SINTEF Applied Chemistry

Address: N-7465 Trondheim, NORWAY
Location: S.P. Andersens vei 15A
Telephone: +47 73 59 20 80 / 12 12
Fax: +47 73 59 70 51

Enterprise No.: NO 948 007 029 MVA

SINTEF REPORT

TITLE

DEEP SPILL JIP
EXPERIMENTAL DISCHARGES OF GAS AND OIL AT HELLAND HANSEN – JUNE 2000
CRUISE REPORT

AUTHOR(S)

Øistein Johansen, Hans V. Jensen and Per Daling

CLIENT(S)

DeepSpill JIP

REPORT NO.	CLASSIFICATION	CLIENTS REF.	
STF66 F00093	Confidential	Cort Cooper, Chevron	
CLASS. THIS PAGE	ISBN	PROJECT NO.	NO. OF PAGES/APPENDICES
		66118210	36
ELECTRONIC FILE CODE		PROJECT MANAGER (NAME, SIGN.)	CHECKED BY (NAME, SIGN.)
DeepSpill Cruise Report.doc		Øistein Johansen	Henrik Rye
FILE CODE	DATE	APPROVED BY (NAME, POSITION, SIGN.)	
	2000-09-01	Tore Aunaas / Research Director	

ABSTRACT

This cruise report includes a review of the field operations during the sea trials that were conducted as a part of the DeepSpill JIP in June 2000. The sea trials were conducted in the Norwegian Sea at the Helland Hansen site (65°00'N, 04°50'E) and included four controlled discharges of oil and gas from a water depth of 844 meters. The main objective of the experiments was to obtain data for verification and testing of numerical models for simulating accidental releases in deep waters. In addition, the experiments were aimed at testing equipment for monitoring and surveillance of accidental releases in deep waters, and evaluation of the safety aspect of accidental releases of gas and oil in deep waters.

Three vessels took part in the experiment – one supply vessel (*Far Grip*) that carried the discharge equipment, and two research vessels (*Håkon Mosby* and *Johan Hjort*) carrying instruments for subsea monitoring and equipment for sampling of surface oil. A total of 42 scientists, operators and observers participated on the three vessels. In addition – surveillance airplanes from various countries were stationed at Kristiansund airport to be ready to make flights over the area. On the last two days of the experiment, seven NOFO response vessels were present, in case any clean up was called. Field operations started on June 21 when the supply vessel left Bergen and ended July 2 when the supply vessel was returned to Mongstad. The field experiments took place in the period from June 26 to June 29.

Mobilization of vessels, deployment of discharge arrangement and experimental discharges were all carried out according to plan, although with some delay due to a few technical problems and weather. Extensive samples and data were acquired during the experiments using aircraft remote sensors, oil samples from the surface slicks, and mapping of subsurface plumes with ROV and echo sounder, as well as by chemical and biologic sampling in the water column. A large amount of data was collected and once analyzed, it is anticipated that it will meet all the objectives of the experiment. The crude oil and diesel came to the surface in a large region and was rapidly dispersed by the substantial winds, waves, and currents at the site. No environmental damage was observed and Chevron decided that no cleanup was required. The SFT on-site representative had no objections to this decision.

KEYWORDS	ENGLISH	NORWEGIAN
GROUP 1	Environment	Miljø
GROUP 2	Offshore	Offshore
SELECTED BY AUTHOR	Marine operations	Marine operasjoner
	Experimental discharges	Eksperimentelle utslipp

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS **3**

1 INTRODUCTION **4**

2 OBJECTIVES OF FIELD EXPERIMENTS **5**

3 FIELD OPERATIONS **6**

3.1 Mobilization of vessels and transfer to site 6
3.1.1 Far Grip 6
3.1.2 Håkon Mosby 10
3.1.3 Johan Hjort 10
3.2 Deployment of discharge unit and instruments 12
3.3 Experimental discharges 13
3.3.1 Nitrogen gas discharge 13
3.3.2 Marine diesel discharge 15
3.3.3 Oil spill response units from NOFO 18
3.3.4 Crude oil discharge 18
3.3.5 LNG discharge 21
3.4 Recovery of discharge unit and instruments 21
3.5 Return to harbor and demobilization of vessels 22

4 FIELD OPERATIONS IN BRIEF **23**

APPENDIX A: PARTICIPATING VESSELS AND CRUISE MEMBERS **26**

APPENDIX B: LOG FROM FAR GRIP **27**

23 June 27
24 June 28
25 June 28
26 June 29
27 June 31
28 June 32
29 June 32
30 June 33
1 July 33
2 July 34

APPENDIX C: SURFACE AND SUBSEA MONITORING **35**

C1: Monitoring and sampling during the Marine Diesel release (June 27th) 35
C2: Monitoring / sampling during the crude oil release (June 29th) 36

