Oil on Water 2022

NOFO

KYSTVERKET

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Summary:
Oil on Water (OoW) 2022 is a collaboration between the Norwegian Clean Seas Association for Operating Companies (NOFO) and the Norwegian Coastal Administration (NCA). The verifications were carried out in the period 6–16 June.

The objective of trials 1, 4 and 5 was to verify movement of an emulsion of high-wax oil with a high solidification point to different skimmers in a Current Buster 4 system. Adequate movement was verified for emulsions of both VLSFO and Duva oil, and the trials provided sufficient measurement data to indicate the recovery rate for the selected types of skimmer. Several observations were also made that may be extremely useful in terms of optimising operational use of the oil spill response equipment that was used.

The main objective of trial 6 was to provide a better understanding of the dispersion of MGO in terms of drift, spreading, weathering and oil film thickness. The results will be used to compare measurements with remote measurement sensors and to verify existing spreading models. Sampling was carried out in the slick, with samples taken to estimate the thickness and weathering of the oil film, and to carry out physical analyses. The slick spread less than expected, and the oil film thickness was thicker than expected in the first hours after the release. Remote measurement data was collected from satellites, aircraft, drones and vessels. Both IR and radar technology were used, as well as visual observations and images.

OoV is an extremely valuable activity in order to be able to meet regulatory requirements that equipment used to counteract acute pollution must be tested under realistic conditions in terms of functionality, operativity and collection efficiency.

The learnings and utility value from this year's OoW were again substantial for all the parties involved. As well as this year's OoW verifications, the collaboration has provided significant learnings related to teamwork and operational understanding, and we consider OoW to be a vital arena for further development of Norway's oil spill preparedness going forward.

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Contents

1 Introduction

1.1 General

Oil on Water (OoW) is a collaboration between NOFO and the Norwegian Coastal Administration (NCA), comprising verifications and trials involving release of oil at sea. One principal goal is to obtain as much knowledge and experience as possible for the organisations involved in oil spill preparedness.

The Norwegian Environment Agency processed NOFO's application for the project activities, and the Agency's release permit laid down the requirements for OoW. A release permit was granted for a period of two weeks for execution of all the trials during OoW 2022. Oil on Water 2022 was executed in the period from 6 to 16 June in accordance with the application and the requirements laid down by the Norwegian Environment Agency.

The present report provides a summary of the execution of OoW and some of the main results. More detailed information is available on request from NOFO or the NCA.

NOFO and the NCA are highly satisfied with the positive cooperation during the trials with the Norwegian Coast Guard, Sundt Air, Aker BP, Neptune Energy, SINTEF, NINA, Tiepoint and the other participants. The NCA and NOFO would like to take this opportunity to thank all parties for their contributions to OoW 2022.

1.2 Purpose

The overall purpose of OoW is to verify and further develop Norway's oil spill preparedness. Separate objectives are also described for the individual trials. These underlie execution of the individual activities, but the project generated many more results than those that can be linked directly to the different objectives.

1.3 Abbreviations and definitions

The table below provides definitions of abbreviations and expressions used in the document. There are, however, several technical terms in the document that are not defined below.

Table 1: Key abbreviations and definitions used in this document

Abbreviation	Description
OoW	Oil on Water
NCA	The Norwegian Coastal Administration
NOFO	The Norwegian Clean Seas Association for Operating Companies
MET	The Norwegian Meteorological Institute
MGO	Marine Gas Oil – Marine bunker oil comprising distillates only
NINA	The Norwegian Institute for Nature Research
ULSFO	Ultra Low Sulphur Fuel Oil
VLSFO	Very Low Sulphur Fuel Oil
IR	Infrared
EO	Electro-optic
KV	The Norwegian Coast Guard

1.4 Organisation

The figure below illustrates the organisation established for OoW. The dark-grey boxes are operational units at sea and in the air. The other boxes show NOFO's onshore preparedness organisation.

The steering group for OoW comprised representatives of NOFO and the NCA. The offshore task force leader (ILS) coordinated the offshore operations, assigning command to the parties responsible during their respective trials. The preparedness organisation acted as a support unit for the operational units, and was also assigned the task of taking over the operations if the activities exceeded the scope described in the operating orders for OoW.

