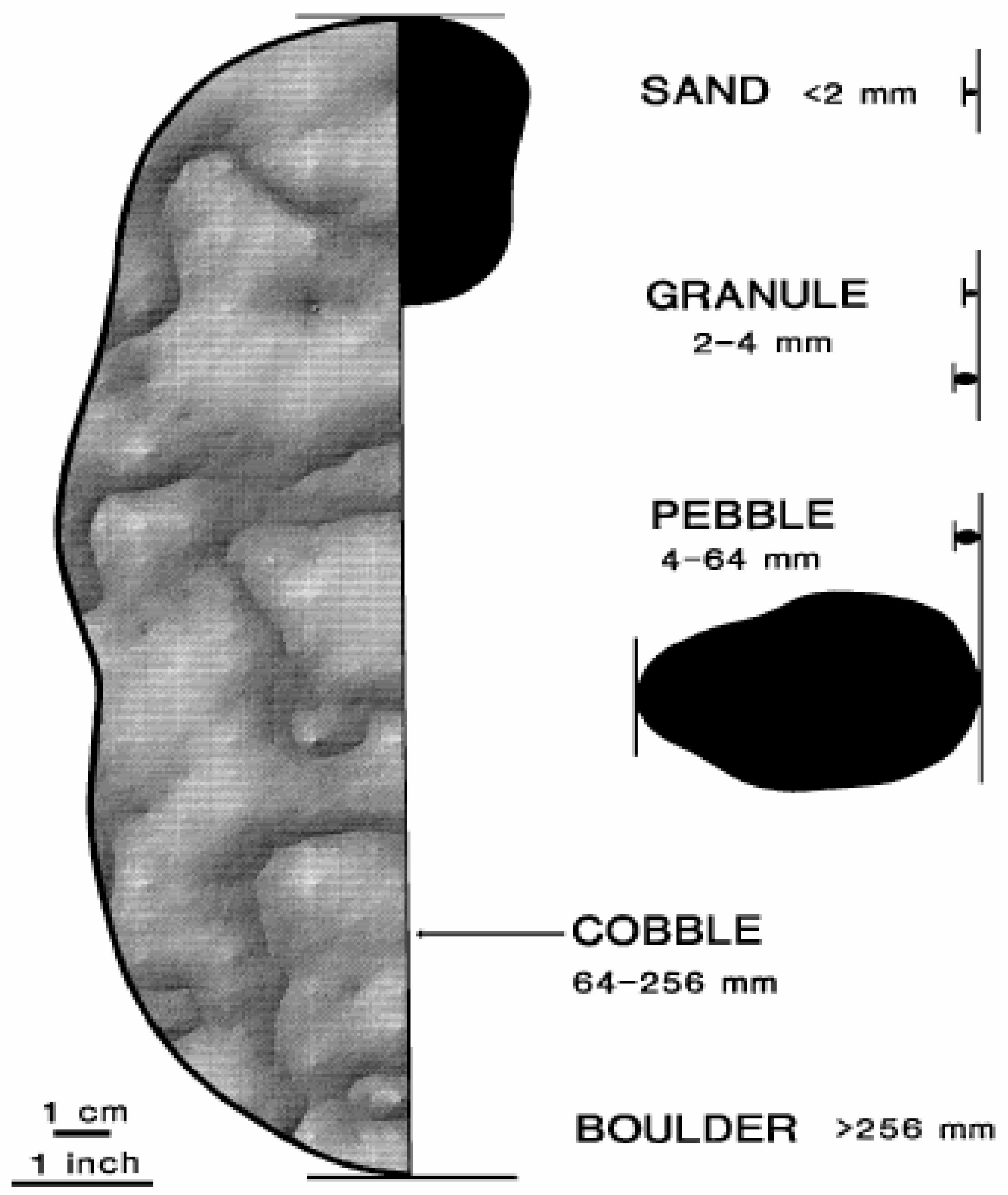
IMPERMEABLE

- *Tundra Cliffs*

PERMEABLE

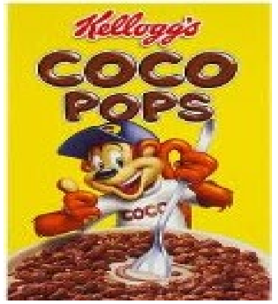
- *Low-Lying Tundra*
- *Peat*

Grain Size (after Wentworth, 1992)