LIST OF ILLUSTRATIONS

Sketch of aft deck of Far Grip showing placement of discharge equipment 7
Sailing route for Far Grip to the experimental site (Helland Hansen). 8
View of main deck on supply vessel Far Grip during mobilization 9
Far Grip in Tananger. Sea fastening of LIN and LNG tanks with pump unit and evaporator. 9
Far Grip in Tananger. Picture of discharge platform 10
Picture of research vessel Håkon Mosby arriving at the experimental site. 11
Picture of research vessel Johan Hjort arriving at the experimental site. 11
ROV launched from Far Grip in preparation for deployment operation 12
Wind recorded at the experimental site. 13
Observation ROV (Aglantha) made ready for deployment from Håkon Mosby 14
Video shot taken from the Work ROV during the nitrogen discharge.. 15
Aerial image of surface slick from diesel discharge. 16
Cort Cooper (Chevron US) and Mary Boatman (MMS) observing echo sounder images 17
Example of image made from the echo sounder recordings. 17
Workboat launched from Johan Hjort to monitor crude oil slick. 19
Workboat in crude oil slick 20
Picture from SFT aircraft. Research vessels in crude oil slick. 20
Inside SFT's surveillance aircraft. View of the radar image of the crude oil slick. 21

1 INTRODUCTION

This cruise report describes the work carried out during the DeepSpill sea trial that took place at the Helland Hansen location in June 2000. The sea trial was a part of the DeepSpill project, which is organized as a Joint Industry Project involving 22 oil companies and a US government agency (Minerals Management Service - MMS). Chevron US has been acting as an administrator of the JIP, while Norsk Chevron has applied for the discharge permit on behalf of this organization. SINTEF Applied Chemistry has been the main contractor, responsible for planning and conductance of the scientific tasks in the project. The Norwegian authorities gave permit for the discharges on certain conditions. This document contains among other things a description of how the DeepSpill project has met these conditions.

The sea trial involved three vessels – the supply vessel *Far Grip* from Farstad Shipping and the two research vessels *Håkon Mosby* and *Johan Hjort* from the University of Bergen and the Institute of Marine Research (IMR). In addition to scientists and technicians from SINTEF and IMR, the sea trial involved personnel from a number of subcontracted companies, observers from oil companies participating in the JIP, an observer from the and the Norwegian Pollution Control Authority (SFT), an ornithologist from the Norwegian Institute of Nature Research (NINA), and a few external observers (see Appendix B). In addition, a number of surveillance airplanes from the Bonn Agreement Countries visited the experimental region during the experiment. The present report is based on observations and field logs received from these different groups.

The main objective of this report is to make a review of the field operations carried out during the sea trial. Actual observations and data obtained from the experiments will be documented and analyzed in forthcoming reports.

The successful accomplishment of the experiment was to a large extent a result of the positive commitments from Chevron, MMS and the other oil companies participating in the JIP. We will also acknowledge the positive contributions from the various subcontracted companies and institutions – both in the planning and preparation phase, during mobilization and during the actual field operations. In alphabetic order:

- Alun Lewis Oil Spill Consultant – Middlesex, UK
- Argus Remote Systems as – Bergen
- Institute of Marine Research – Bergen
- JM Consult as – Stavanger
- Krytem GmbH – Willich, Germany
- Norwegian Institute of Nature Research, NINA – Trondheim
- Norwegian Maritime Technology Research Institute, MARINTEK – Trondheim
- Oceaneering A/S – Stavanger
- Seabrokers Chartering AS - Stavanger
- Schlumberger Norge A/S – Bergen and Stavanger
- University of Bergen, Institute for Fishery- and Marine Biology - Bergen

We also want to acknowledge the Norwegian Clean Sea Association (NOFO) for their willingness to provide the oil spill contingency required during the field experiment, and the Norwegian Pollution Control Authority (SFT) for bringing forward aerial surveillance aircraft from a number of neighboring countries.

2 OBJECTIVES OF FIELD EXPERIMENTS

The DeepSpill joint industry project (JIP) was established with the aim of determining the fate of oil and gas released in deepwater by performing full-scale field experimental releases. The main purposes of these experiments were:

- to obtain data for verification and testing of numerical models for simulating accidental releases in deep waters.
- to test equipment for monitoring and surveillance of accidental releases in deep waters.
- to evaluate the safety aspect of accidental releases of gas and oil in deep waters.

Verified numerical models combined with improved surveillance of the releases should then provide a better basis for oil spill contingency planning and environmental impact assessments in conjunction with future deep water exploration, development and production.

3 FIELD OPERATIONS

This chapter contains a chronological review of the work carried out during the sea trial. Note that all time indications are given as local time. A brief overview of the major events during the field operations is given in the next chapter.

3.1 Mobilization of vessels and transfer to site

The sea trial involved three vessels – the supply vessel *Far Grip* from Farstad Shipping and the two research vessels *Johan Hjort* from Institute of Marine Research (IMR) and *Håkon Mosby* from University of Bergen (UiB). To get an idea of the size of the vessels – please note that the overall length of the supply vessel (*Far Grip*) was 74.5 meters, while the corresponding dimensions of the two research vessels (*Johan Hjort* and *Håkon Mosby*) were 65 meters and 47 meters respectively.

According to the original plan, the three vessels should meet in Kristiansund before departure to the experimental site. However – the TAC decided to skip the gathering in Kristiansund to make more time available for the deployment operation to be conducted by *Far Grip* and *Håkon Mosby*. The main issue was to assure that the crews involved in the deployment operations should get a night's sleep before the first experimental discharge – planned to take place at 1000 Monday morning after a few hours' preparations.