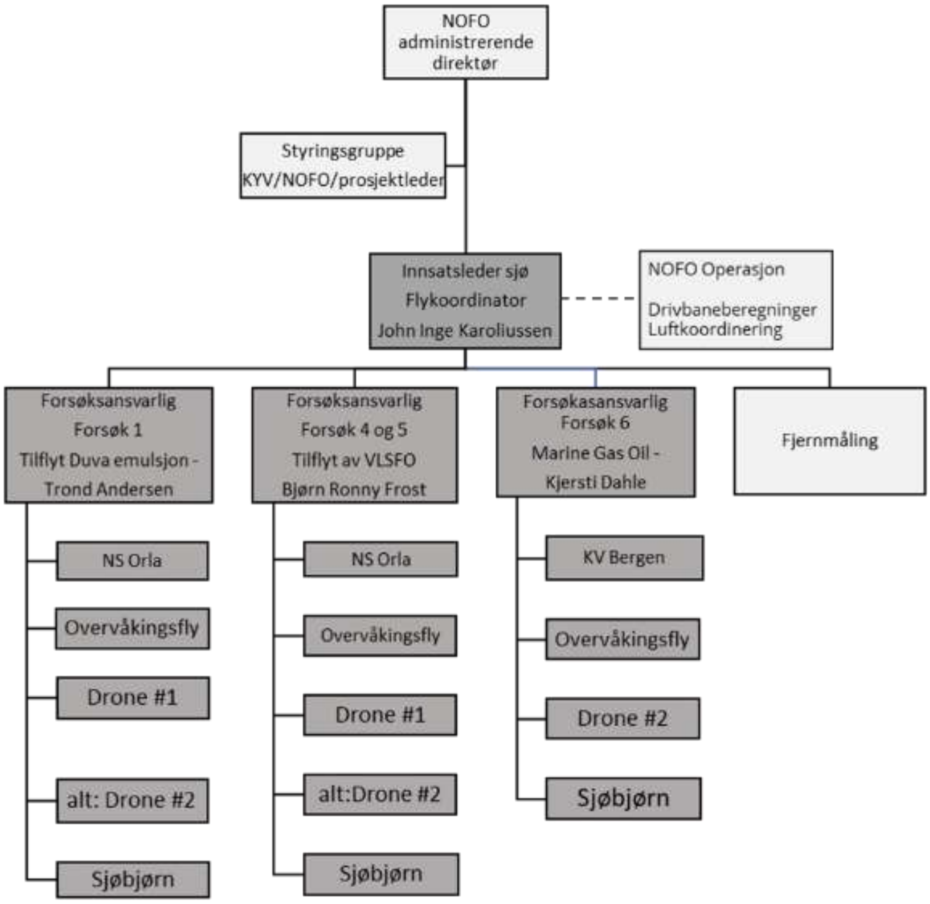

Figure 1: Organisation chart for OoW 2022

1.5 Trial area

The trials were conducted at the Frigg field within a radius of 10 nautical miles from position 59º50'N 002º25'E (see Figure 2).