Up to 2 mm = Sand =

Up to 4 mm = Granule =



Up to 64 mm = Pebble =

Up to 256 mm = Cobble =

Shoreline Treatment Options

STRATEGY		TACTIC(S)
NATURAL RECOVERY		• monitor

PHYSICAL	Water Wash and Recover	• flood and/or wash
		  ○ low or high pressure
		  ○ unheated or heated water
		• recover

	Removal	• manual or mechanical removal, cutting, sieving, or sorbent recovery • vacuum recovery
	In Situ Treatment	• mixing • sediment relocation • incineration
BIOLOGICAL	Bioremediation	• broadcasting nutrients and mixing
CHEMICAL	Surface Washing Agents (SWA's)	• detergents • herders • dispersants

Feasibility Analysis Examples - 1

- **Earthmoving equipment for removal** can be operated on a sand beach (*FEASIBLE*) but not on a bedrock platform (*OPERATIONALLY INCOMPATIBLE*) – for all oil types
- **Bioremediation** is not logical (*TECHNICALLY FEASIBLE BUT OF LITTLE/NO VALUE*) for solid oils but *FEASIBLE* for small amounts of light and medium oils on sediment shorelines

Feasibility Analysis Examples - 2

- "*feasible but environmentally inappropriate or unacceptable*"
  - machinery in a marsh
  - manual removal (walking) on an oiled mud flat
  - high-pressure heated water on intertidal flora/fauna bedrock
  - etc.