This decision implied that *Far Grip* should make the transit to the experimental site directly after loading of crude oil at Sotra outside Bergen, while *Håkon Mosby* should make the transit directly after mobilization in Bergen. Only *Johan Hjort* should visit Kristiansund to pick up SINTEF equipment and personnel before transit to the experimental site. With this modified plan - the expected time of arrival for *Far Grip* and *Håkon Mosby* at the experimental site was set to Sunday June 24 at 1600 – 24 hours after departure from respectively Sotra or Bergen. The deployment operation was expected to be finished by midnight – 8 hours after arrival of the two vessels. The expected time of arrival for *Johan Hjort* was set to Monday June 26 at 0400 – 12 hours after arrival of the two other vessels.

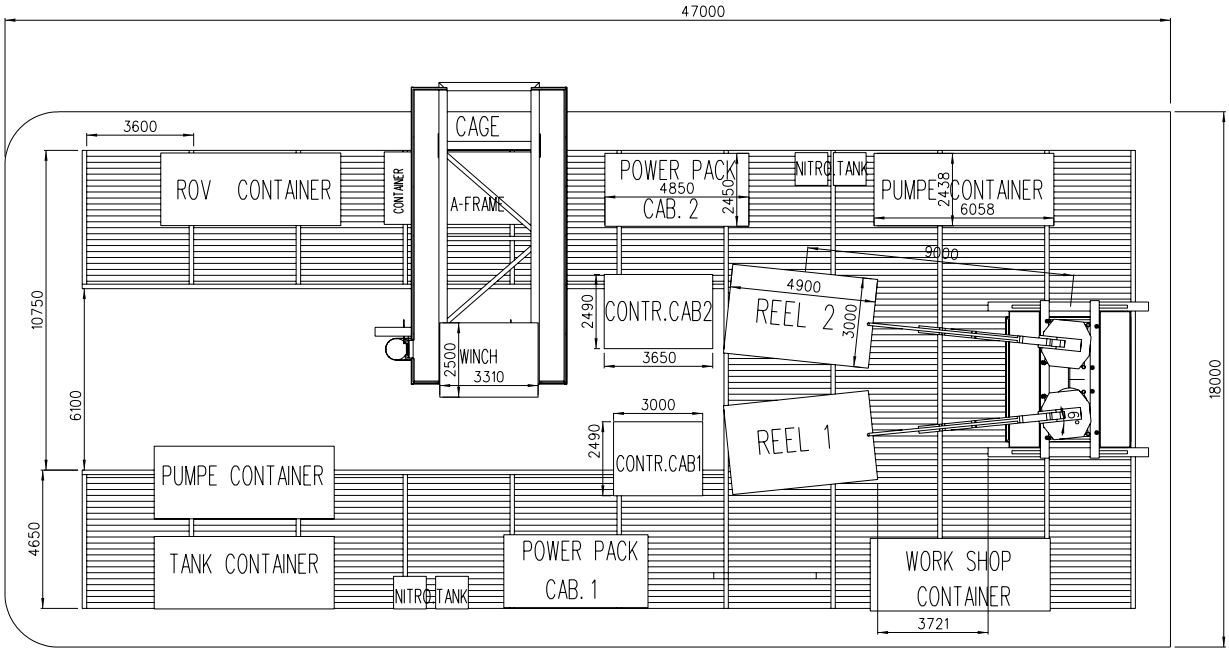
3.1.1 Far Grip

The hire of *Far Grip* started when it sailed from Mongstad Wednesday June 21 at 0500 for transit to the ASCO Base in Tananger. After a short stop at the CCB base at Ågotnes, Sotra for bunkering fuel oil, the vessel arrived in Tananger at 2300 to make the vessel ready for the sea trial. The 60 m^3 of marine diesel to be discharged in the experiment was also loaded during the stop at the CCB base. The work at the ASCO-base involved loading, installation and sea fastening of the work ROV (WROV) with related equipment, as well as various heavy equipment designed for discharge of oil and gas. Besides - the liquid nitrogen tank was filled from a truck tank in this harbor. In addition to the installation and sea fastening crews, key personnel from the DeepSpill project were present on the vessel to supervise the installation work. An inspector from the classification company Norske Veritas (DNV) came onboard on the afternoon of Friday June 23 to conduct a final inspection/approval of the installations before the vessel could leave Tanager.

The ASCO base was left Friday June 23 at 2240 for transit to the CCB base at Ågotnes, Sotra. The vessel arrived there in the morning of Saturday June 24 for loading the 60 m^3 of crude oil and 18 m^3 of LNG to be discharged in the experiments. Two tank trucks that had been filled at the

Sture oil terminal delivered the Oseberg Blend crude oil, while the LNG was delivered with a cryogenic tank truck filled at the Tjelbergodden gas plant near Kristiansund.

The vessel departed the CCB base practically on schedule at 1645 the same day for transit to the Helland Hansen site. *Far Grip* arrived at the planned site Sunday June 25 at 1855 – delayed about three hours relative to schedule due to unexpected heavy northerly winds.