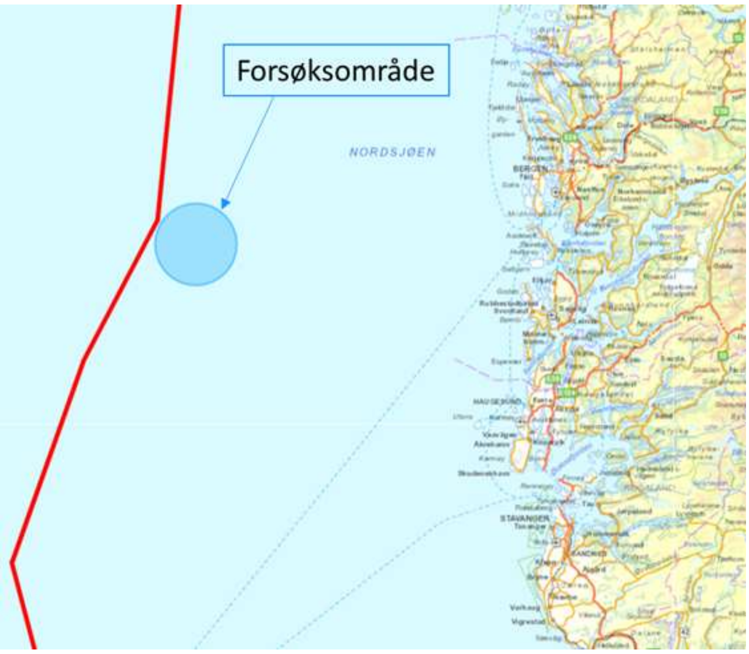

Figure 2: Map extract showing the area in which OoW was conducted (blue circle).

1.6 Participating units

A large number of persons and organisations are involved in the planning and execution of OoW. The table below provides an overview of the key units during execution of the offshore activities.

Table 2: Overview of participating resources during OoW.

Name	Role
KV Bergen	Release / Drone / Remote measurement / Trial 6 / Preparedness / Command
NS Orla	Release / Remote measurement / Drone / Trials 1, 4 and 5
LN-KYV	Remote measurement from aircraft (detection and surveillance)
NOFO's preparedness centre	Supporting offshore operations
NOFO, Stavanger base	Mobilisation and demobilisation of vessels and equipment
Tiepoint	Drones – surveillance
SINTEF	Oil chemistry
NINA	Clearance for trial area and drift trajectory in relation to seabirds and sea mammals
Kongsberg Satellite Services (KSAT)	Satellite surveillance
MetOcean	Drifting buoys – supplement to AIS buoys
Furuno	Operating/tuning oil radar for use in Trial 6
NorbitAptomar	Operating/tuning SECurus spill detection system for use in Trial 6
The Norwegian Meteorological Institute	Weather forecasts and drift trajectory model
Sjøbjørn (KV Bergen's MOB boat)	Practical support for execution of trial

1.7 The trials

The table below provides an overview of the trials and the volumes of oil released. Trials 2, 3, 7 and 8 were cancelled in the planning phase.

Vessels were mobilised for trials 1, 4, 5 and 6 on 6 June 2022. On 8 and 9 June 2022, conditions were right for trials 1, 4 and 5. On completion of these trials, the vessels returned to dock to await satisfactory weather conditions. Trial 6 was executed on 15 June. Demobilisation of all the resources was complete on Friday 16 June.

Table 3: Overview of trial, release medium and volume. Max. permitted release volume in brackets.

#	Trial	Duva emulsion	ULSFO	VLSFO	MGO
1	Movement of Duva oil in CB4/MS 50	17 m^3 (18 m^3)	-	-	-
2	Movement of ULSFO CB4/Foxtail 4-9	-	0 m^3 (10 m^3)	-	-
3	Movement of ULSFO CB4/LWS 500	-	0 m^3 (10 m^3)	-	-
4	Movement of VLSFO CB4/Foxtail 4-9	-	-	3.9 m^3 (10 m^3)	-
5	Movement of VLSFO CB4/LWS 500	-	-	4.8 m^3 (10 m^3)	-
6	Spreading of marine gas oil (MGO)	-	-	-	10 m^3 (10 m^3)
7	Remote measurement – Categorisation of releases	-	-	-	-
8	Remote measurement – Verification of remote measurement sensors	-	-	-	-

1.8 Remote measurement and preparedness

A comprehensive remote measurement programme was planned and executed in order to have oversight of where the oil was, its extent and direction of drift at any time. Various platforms and sensors such as satellite passes were utilised both morning and evening, along with remote measurement aircraft and sensors on vessels, drifting buoys and drones, giving the preparedness organisation a good overview of the oil and how it spread. KV Bergen was set up with NorLense, Noren and Foxtail skimmers on board. In order to deal with combatable oil after boom leaks or unintentional releases, a Current Buster 6 system was also mobilised on KV Bergen for mechanical collection, as well as dispersants and spray booms so that both combat measures were available.

