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NORWEGIAN COASTAL ADMINISTRATION

Tests with In-Situ Burning (ISB) in Norway

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Outline:

- Studies performed; in laboratories, small –scale and field tests
  - ignition
  - smoke emissions
  - soot, black carbon (BC)
  - residues
  - burning efficiency (BE)
  - Fire booms
- Field test - Oil on Water exercise, 2018 (results) and 2019 (plan)
- Two incidents in Norway
  - KNM Helge Ingstad
  - Northguider

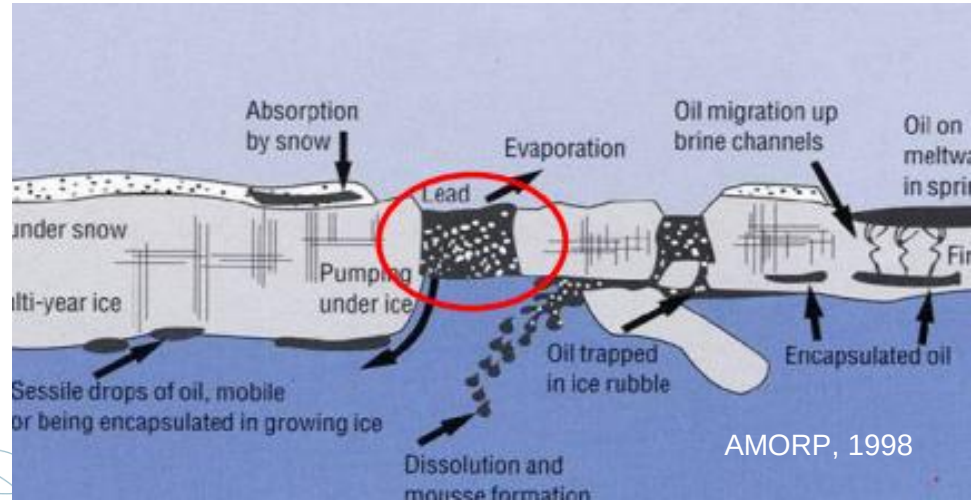
Main stratety for NCA is still mechanical recovery

ISB:

- Not in the toolbox today – increase knowlegde of ISB
- Ice infected areas - Arctic areas

- Oil removed from surface – waste management

- Ignition
- Emission gasses – soot
- Residue



AMORP, 1998

Oils tested:

- MGO – Marine gas oil 0,05% S
- GO – Gas oil 0,001% S
- WRG – Wide Range Gas oil
- IFO 180 (Heavy fuel oil)
- ULSFO and HDME 50, S < 0,1 %.
  Hybrid oils, can be used in S-restricted areas
  Oils that can be used in machinery designed to burn HFO
- Crude oils