Sketch of aft deck of Far Grip showing placement of discharge equipment

Top left to right:
The ROV CONTAINER is the control cabin for the ROV. Next comes the platform installed for the ROV, supporting the WINCH and the AFRAME used for launching of the CAGE with the ROV. The maintenance CONTAINER for the ROV is placed below the platform. Next comes the hydraulic power pack for the portside coiled tubing unit, a packet of pressurized NITROGEN flasks, and the PUMP CONTAINER with the high-pressure pump powered by a diesel engine.

Middle left to right:
CONTROL CABINS 1 and 2 for portside and starboard coiled tubing reel (REEL 1 and 2) followed by the support frame for the injectors mounted on top of the moonpool (a 4x4 meter well in the deck). The discharge platform is located in the moonpool during transit.

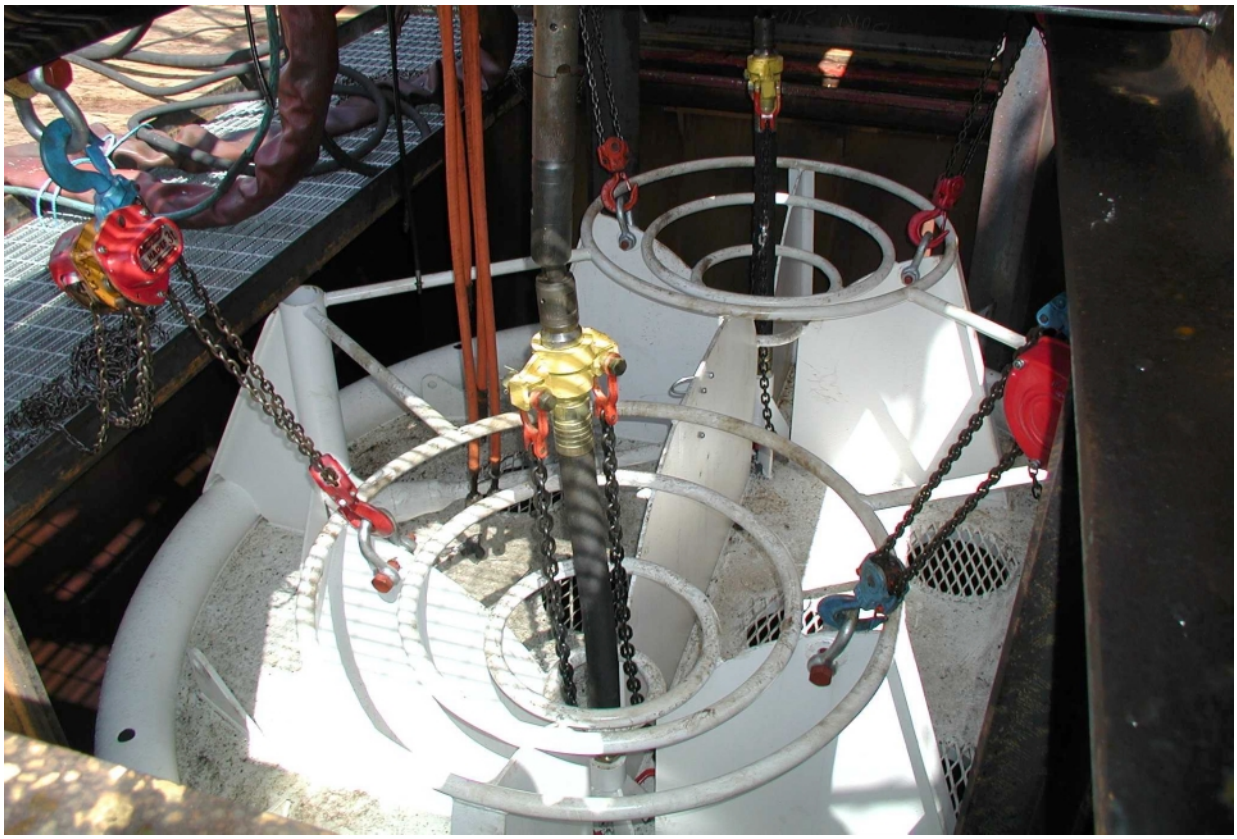
Bottom left to right:
TANK CONTAINER for transport of liquefied gases (LNG and LIN) and PUMP CONTAINER with the cryogenic pump and the seawater heated evaporator. Next comes a second package of pressurized nitrogen flasks, followed by the POWER PACK for the starboard coiled tubing unit. And the WORKSHOP CONTAINER for maintenance of coiled tubing system.

Below deck:
The 60 m^3 of crude oil to be discharged in the experiment was stored in the methanol tank located under the aft deck, while the same volume of marine diesel was stored in one of the combined bunkers and oil recovery wing tanks. Onboard pumps fitted to these tanks were used to feed oil to the high-pressure pump.

Sailing route for Far Grip to the experimental site (Helland Hansen). The vessel was chartered at Mongstad and sailed to Stavanger to mobilize equipment and personnel. Next stop was at Sotra outside Bergen to load crude oil and LNG.

View of main deck on supply vessel Far Grip during mobilization at the ASCO base in Tananger. Reels with coiled steel tubing, goose necks and injector heads seen from the rear of the vessel.