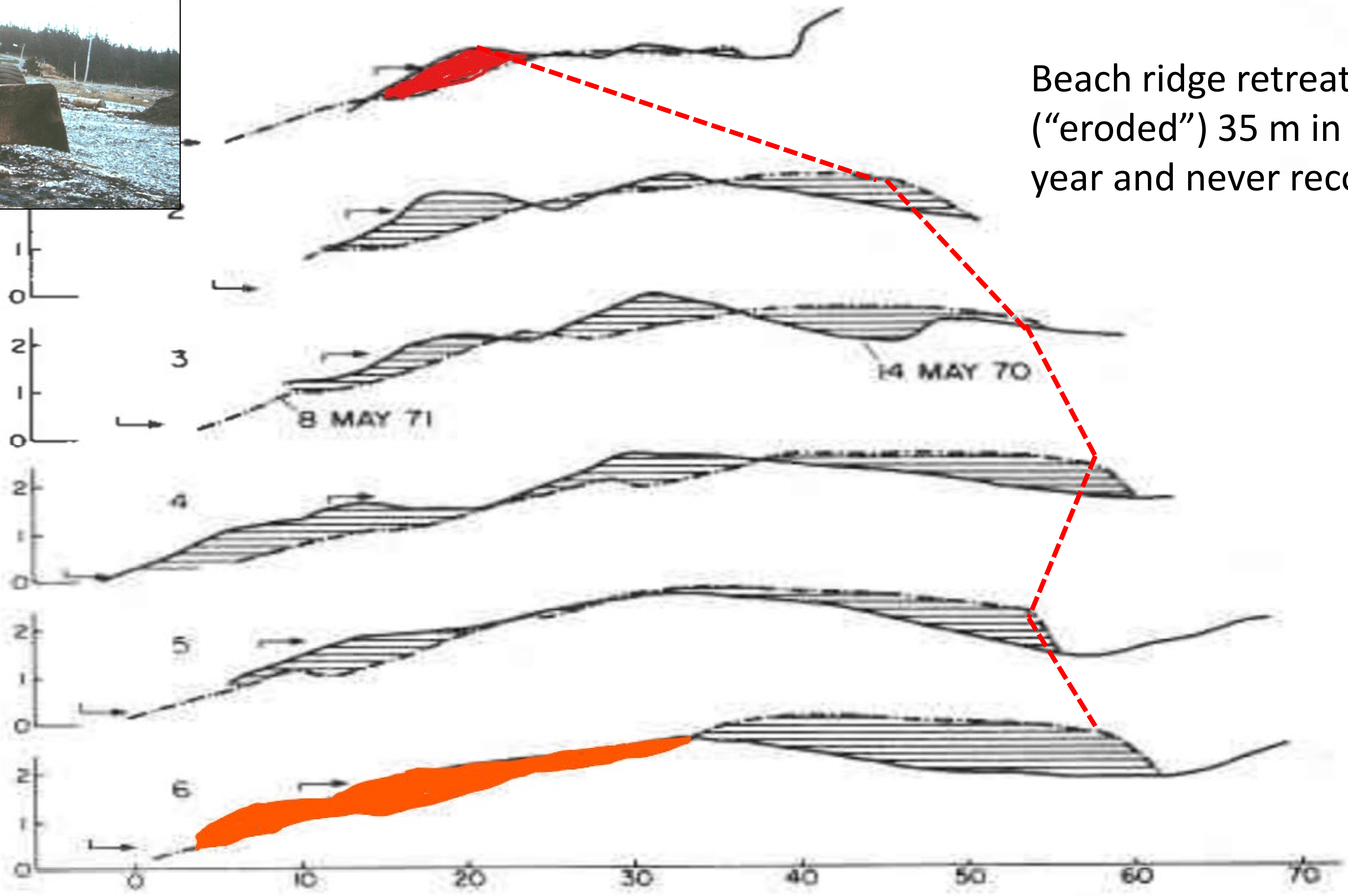
Feasibility Analysis Examples - 3

- "*feasible but environmentally inappropriate or unacceptable*"
  - Many coarse-sediment beaches in Canada and Norway are "relict"
  - They developed from erosion of glacial surficial sediments which are only slowly replace, if at all, if they are removed
  - We documented this in Nova Scotia where sediment was not replaced naturally and resulted in beach erosion

Glacial Till Cliff Materials (%) by Volume

Boulder	Cobble	Pebble	Granule	Sand	Silt/Clay	Water
6.5	6.2	12.8	3.4	15.9	**37.3**	**17.9**

55% of the material eroded from this high cliff does not stay on the beach so that the replenishment rate is very slow



Beach ridge retreated (“eroded”) 35 m in one year and never recovered

Trade-Offs and Consequences

If more than one techniques is feasible and acceptable then what are the key factors in the selection of the better option(s)?

- Environment consequences (Net Environmental Benefit)
- Effort involved (manpower, equipment and logistics support)
- Time to completion
- Waste generation(type and volume)

Shoreline Treatment Tradeoff Matrix

TREATMENT / TRADEOFF	↑ **Waste** ⓘ	Effort ⓘ	Time ⓘ	Environmental Consequences ⓘ
— Natural Attenuation	None	Very Low	Very Slow	No effects
○ Low Pressure Ambient Wash	High	Very High	Very Slow	Medium
○ Physical Mechanical Removal	High	Low	Rapid	Medium