SINTEF has performed the tests

→ **Greater variation of marine fuel, MGO is used to a greater extent**

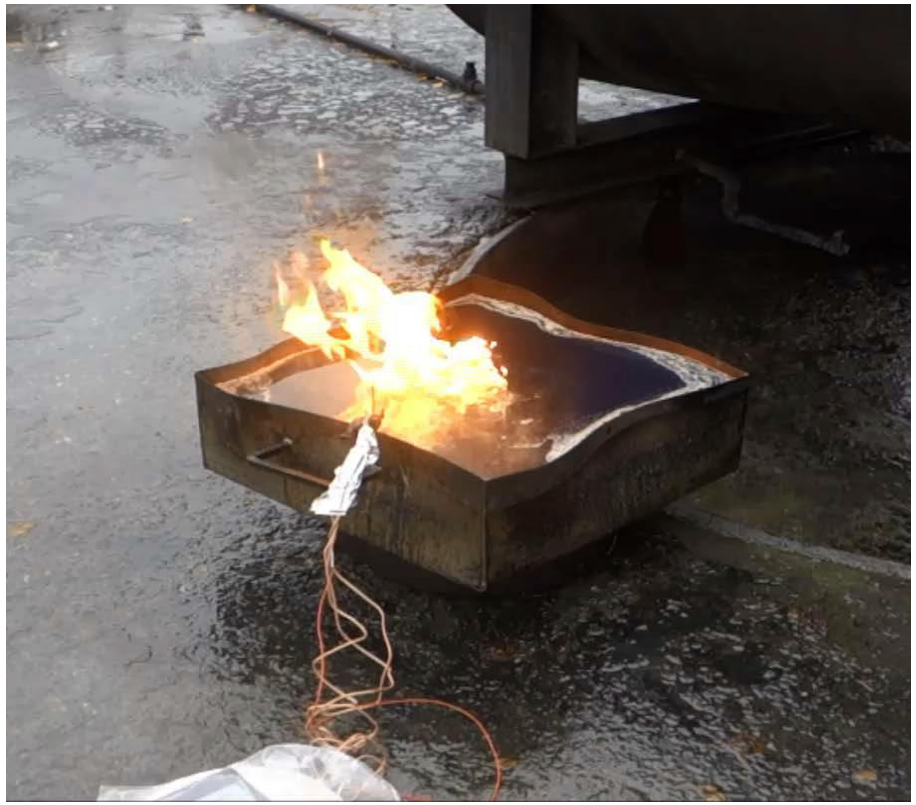
Small scale projects to ignite oil

- Can the oils be ignited?

Burn cell

Ca 110 ml oil

Container, 60 x 60 cm



Ca 4,5 l oil

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Results from burn cell- ignition (small scale tests)

Name	Flash point	Oil applied (g)	Oil after burning (g)	Ignitibility				Burning time (min.)	Burning efficiency (BE%)
				A	B	C	D		
MGO Fresh	62,5	106	32	-	x			18	70
MGO 250°C+	110	113	20	-	-	-	x	8	82
GO Fresh	71,5	102	16	-	-	-	x	10	84
GO 250°C+	107,5	103	25	-	-	-	x	6	75
WRG Fresh	115,5	105	105	-	-	-	-	-	0
ULSFO Fresh	75	117	56	x				16	48
ULSFO Fresh, 10 % water	-	101	-	-	-	-	x	19	-
ULSFO 250°C+	112	110	55	-	-	-	x	11	50
Rotterdam Diesel Fresh	82,5	119	-	-	-	-	x	-	-

Green - oil lit during 3 ignition experiments
Yellow - oil lit with extended ignition time
Red - no ignition

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Burning in container, 60 x 60 cm

- **Used gasoline gel bags (500 ml)**
- **Ignition time varied and can be long**
  MGO and ULSFO were the easiest to ignite
- **Ignition source and method are important!**

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ISB – window of opportunity

Oil	Predicted ignitability			
	13 °C		0 °C	
	2 m/s	5 m/s	2 m/s	5 m/s
MGO	> 5 days	> 5 days	> 5 days	> 5 days
GO	> 5 days	> 5 days	> 5 days	> 5 days
WRG	< 12 hours	< 3 hours	< 2 hours	< 0.5 hours
Rotterdam Diesel	> 5 days	> 5 days	> 5 days	> 5 days
HDME 50	< 2 hours	< 0.5 hour	> 5 days	< 2 days
ULSFO	< 1 day	< 6 hours	< 2 days	< 9 hours

- 5 mm oil thickness
- Time window for how long the oil can be ignited is calculated with the SINTEF Oil Weathering Model (uses: water content, viscosity, wax, asphaltenes, flash point)
- The calculation involves uncertainty, but gives an indication
- The window of opportunity depends on the characteristics of the oil and the weather situation

Smoke emissions

- ISB performed in the RISE lab in Trondheim
- Smoke emissions and residue investigated

- The burning efficiency was 90%, due to splashing it might be overestimated
- Densities of residue < 1

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Oil on Water exercise - OPV 2018

- NOFO (Norwegian Clean Sea Association for Operating Companies) and NCA (Norwegian Coastal Administration) are the organizers of the ISBs
- Performed in the North Sea
- NOFO and NCA plan to use ISB as a response method.
- Application to the Environmental Agency for release of oils, weather restrictions, wind < 8m/s
- Verification of the results from the small scale testing
- Operational experience
- Two ISBs performed

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Two ISB tests, oil pumped into the boom:
- 5,8 m^3 of ULSFO
- 6 m^3 of Oseberg crude