Far Grip *in Tananger. Sea fastening of LIN and LNG tanks with pump unit and evaporator.*



Far Grip *in Tananger. Picture of discharge platform secured by chains in the 4x4 meter moonpool.*

3.1.2 Håkon Mosby

The Aglantha observation ROV (OROV) with related equipment was loaded onboard *Håkon Mosby* at *Marineholmen* harbor in Bergen Saturday June 24. When the SINTEF personnel and the JIP observers had been embarked, the vessel moved to *Nykirkekaien* harbor to load the current meter instrument (ADCP) with mooring, and ropes and wire for the deployment operation. After a safety rehearsal, *Håkon Mosby* left Bergen the same day about 1700 for transit to the experimental site. The vessel arrived on the experimental site Sunday June 25 at 1945 – about 4 hours after schedule – a delay mainly caused by the above mentioned unexpected heavy northerly winds.

3.1.3 Johan Hjort

Johan Hjort left Bergen harbor Thursday June 22 at 2100 for transit to Helland Hansen to conduct a biological survey in the experimental area. The vessel arrived in the experimental area Friday June 23 at 2400. An ornithologist from the Norwegian Institute of natural Research (NINA) participated on this survey to make the sea bird observations required by the spill permit. *Johan Hjort* reported to the cruise commander on *Far Grip* at 1700 Saturday June 24 and was granted 3 extra hours on site before leave to Kristiansund. The research vessel left the experimental area Saturday June 24 about 2000 to pick up SINTEF's laboratory container, SINTEF personnel and JIP observers in Kristiansund. *Johan Hjort* arrived there the next morning at 0945 and departed at 1700 the same day to join the two other vessels at he experimental site. Reported time of arrival at the experimental site was Monday June 26 at 0800.

Picture of research vessel Håkon Mosby *arriving at the experimental site.*

Picture of research vessel Johan Hjort *arriving at the experimental site.*

3.2 Deployment of discharge unit and instruments

The deployment of the discharge platform should commence as soon as *Far Grip* and *Håkon Mosby* had arrived at the experimental site. The operation started about 6 hours after schedule due to late arrival of both vessels. Before that, the WROV had been down to inspect the conditions at the bottom – and reported that the seabed consisted of clay with a soft layer a few cm thick. Just before midnight Sunday June 25, the tow wire connected to the discharge platform was transferred to *Håkon Mosby*. The operation continued into the night of Monday June 26 and was finished at 0300 in the morning when the platform was reported to be resting safely on the seabed at 844 meters depth in the position 65°00'N, 04°50'E.

With the delay of only 3 hours relative to the plan – the first experiment with a planned start at 1000 could still have been conducted according to the plan. However – other unforeseen run-in problems the first day caused more serious delays.

When this deployment operation was finished - *Håkon Mosby* deployed the ADCP mooring at the seabed south east of *Far Grip*. Problems with the acoustic communication with the ADCP were reported about 0700. In order to solve the problems – it was decided to move the acoustic transceiver and the two ADCP operators to *Johan Hjort*. As a result – connection with the instrument was established about 1400. Real reading of data from the ADCP by use of the acoustic modem was limited to brief periods when the vessel was located directly above the ADCP mooring with the main engine idling. However – the instrument was recording internally and continuous time series would be available later after the instrument had been retrieved. In addition to this upward looking ADCP with a depth range of about 400 m above bottom – a downward looking ADCP was mounted on Håkon Mosby, providing ocean current data down to 300 m depth.

ROV launched from Far Grip in preparation for deployment operation. Research vessel Håkon Mosby seen in the background.

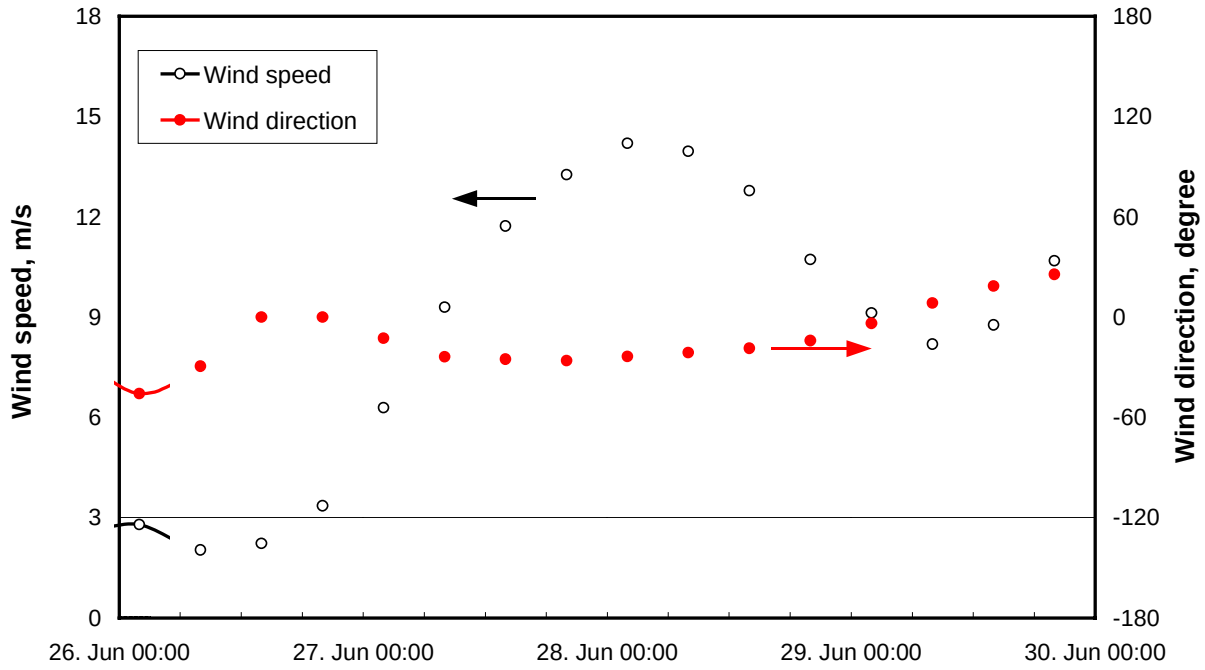
Since reliable ocean current data were considered to be an essential part of the planned experiments – the communication problems with the ADCP alone could have caused serious postponement of the planned discharges. However – as explained in the next section – the actual commencement of the first experiment was delayed more due to other unforeseen problems.