2 Execution and results

2.1 Movement in Current Buster 4 – trials 1, 4 and 5

2.1.1 Purpose

Both NOFO and the NCA use the Current Buster 4 (CB4) system as a core part of their oil spill preparedness. The objective of the trials is to verify the movement of an emulsion of high-wax oil with a high solidification point to different skimmers in the CB4 system. In addition, for the trials involving low-sulphur bunker oils, we wanted to be able to compare the skimmers' properties and recovery rates for the same oil types in order to have the best possible decision-making basis when choosing oil spill response equipment for these new bunker oils.

2.1.2 Execution

The CB4 system and the various skimmers were mobilised on board NS Orla together with a system for releasing the different oil emulsions. Trials 1, 4 and 5 were executed sequentially in the same way but using a different oil emulsion, volume and skimmer in accordance with Table 3.

The CB4 system was deployed and operated in formation on the vessel's starboard side. Emulsion for the different trials was discharged on to the surface just in front of the opening of the CB4 system, such that the entire volume was channelled into the separator. Once the emulsion had been collected in the separator, lifting gear at the rear on the starboard side was used to lift the skimmer up into the separator for recovery.

CB4 is basically a shoreline system, which is normally operated by smaller vessels that tow the CB4 behind them, with skimming carried out with the aid of another vessel. Operating the equipment on a larger offshore vessel, as during the trials, meant that both release and recovery of the emulsion were carried out by the same vessel. This affords very good coordination and control during both release and recovery.

Figure 3: Release of oil emulsion in the CB 4 system.

2.1.3 Remote measurement and preparedness

NS Orla had drones mobilised to document execution of the trials and to detect any boom leakage from the CB4 system during the trials. There was redundancy for both drones and drone pilots, and the drones had both IR and EO capacity.

While trials 1, 4 and 5 were executed on board NS Orla, KV Bergen was in immediate proximity behind NS Orla with various remote measurement sensors to detect any boom leakage involving combatable oil emulsion (Figure 4). A fixed IR and EO camera, oil-detecting radar, and drones with IR and EO capacity were used for this work. KV Bergen was fitted with equipment for both mechanical collection and chemical dispersion.

Figure 4: KV Bergen on standby behind NS Orla, which is conducting a trial. IR photography is actively used to detect any boom leakage.

2.1.4 Release of oil

The emulsion of Duva crude oil and VLSFO was placed in separate 20 m^3 container tanks on deck, connected to a common release system. By having separate tanks of appropriate size, we had control of the volume released in the various trials. The release system was connected to a pump and hose system, which was rigged such that the emulsion was discharged in a controlled manner onto the surface just in front of the CB4 system and was channelled into and collected in the separator part ready for recovery.

The entire release system was connected using a valve and hose system so that the releases could be prepared and carried out without needing to stop to connect hoses. Water was also prepared to rinse through the hoses after use to ensure that all the oil emulsion had been discharged.

The emulsion of Duva crude oil was stored in IBC containers in a refrigerated container on deck during transit before being transferred to container tanks prior to release. This was done to ensure that the emulsion did not separate during storage. As well as storing the emulsion in a refrigerated container, the release system was designed such that the emulsions could be circulated in the container if they still showed signs of separating.

Both visual observations and observations using an IR camera showed that the emulsions stayed on the surface in an even pattern and were channelled into the separator without visible boom leakage from the separator. On a few occasions, it was possible to identify a trace of a leak that apparently was not coming from the separator but from the transition between the deflector and channel leading in to the separator. No combatable emulsion was observed at sea.

2.1.5 Recovery of oil

The skimmers used were powered by their own hydraulic aggregates, which is how they are operated for the purposes of shoreline preparedness. The trials were executed from an offshore vessel, and the wind and wave conditions did not therefore present a challenge for a vessel of this size. However, the relative movements between the CB4 system on the sea and the skimmer, which was being operated by the lifting gear on the vessel, were greater than is normal in shoreline preparedness. It worked satisfactorily, but made greater demands of precision from the operators of the equipment during the trial. The properties of the emulsions also demanded greater precision in terms of speed of brush and pump.