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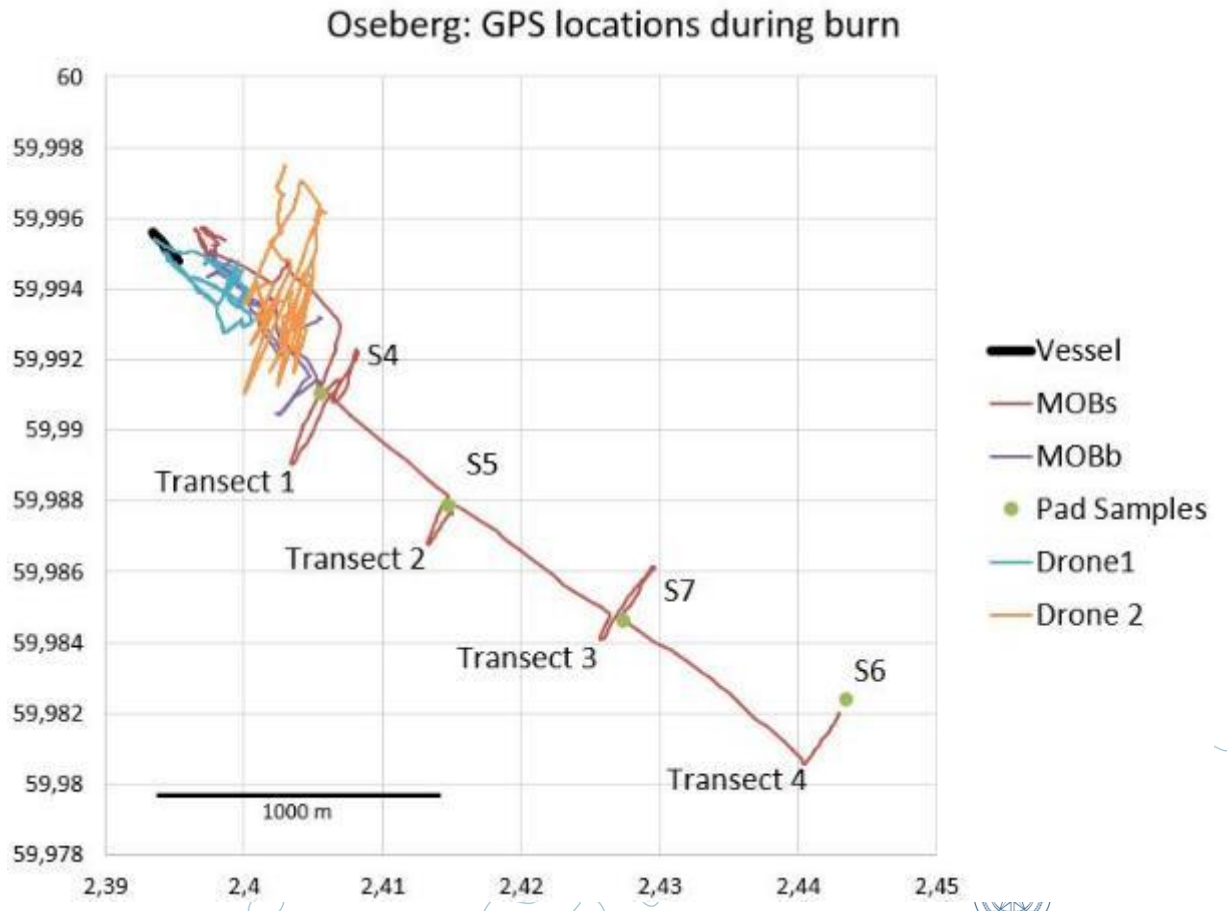
Monitoring program

Drone 1 and MOB-B: Near zone to the burn (< 400m)
Drone 2: From approx. 400 to 800m from the burn
MOB-S: Up to approx. 3 km from the burn

Parameter	Drone 1	Drone 2	MOB-S	MOB-B
Particulate matter (PM)				
PM 1, 2.5, 4, 10 and total	X		X	X
PM 2.5		X		
Soot on filter (to PAH)	X	X		
Gases				
NO_X	X			
SO_2	X			
CO	X			
CO_2	X			
Soot downfall on sea surface			X	
ISB residue			X	
Human exposure				
TVOC/BTEX				X
Filter (PAH)				X