3.3 Experimental discharges

Four experimental discharges were planned – the first with nitrogen and dyed sea water, the second with natural gas and marine diesel, the third with natural gas and crude oil, and the last with natural gas and sea water. The first two releases were planned for Monday June 26, while the last two were planned for the next day. However – the actual experimental schedule deviated from the plan due to unforeseen run-in problems on the first day and adverse weather conditions on the second day. Unfortunately – these delays affected the participation of the surveillance airplanes from various North Sea countries. The airplanes were stationed at Kristiansund airport Monday and Tuesday on standby to make flights to the experimental site to monitor the surface slicks formed from the marine diesel and crude oil discharges. However – while the Norwegian aircraft had allowed for extra days due to possible delays, the other airplanes had to leave the airport by the end of the second day to attend to other tasks.

3.3.1 Nitrogen gas discharge

The first experiment that involved discharges of nitrogen gas together with dyed seawater was planned to start at 1000 Monday June 26. However – the start had to be delayed in the first place due to the above mentioned problems with the ADCP. At 1220 when it was obvious that the delay would cause postponement of the next experiment with marine diesel, the flight co-ordinator was informed about the situation. Later – when the ADCP-problem was reported to be solved, the start-up had to be delayed further due to operational problems with the OROV.



Wind recorded at the experimental site. Smoothed data from the weather station at Håkon Mosby.

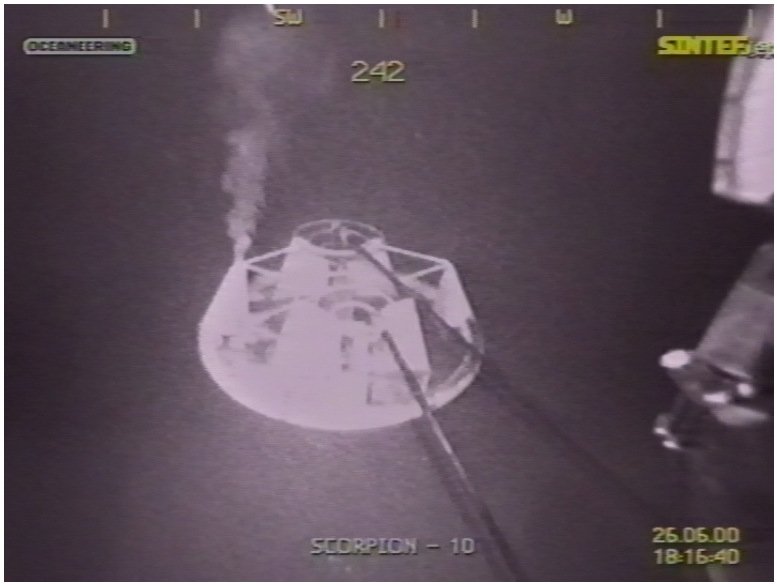
Observation ROV (Aglantha) *made ready for deployment from* Håkon Mosby

The OROV was requested to go down to inspect the discharge platform at 0700. At 1100, when the OROV crew reported the first sightings of the platform, they also reported that the ROV umbilical had been ensnared between the coiled steel tubing (CST) and the seabed. To solve the problem, *Far Grip* was moved a small distance with the aim of lifting the CST from the seabed at the point of entrapment. This maneuver was successful, and at 1200 the OROV crew reported that the umbilical was free from the CST. However – the freedom of movement of the OROV was still restricted, probably due to another entanglement in the CST higher up in the water column.

Finally – at 1620, the OROV was reported to be operational, and preparations for the discharge of nitrogen could be started. The actual nitrogen discharge commenced at 1810 Monday June 26 when the cryogenic pump was reported to deliver liquid nitrogen (LIN) at full rate. At this time, the high-pressure pump had been pumping seawater for about one hour. When the nitrogen discharge was started – the WROV was resting on the seabed near the discharge platform, ready to make observations of the emerging jet of gas and dyed seawater, while the OROV was approaching the discharge platform to make observations in the plume.