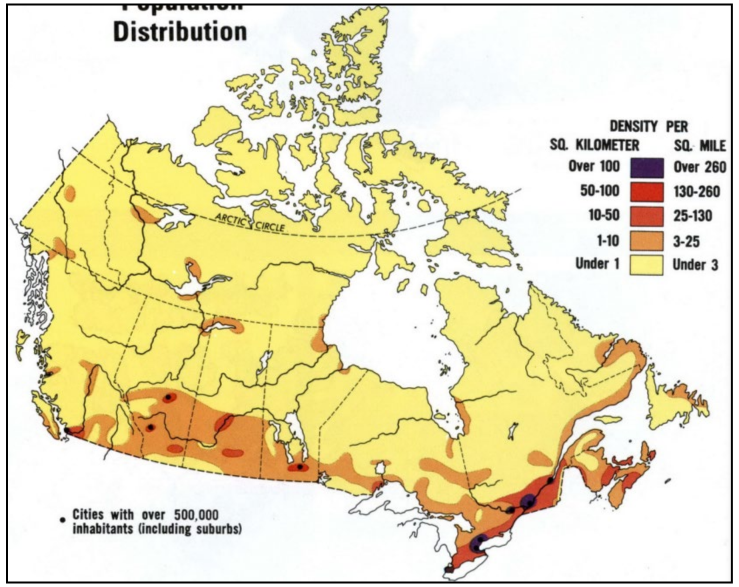
SHORELINE TREATMENT LOGIC

2. OPERATIONAL VIABILITY ANALYSIS

- can use the same environmental (metocean) data already in COSRVA

But, different from COSRVA:

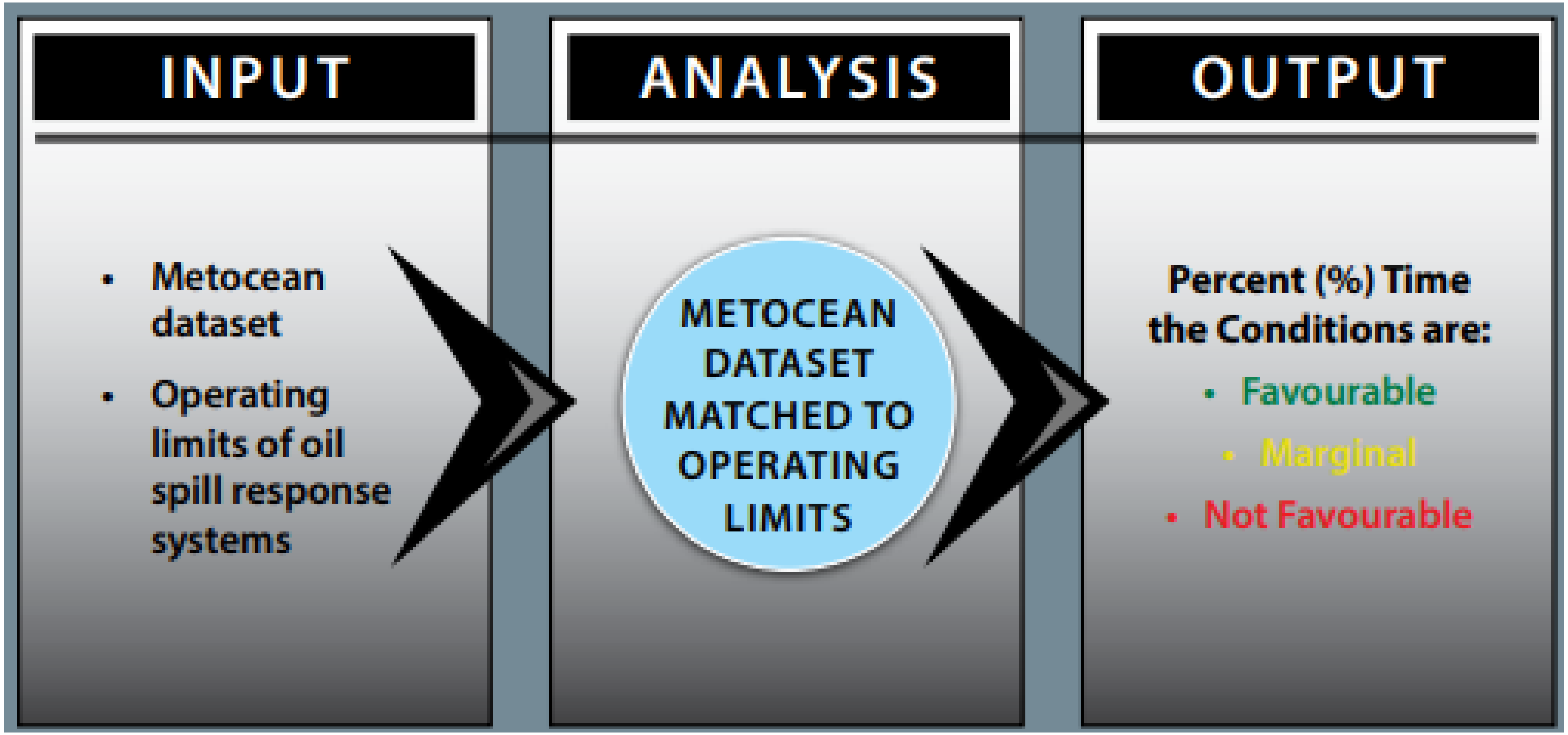
- need to add **ACCESS** in order to implement the treatment option(s) - *nothing happens without LOGISTICS*