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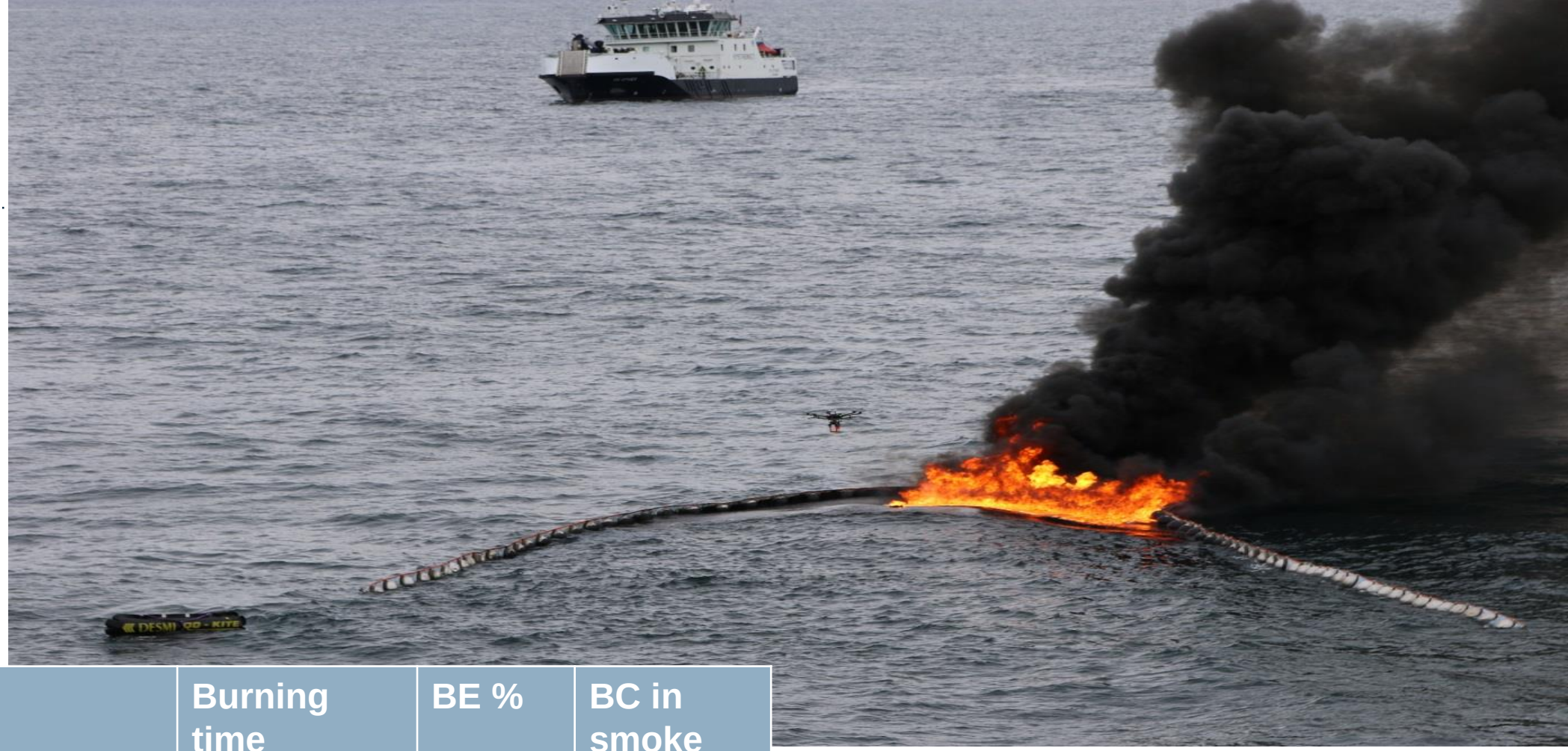
Film



ISB, June 2018	Burning time	BE %	BC in smoke
ULSFO, 5,8t Ultra Low Sulphur Fuel Oil - hybridoil	48 min	> 57	11%
Oseberg, 6t pre-weathered -approx. 1/2 day on sea)	43 min	Ca 80	10%

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Results, from Oil on Water 2018 and testing in laboratory

Oil on Water – 2018, ULSFO & Oseberg oils

Smoke emissions

- NO_x (1,2 ppm) and SO_2 (2.1 ppm) were low
- CO_2 concentration 200 -500 ppm above background level

Soot/BC

- 90% of the particles were smaller than 2,5 µm (PM 2,5)
- BC was 97g/kg for Oseberg, 107 g/kg for ULSFO (from OPV 2018)

Laboratory and small-scale tests:

Oil on Water exercise verified former results

IFO 180 more release of BC (app. 250g/kg) and emission gasses.