The oil emulsion that was pumped on board was pumped through a dedicated system of hoses and valves into separate container tanks on deck in order to keep check of the amount collected both during and after the trial. These tanks were drained after the emulsion had settled in them, with total volume, drained volume and remaining volume all being recorded. Together with the start and finish times, this provided a basis for calculating pump rates.

Trial 1 – Markleen MS 50 (brush skimmer/multiskimmer)

Trial 5 – Foxtail 4 – 9 (adhesion band skimmer)

Trial 4 – Lamor LWS 500 (brush skimmer)

Figure 5: Recovery of emulsion with respective skimmer

2.1.6 Sampling

Samples of emulsion were taken during the trials. During recovery, continuous samples were taken to check the ratio of emulsion to free water. The visual result of these samples was used to provide immediate feedback to the operator so as to optimise operation of the skimmer. The samples were analysed on a number of parameters, including viscosity and water content.

2.1.7 Results

Adequate movement to the skimmer was verified in all three trials. Measurement data was also logged in order to indicate recovery rate; see Table 4. Once the measurement period in the trials was concluded, the remaining emulsion in the boom was pumped on board before the next trial started.

Table 4: Overview of measurement results from trials 1, 4 and 5

Trial	Skimmer	Release (m^3)	Recovery of oil* (m^3)	Recovery of water (m^3)	Viscosity @ $10s^{-1}$ (mPas)	Temperature (°C)	Recovery rate* (m^3/t)
1	MS 50 - Part 1	9.6	7.3	1.3	2644-4368	14-18	***
1	MS 50 - Part 2	6.8	4.9	0	4079-5098	13-14	14.7
4	Foxtail 4-9	3.9	3.5	1.4	5867-6731**	13-17	8.4
5	LWS 500	4.8	3.3	0.8	6180-7491**	13-15	13.7

* in the measurement period
** analyses of the samples were not carried out in the field and this may have affected the analysis results
*** scraper on skimmer came out of alignment

Table 5: Documentation from following platforms/sensors/roles

Sensor/source	Platform	Contents	Comments
Tiepoint drone (IR, EO)	NS Orla	Freeze frame, video	Large volume of material.
NCA drone (IR, EO)	KV Bergen	Freeze frame, video	Large volume of material.
Oil samples	NS Orla	Report, log	
OSD	KV Bergen	Screen dump	
SECurus (IR, EO)	KV Bergen	Video, images, screen dump	
Handheld camera	Images/film		Multiple persons from NOFO, NCA, NINA, SINTEF

2.1.8 Achievement of goals and utility value

Movement of Duva oil – trial 1

Adequate movement of an emulsion of Duva crude oil was verified to Markleen MS 50 skimmer in the CB4 system. One of the pumping periods indicates a recovery rate of approx. 15 m^3 per hour without incorporation of free water.

Observations were also made that may be useful in terms of optimising the equipment used for oils with properties of this type. This concerns the following aspects, which includes both operational use and technical design:

- An emulsion with properties of this type requires brushes to run at relatively low speed to ensure low recovery of free water, especially when there is little oil in the separator
- The movement to the skimmer was reduced as the oil thickness in the separator decreased – towards the end of the trials
- It seems as if the separator in the CB4 system holds less emulsion (with properties of this type) before it builds up in the channel and deflectors

Movement of VLSFO – trials 4 and 5

The objective of the trial was to verify movement and recovery of an emulsion of a VLSFO bunker oil by the Norwegian Coastal Administration's standard skimmers in the CB4 system. The Norwegian Coastal Administration wanted to conduct this trial as a continuation of earlier tests using other VLSFO oils in its test basin. During Oil on Water, we wanted to be able to verify recovery of VLSFO oils in more realistic weather and operational conditions, providing valuable experience for an oil spill response operation.

The Norwegian Coastal Administration was able to verify that the selected skimmers function in terms of recovering the selected VLSFO bunker oil. The VLSFO oil adhered relatively well to both the adhesion band skimmer and the brush skimmer, but its inflow into the brush skimmer was somewhat poor. Nevertheless, there was good recovery because of the large quantity of oil in the recovery chamber.