Remoteness

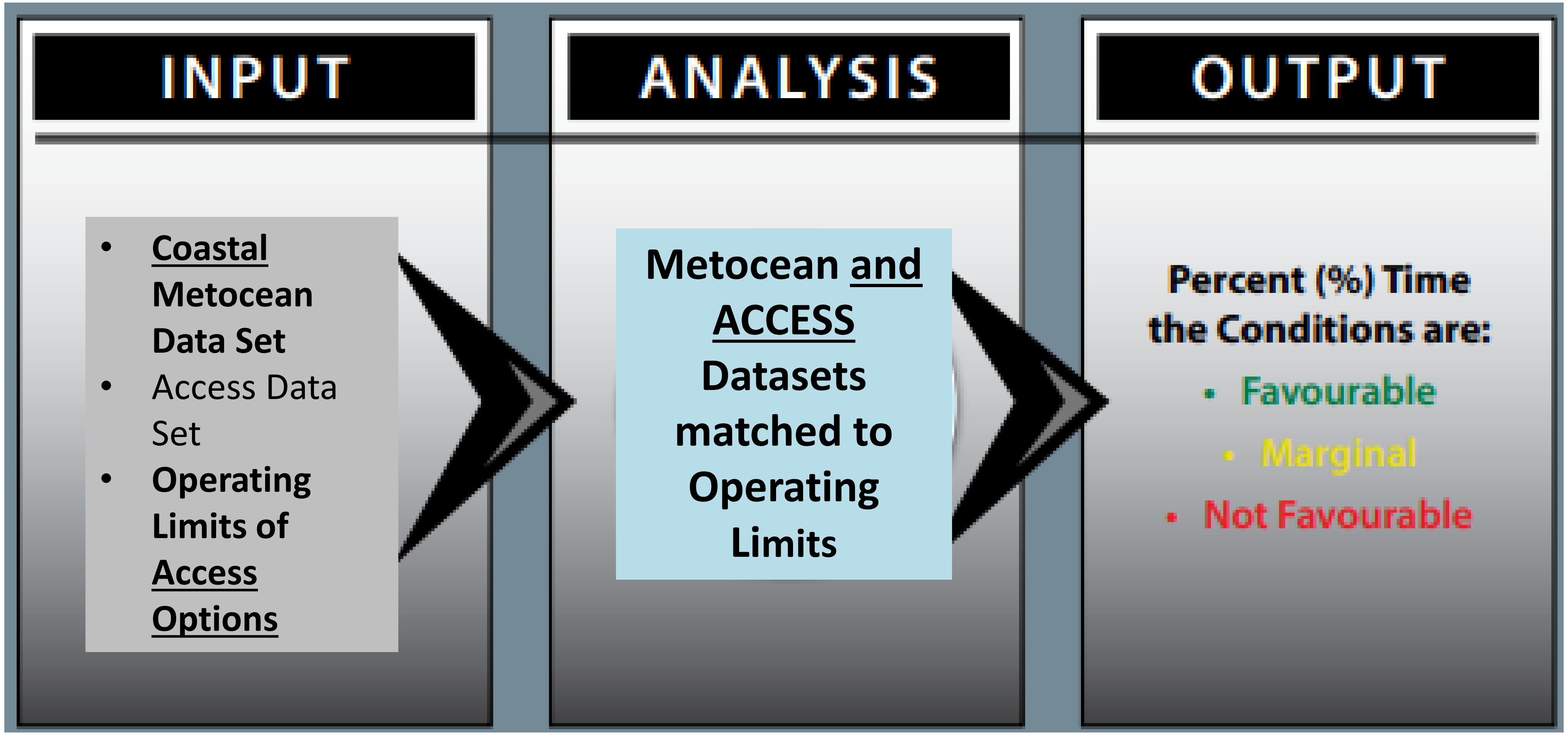
- About 99% of the coast of Canada is “remote” in the sense that shoreline operations would require creating temporary onshore or on water staging support.
  - Population density of 4 per km^2 - and 90% lives within 150 km of the US border !!!
- Norway would not be much different! (15 per km^2)
- An important element in the Operational Viability Analysis