At 1826 - the WROV crew reported that the sonar image was distorted due to electric noise from the cryogenic pump. The pump and the WROV was powered from a common circuit supplied by the onboard electric generator. Unfortunately – no power supply replacement was available, and the problem persisted throughout the experiments.

Shortly after the nitrogen discharge was started, the Schlumberger crew reported overheating problems with the diesel engine running the high-pressure pump. The nitrogen-pumping rate was reduced until the overheating problem was solved and the seawater pump could be restarted after a one-hour stop. The nitrogen discharge then continued until 1920, while the release of dyed seawater was shut down about 30 minutes later.



Video shot taken from the Work ROV during the nitrogen discharge. Plume of nitrogen gas bubbles rising from the discharge platform. Coiled tubings can be seen on the seabed entering the platform.

During this period, the ROV crew on Håkon Mosby made several attempts to bring the observation ROV down to the discharge platform and into the plume. However – none of the attempts were successful, and for this reason, no data was obtained from the instruments mounted onboard the OROV. However, at the same time, the WROV made video recordings of the bubble plume emerging from the discharge platform and close ups of individual gas bubbles.

Due to the serious delay of the first experiment – no attempts were made to continue with the second experiment – i.e. the marine diesel discharge was postponed to the next day. The weather forecast from the Norwegian Meteorological Institute (DNMI) Monday June 26 at 1830 – indicated increasing wind speed, from 15 to 20 knots in the morning and further up to 25 knots in the afternoon. For this reason – it was decided to make preparations for the marine diesel discharge early morning the next day.

3.3.2 Marine diesel discharge

The weather forecast issued at 0600 Tuesday June 27 confirmed the expected strengthening of the wind, and indicated even stronger winds for the afternoon (up to 30 knots). However – in order to make the most of the presently favorable wind conditions – it was decided to start the preparations for the diesel discharge as soon as possible. Thus – deployment of the OROV was started at 0620, and at 0700 – the MOB-boat from *Far Grip* was directed to *Johan Hjort* to serve as a workboat for sampling of surface oil. At the same time – *Far Grip* started to deploy the WROV.

At 0740 – the safety officer reported that everything was ready for start of discharge. Full rate discharge of diesel oil together with natural gas was reported at 0830 after some minor pumping-problems. The discharge was stopped as planned after one hour when the marine diesel supply was consumed. About that time (0935) – the first traces of diesel were observed on the sea surface North East of *Far Grip*, and the workboats were directed to the slick to start surface sampling and underwater monitoring.

Aerial image of surface slick from diesel discharge.

Picture taken from the Norwegian surveillance aircraft at 1039 Tuesday June 27. The vessels seen on the picture are (from left to right): Far Grip, Håkon Mosby and Johan Hjort. The two small boats are sampling boats operated from Johan Hjort.

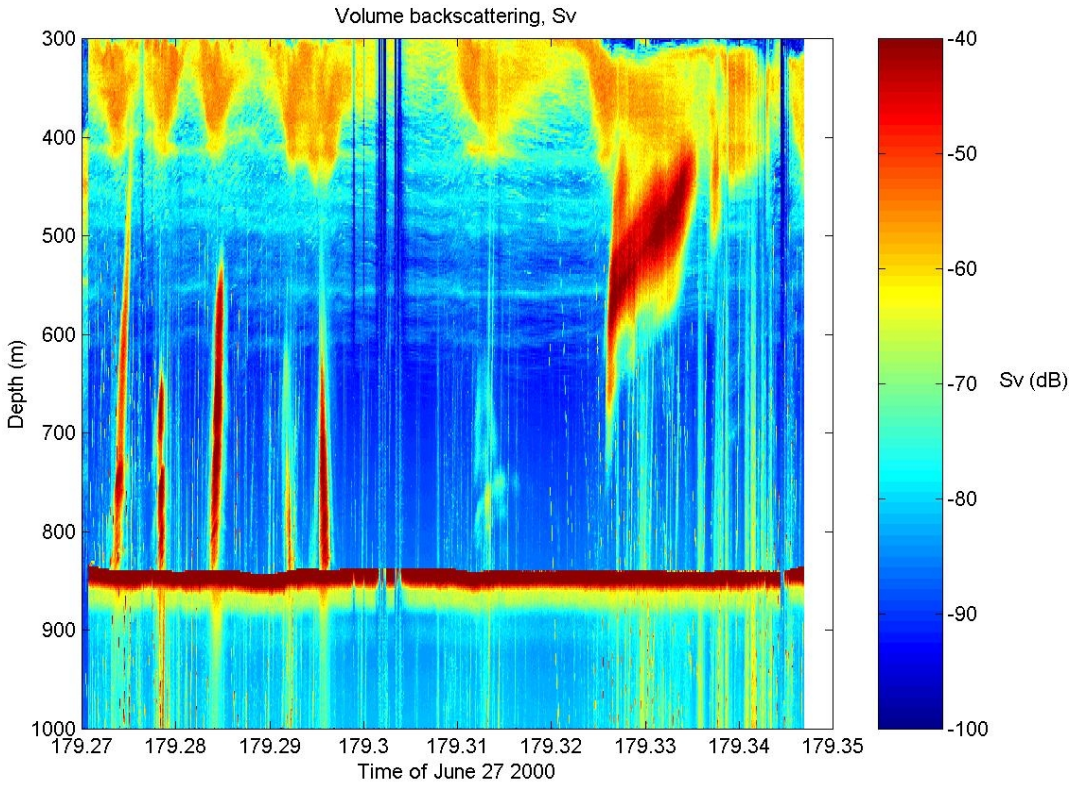
At 1000 – the wind was reported to be 25 knots, and the workboats were operating under marginal conditions. However, the workboats continued to operate assisted by various surveillance airplanes – until about 1300 when the surface sampling boat reported engine problems and had to be rescued by the other workboat.