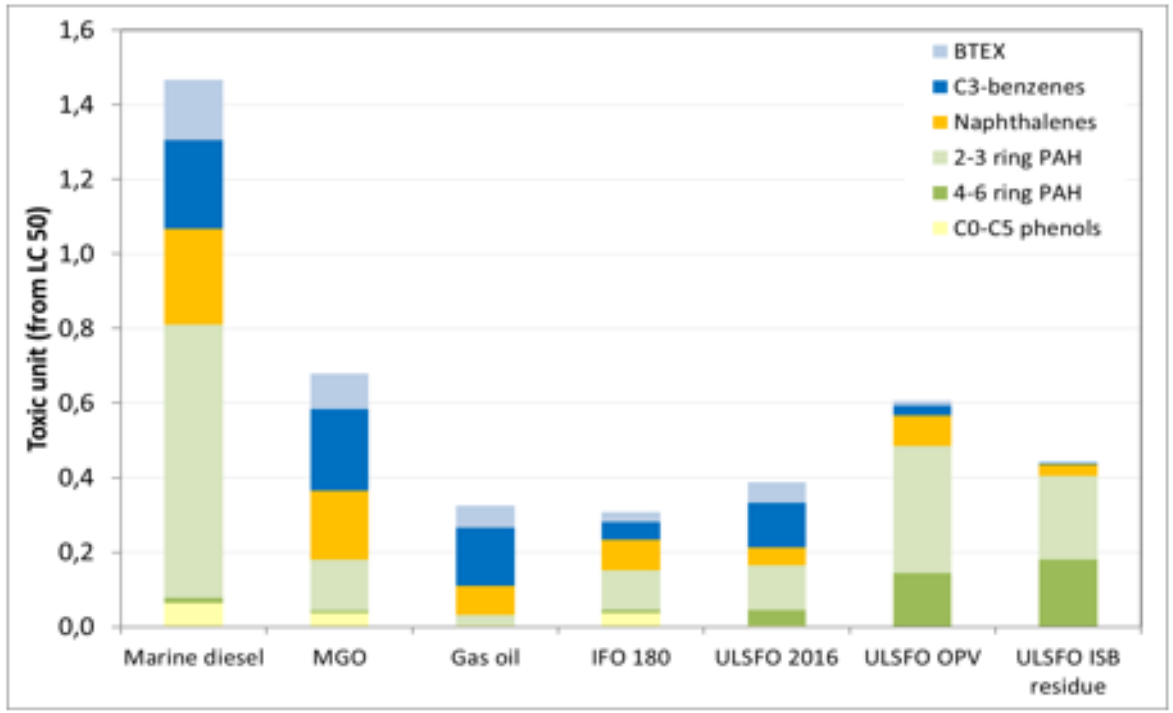
Black Carbon (BC) is the lightabsorbing parts of the fine particles (PM 2,5)
Organ Carbon (OC) is the lightreflecting parts of 2,5 PM
BC + OC = soot

Residue

-Water accommodated fraction (WAF) of unburned oil and residue of oil was tested (SINTEF)

- Toxit Unit (TU) below 1. Tested on Calanus finmarchias CV & nauplii (zooplankton)
- If residue contains a mixture of unburned oil → more toxic

- Develop methodology for chemical analyses of the burn residue (50, 70 and 90 %) to decide Burn efficiency (BE) (SINTEF and SL Ross)
- Sinking of IFO 180 residue?
- MGO residue is very thin



TU > 1 indicats a mortality of 50% for the tested organisms.

Field experiments

2018

- Two successful burns were performed
- Both slicks were ignited by the Pyrodrone
- The Pyroboom was less robust than expected
- A large amount of monitoring data collected….

2019

- Five ISBs are planned in June

Reports are public and available:
https://www.kystverket.no/Beredskap/forskning-og-utvikling/in-situ-brenning-isb/

KNM Helge Ingstad, grounding in November 2018

Oil budget	Amount of
Oil onboard	Total 500 m^3 oil, of which 460 m^3 marin diesel
Oil pumped from vessel	143 m^3 marin diesel
Oil in vessel when taken to land	App. 5 m3
Total leakage to sea	App. 352 m^3
Recovered oil (booms etc)	68 m^3
Discharges to the sea, evaporated + dissolved	284 m3

- Monitoring
- Mechanical oil recovery
- Environmental impact program

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Northguider, fishing vessel, grounded in Svalbard- December 2018