2.2 Spreading of marine gas oil (MGO) – trial 7

2.2.1 Purpose

In light of the change in fuel types used in shipping, with heavy oil being replaced by other fuel grades such as MGO, there is a need for greater knowledge linked to releases of light distillates. The purpose of the trial is to gain:

- Better knowledge of the drift and spreading of light oil types.
- Better knowledge of the window for measures in connection with releases of light oil types.
- Documentation of spreading, weathering and oil thickness under actual conditions.
- Verification and comparison of remote measurement sensors on thin oil films with limited self-colour.
- Verification of existing spreading models.

2.2.2 Execution

10 m^3 MGO was released onto the sea as a point discharge. The MGO slick was able to drift freely and spread unhindered. A light boat (Sjøbjørn) was used with two boatmen and two persons from SINTEF. These persons carried out all the sampling from the sea during the trial. Safety masks were worn in the light boat as respiratory protection against evaporation from the diesel on the sea. According to the plan, the light boat would navigate as little as possible within the area of the slick and not influence the spreading and drift, but navigation into and out of the slick proved to have little effect. In parallel with this, data was collected from drones, satellites, aircraft, SECurus and OSD, as well as visual observations.

The trial was finished after 8 hours. Smaller areas with thicker diesel remained at the end of the trial (identified by means of sampling and IR camera) and were mechanically dispersed by KV Bergen and Sjøbjørn. Sensors from aircraft, satellites and on board KV Bergen detected no combatable diesel once mechanical dispersal was complete.

2.2.3 Remote measurement and preparedness

KV Bergen had a drone mobilised to document execution of the trial. There was redundancy for drone pilots, and the drones had both IR and EO capacity. A fixed IR and EO camera, oil-detecting radar and drones with IR and EO capacity were used for this work.

In trial 6, the diesel was to float freely and preparedness measures were to be available if there was assessed to be combatable diesel remaining after 8 hours. KV Bergen was fitted with equipment for both mechanical collection and chemical dispersion.

2.2.4 Release of MGO

10 m^3 marine diesel (MGO) was released into the sea from KV Bergen. The release system was rigged such that the oil came out immediately beneath the surface and a short distance from the side of the vessel, so that the oil could start drifting unaffected by the side of the vessel and the slipstream. The entire release took approx. 25 mins.

Figure 6: Release of marine diesel into the sea.

2.2.5 Weathering and spreading of MGO

The diesel remained as a cohesive slick throughout the trial, at the same time as it moved slowly beyond its original boundaries. The slick was also clearly visible both visually and by other means of detection for longer than expected. Estimation of area/extent varied significantly using different detection methods.

Visual observations from the bridge estimated the slick to be 200 m x 400 m=80,000 m^2, the SECurus EO camera on the roof of the bridge measured 8,000 m^2, and oil-detecting radar (OSD) 1,300,000 m^2. The drone using EO and IR cameras estimated the extent to be 200 m x 600 m=120,000 m^2. OSD took little regard of thinner and broken-up areas.

The Bonn Agreement Oil Appearance Code (the Bonn Code) for estimating the volume of oil at sea uses colour codes as a guide to the thickness of oil slicks; see Table 6.

Table 6: The Bonn Code of volume estimation at sea

Code	Description – Appearance	Layer Thickness Interval (µm)	Litres per km^2
1	Sheen (silvery/grey)	0.04 to 0.30	40–300
2	Rainbow	0.30 to 5.0	300–5,000
3	Metallic	5.0 to 50	5,000–50,000
4	Discontinuous True Colour	50 to 200	50,000–200,000
5	Continuous True Colour	More than 200	More than 200,000

Observations were made using the above colour codes. With the naked eye, we judged most observations of the slick as “Sheen” and “Metallic” with patches of “Rainbow”. However, sampling in the slick showed that much of what looked “Metallic” was in reality “Continuous True Colour”, i.e. much thicker and hence greater in volume. In the case of visual observation of transparent oils such as MGO, by both the naked eye and aerial images, volume in the sea can easily be miscalculated if relying on estimates based on the colour code in the Bonn Code.

The drift trajectory model, where modelling was set to drift for 24 hours, shows a total drift of approx. 11 km with 8 m^3 of the total release of 10 m^3 still on the surface.