COSRVA
OPERATIONAL VIABILITY ANALYSIS



S-COSRVA

OPERATIONAL VIABILITY ANALYSIS



SHORELINE TREATMENT LOGIC
OPERATIONAL VIABILITY ANALYSIS

? Is the site accessible – by land, sea or air

? Is the site trafficable

- can people move around easily
- can machinery operate on the oiled areas

? Is the site safe and are staging areas available

SHORELINE TREATMENT
OPERATIONAL VIABILITY ANALYSIS

1. Marine Access

- Physical and Logistics Viability
- Operating Environment (metocean) Viability

2. Terrestrial Access

- Physical and Logistics Viability
- Operating Environment (shore zone) Viability

3. Aerial Access (VTOL)

- Physical and Logistics Viability
- Operating Environment (metocean) Viability

Marine Access Viability

Physical and Logistics

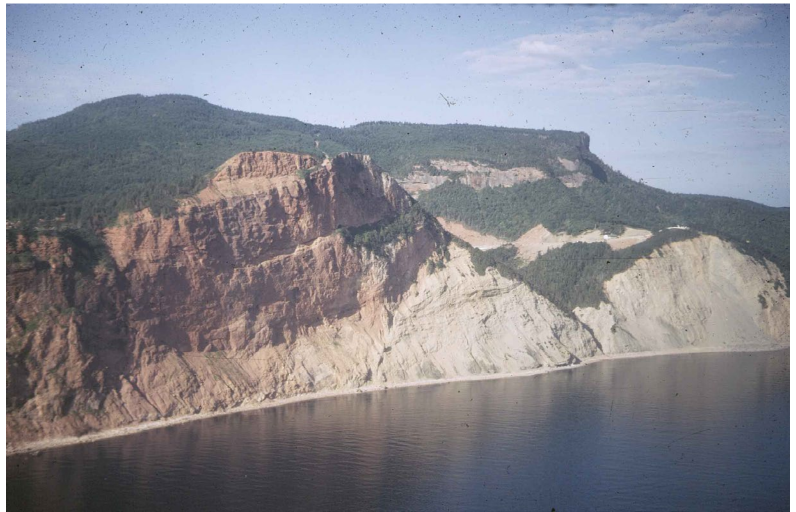
- Water depth
- Obstacles (reef, rocks)
- Infrastructure (dock/wharf)
- Distance (greater or less than 12 hours one way at 5 knots)

Operating Environment

- Significant wave height (<1m - >1m)
- Average wave period
- Sea ice coverage
- Superstructure icing
- Wind speed
- Daylight/darkness
- Horizontal visibility