79°53.880 N, 18°04.517 E

- The vessel had 330 m3 marine diesel on board
- Vessels were emptied from 9-13.1 2019, IBC containers used
- If all MGO had leaked into 90% ice - diesel would had a very long life time
- Large amounts of seabirds in the spring, as well as seals, polar bears and whales
- Had diesel been conserved in ice it would have become a serious and demanding environmental incident

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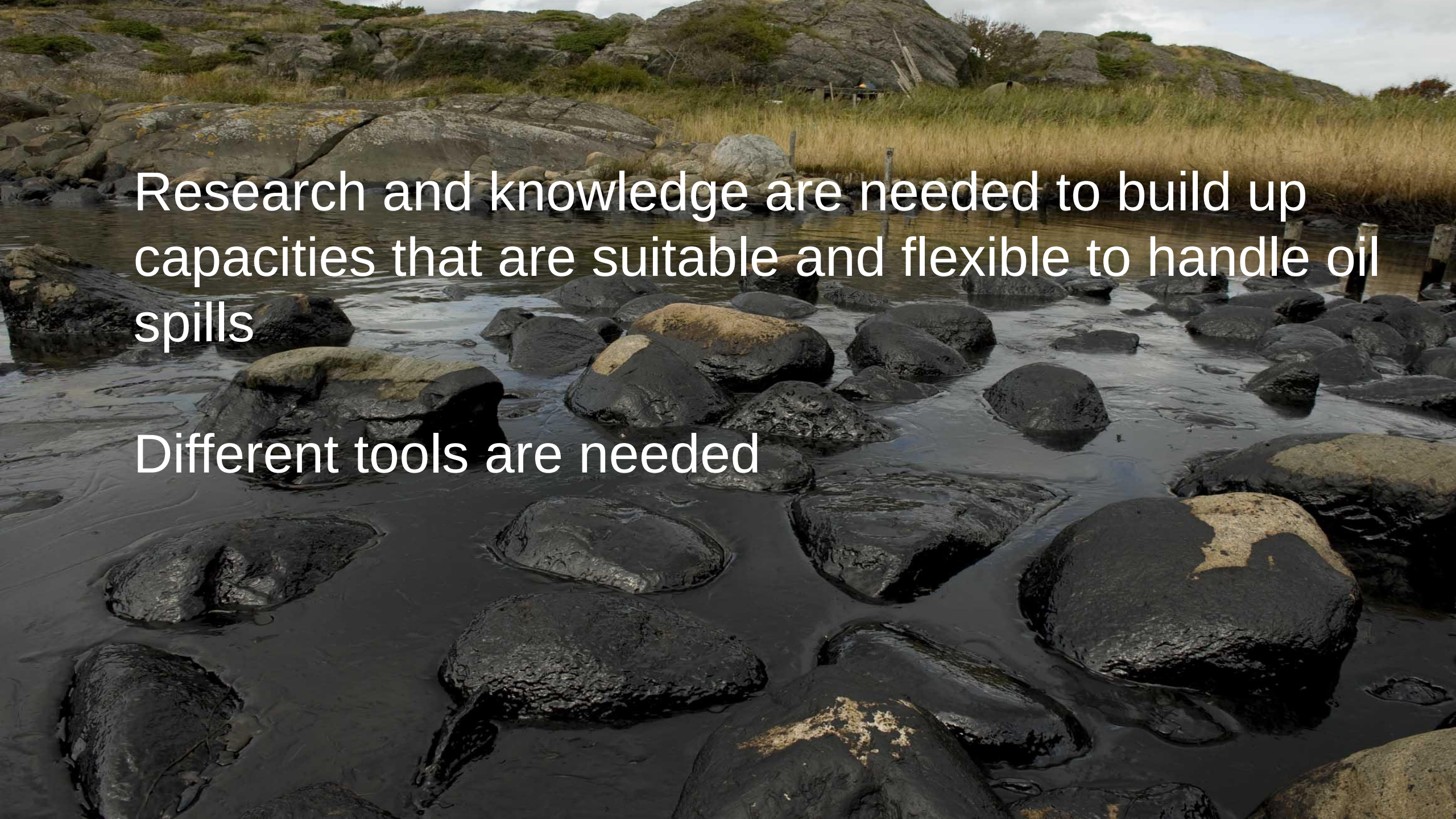

Research and knowledge are needed to build up capacities that are suitable and flexible to handle oil spills

Different tools are needed