Figure 7: Drift trajectory calculation of release of 10 m^3 diesel and estimate of 24-hour drift. After 24 hours, 8 m^3 of the drift is still on the surface and the slick as a whole has drifted 11 km.

Figure 8: 10 m^3 diesel on the sea 4 hours after release. The slick remains cohesive without significant spreading.

2.2.6 Sampling of MGO

All samples were taken in the area of the oil slick where a thick oil film was observed. This was a relatively small area at the front of the slick.

Beforehand, polypropylene pads were divided into four equal parts (21.1 cm x 21.6 cm), weighed individually and placed in zip lock bags. After sampling, the pads were reweighed, the quantity of diesel calculated and the oil film thickness estimated. The samples (Table 7) were analysed in terms of density, viscosity, water content and evaporation (GC screening). Details of the padsamples are shown in Table 8.

Table 7: List of samples

SINTEF ID	Prøvebeskrivelse	Kommentar
2022-4491	MGO (utgangsolje fra tank på dekk)	GC og fysikalske analyser
2022-4491-S1	Bulkprøve 1. Etter ca 6 timer (10:47 UTC)	Tetthet
2022-4491-S2	Bulkprøve 2. Etter ca 7 timer (11:53 UTC)	Tetthet
2022-4491-S3	Bulkprøve 3. Etter ca 8 timer (13:05 UTC)	GC og fysikalske analyser
2022-4491-S4	Teflonpad-prøve. Etter ca 0.5 time (05:40 UTC)	GC
2022-4491-S5	Teflonpad-prøve. Etter ca 1.5 time	Ingen analyser
2022-4491-S6	Teflonpad-prøve. Etter ca 2 timer (07:18 UTC)	GC (tatt i metallic del av flaket)
2022-4491-S7	Teflonpad-prøve. Etter ca 6 timer	Ingen analyser

The following samples were taken:

- Sample of MGO taken before release
- 3 bulk samples (from approx. 6, 7 and 8 hours)
- 4 Teflon pad samples (from approx. 0.5, 1.5, 2 and 6 hours)
- 23 pad samples (described in Table 3.1)

Table 8: Details of the pad samples

Prøve	Tid (UTC)	Posisjon N (desimalgrader)	Posisjon E (desimalgrader)	Oljetykkelse (mm)	Kommentar
1	05:20	59.700833	2.414000	2,9	Mettet med diesel, 50% dekning
2	05:23	59.701333	2.414167	5,7	Mettet med diesel
3	05:27	59.702000	2.414000	1,7	Ikke helt mettet
4	05:31	59.702500	2.414000	5,7	Fullstendig mettet. Venter litt med neste pad siden flaket er for tykt
5	05:42	59.704333	2.413333	0,1	Bommet vi med paden?
6	05:43	59.704833	2.413333	6,0	Mettet med diesel
7	06:22	59.711167	2.413333	0,1	Lite diesel på paden
8	06:29	59.712000	2.413667	4,4	Nær drifter, bra med diesel
9	07:06	59.717417	2.415233	3,1	Bra med diesel
10	07:09	59.717517	2.415467	5,5	Masse diesel
11	08:03	59.725467	2.419283	0,9	Dekning 100%. Kan se ut som området med tykk diesel har minsket noe
12	08:12	59.726333	2.418833	5,9	Tykk diesel. Pad mettet
13	08:51	59.730100	2.420533	3,2	Tykk diesel
14	09:29	59.732750	2.419500	6,6	Mettet pad. Tykk diesel
15	10:38	59.735517	2.418883	0,6	
16	10:42	59.736183	2.418617	2,4	Ikke så tykt lenger
17	11:15	59.737550	2.420850	5,7	Nær drifter, ganske tykk diesel
18	11:58	59.739000	2.424283	1,1	Mindre diesel på denne paden
19	12:00	59.739000	2.424283	1,6	Samme posisjon som forrige. Ikke mettet. Noe tynnere diesel enn tidligere
20	12:38	59.739883	2.427167	2,1	Pad blir ikke mettet
21	13:00	59.740783	2.428083	2,8	
22	13:02	59.740733	2.429183	1,3	
23	13:04	59.740817	2.429317	1,7	