Terrestrial Access Viability

Physical and Logistics
- Backshore slope
- Obstacles (cliffs, woody debris)
- Habitation distance
- Infrastructure (roads)



Operating Environment
- Tidal range
- Shore-zone ice
- Wind chill
- Daylight/darkness

Aerial Access (VTOL) Viability

Physical and Logistics

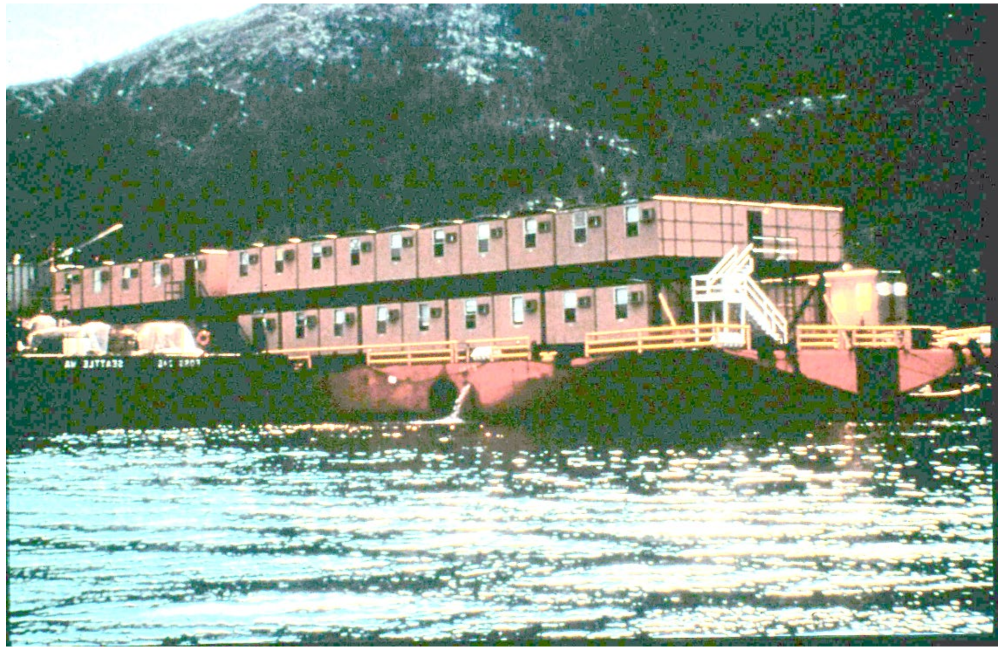
- Terrain (landing site)
- Distance
  - small helo 500 km one way
  - large helo 750 km one way)

Operating Environment

- Wind speed
- Icing
- Daylight/darkness
- Horizontal visibility
- Cloud ceiling

S-COSRVA

- **Feasibility** is about treatment options that are appropriate, practical and reasonable
- **Operational Viability** is primarily about the ability to implement those treatment options: access and logistics



Decision Support Tools and the Complexity of a Shoreline Response

- Shoreline cleanup often is a relatively slow process that takes time to complete – usually ***weeks or even months***
- As a result the opportunity exists for many agencies or interested parties to become involved and ***many meetings and discussions*** can take place during that time period
- S-COSRVA helps ***reduce the complexity*** for planners and decision-makers
- Importantly, offers a way to ***explain the practical options*** (the "Treatment Logic") in an easily understood visual, non-technical format
- Helps explain to local communities as well as the public/politicians the reasons why a decision has been developed, and which is backed by ***solid science***

"S-COSRVA"

- ✓ See a strong potential to add an online "***shoreline response viability***" component to the existing COSRVA concept
- ✓ Considerable ***overlap***, particularly for the environmental metocean data layers
- ✓ Substantial effort ***already completed*** for the Canadian MPRI Shoreline Response Decision Support Tool
- ✓ See a direct application for the coasts of ***all of the Arctic*** as the shore types are the same as those used for the Canadian coast