Analyses of viscosity (at 10.0 °C) and density (at 15.6 °C) were measured in the mother oil and in bulk samples from the slick. There was not time to carry out the physical analyses offshore, so the samples were analysed in the laboratory in Trondheim. In addition, the water content was measured using Karl Fischer titration. The mother oil and samples taken with Teflon nets were analysed using gas chromatography with flame ionisation detector (GC/FID). The Teflon nets were extracted using dichloromethane (DCM) and upgraded to approx. 1 ml prior to analysis. The diesel and the bulk samples were dissolved in DCM prior to analysis using GC/FID.

To test dispersion, the FET test (Field Effectiveness Test) was used to study whether e.g. oil taken from the surface of the sea is still dispersible. Two measuring cylinders (100 ml) are filled with seawater (80 ml), and oil/emulsion (1.5 ml) is added to both. Dispersant (6 drops Dasic NS) is added to one of the measuring cylinders (equivalent to a dosage rate (DOR) of 1:25). The second measuring cylinder is used as reference and no dispersant is added. Both the measuring cylinders are turned up and down for one minute to simulate energy impact. The following criteria are used for dispersibility:

- Good dispersibility: Formation of brown dispersion (drops of oil) that rises slowly to the surface when the measuring cylinder is still.
- Reduced dispersibility: Formation of large drops of oil that rise quickly to the surface.
- Low dispersibility: Little or no difference from the reference oil (no dispersant added).

2.2.7 Results

The slick demonstrated good cohesion and was still clearly visible at the end of the trial. Estimated oil film thicknesses are given in Table 8 and show that the oil film is relatively thick (5–6 mm) for up to 6 hours, while the sampling indicated that the oil film thickness was reduced to approx. 1–3 mm in the last two hours of the trial. All the samples were taken in a relatively small area at the front of the slick where a thick oil film was observed.

The FET test showed reduced dispersibility without the addition of dispersants and good dispersibility with the addition of dispersants; Figure 9.

Figure 9: FET test after 8 hours, without dispersant (left) and with dispersant (right).

2.2.8 Achievement of goals and utility value

Use of drone

Obtaining an overview at height is an extremely useful aid, both for piloting operations in towards an oil slick and for gaining an overview of the extent of the slick. The drone's range, window of operations and image quality for both the daylight and infrared camera are good. This is a good tool for the ILS because it is possible to see vertically down over the slick, making it easier to estimate thickness and quantity of pollution, and navigate the resources in terms of optimal operation. Having drone pilots with the ILS on the bridge for good communication is beneficial, but provided “live” images are available for the ILS and/or group leader, using a drone as an aid in an operation is in any case a big advantage. On KV Bergen, neither the drone nor OSD were integrated with the system for common operational pictures (SeaCOP). When this is in place on all platforms, with all the sensors connected, it will be a really good tool.

LN-KYV
Diesel shows a “True Colour” that, because of its transparency, is easy to confuse with “Metallic”. This means it is easy for the aircraft to underestimate large quantities of diesel at sea if using the Bonn Agreement’s colour code for estimating the volume of a slick. SLAR was also unable to detect the oil slick on the sea from satellite images. In terms of IR and visually, communicating directly with the vessel is invaluable when using the aircraft. The aircraft has a long operational time, large range and can cover large areas in a short time. Low cloud cover is limiting, which is something we experienced several times during the trial.

Sampling in the slick was carried out by SINTEF, with samples taken to estimate oil film thickness, bulk samples for physical analyses and Teflon net samples to estimate evaporation. Most of the samples were taken in the thickest part of the sample, i.e. in the central area at the front of the slick.
The slick spread less than expected, and estimated oil film thicknesses showed that the oil film was relatively thick (5–6 mm) for up to 6 hours, and then decreased to approx. 1–3 mm in the last two hours before the trial was ended, after a total of 8 hours of almost unaffected drift in the open sea. Evaporation was estimated at approx. 15% in the course of the 8 hours for which the trial lasted.