The surface sampling boat reported thin oil films (< 50 µm) – mostly too thin for oil sampling. The relatively rough sea also made surface sampling difficult. However – one surface oil sample was taken, together with a few adsorption pad samples and Teflon net samples. The subsurface monitoring boat made transects along and across the slick with in situ UVF measurements at 1 and 8 meter depths and secured water samples for calibration purposes. An overview of the samples taken during this and the crude oil experiment is given in Appendix C.

The first surveillance aircraft (LN-SFT) arrived on site at 1012 and stayed for about half an hour. On this morning's flights, the Norwegian aircraft was followed by the German aircraft (on scene 1130), the French aircraft (1200), the Danish aircraft (1230), and finally the Dutch aircraft (1300). The UK aircraft made a final visit at the site in the afternoon.

During the discharge period – the WROV operated from *Far Grip* was down by the discharge platform making video recordings of the rising plume and close-ups of oil droplets and gas bubbles. However – the OROV crew on *Håkon Mosby* reported problems with the video transmission shortly after deployment, and due to this – the OROV was recovered before the experiment commenced. Thus – no data were obtained from the customized instruments mounted on the OROV for monitoring of the plume.

Cort Cooper (Chevron US) and Mary Boatman (MMS) observing echo sounder images of rising oil plume (see insert) with captain of Håkon Mosby in the background.



Example of image made from the echo sounder recordings. Data obtained from the start of the marine diesel experiment June 27. Time axis is in decimal days from start of year.

Fortunately – the echo sounders on both research vessels had been found to provide images of the rising plume during the nitrogen gas discharge on the first day, and these instruments could thus provide partial replacement for the instruments on the malfunctioning OROV. With assistance from the echo sounder images, it also proved possible to take water samples in the plume of rising droplets with the rosette water sampler operated from *Johan Hjort*.

Two successful sampling series covering depths from 10 to 400 meters were made during the marine diesel experiment – each lasting for about 15 minutes, the first starting at 1100, the second at 1445. The water samples were sealed up in 1 liter flasks and 25 ml vials to be brought back to SINTEF's laboratories for extraction and analysis of the oil content.

3.3.3 Oil spill response units from NOFO

The Norwegian Clean Sea Association (NOFO) had coordinated their oil-on-sea trial with the DeepSpill experiment to assist in oil spill response in case oil recovery was considered necessary. According to plan - the NOFO trials should take place in the morning of Wednesday June 28. However - the NOFO units – including three oil spill response vessels and two towing boats were scheduled to arrive at the experimental site Tuesday June 27 at 1800 – in time to provide oil spill response in case needed after the planned crude oil discharge. Two oil recovery vessels and towing boats arrived on schedule Tuesday June 27 at 1800, while the third oil recovery vessel arrived some hours later – in the night of Wednesday June 28. However – due to the forecasted adverse weather conditions for the following morning (Wednesday) – the sea trials were postponed in anticipation of acceptable weather conditions on Thursday June 29. Finally – as the weather conditions did improve sufficiently to conduct the planned tests – NOFO decided to cancel the planned sea trials completely. However – as planned, two of the NOFO oil recovery units remained in the area up to the end of the DeepSpill experiment – and departed Thursday June 29 at 1630 after the LN-SFT aircraft had informed Chevron that the slick was not recoverable.

3.3.4 Crude oil discharge

The crude oil discharge was planned as the first of two experiments to be conducted the day after the marine diesel discharge. However – the discharge of crude oil had to be postponed due to adverse weather conditions on the day following the diesel discharge (Wednesday June 28). The weather forecasts issued that day indicated that wind conditions would be improving during the night and reach acceptable levels (20 knots) early Thursday morning, and that the sea would calm down – but still might be a problem in the following day. This forecast was confirmed by a check of the weather conditions early morning on Thursday June 29. At 0345 the wind speed was 20 knots and the sea was calming down. It was thus decided to prepare for a discharge of crude oil at 0600. However – at 0500, *Far Grip* reported that the prevailing swell prohibited launching of the ROV – and also the MOB-boat. At 0520, the ornithologist on Johan Hjort reported that the conditions were well suited for the crude oil discharge – only 5 flying seabirds (fulmar) and no swimming seabirds were observed in the area.

When *Johan Hjort* at 0656 reported to be ready to launch its workboat – orders for starting the discharge were given, even if the prevailing swell prevented launching of the ROV from *Far Grip*, and the observation ROV on *Håkon Mosby* was out of operation due to the broken video cable. The experiment commenced at 0723 when full pumping rates of crude oil and LNG was established and continued until 0810 when the 60 m^3 crude oil supply was emptied. At 0816 –

Håkon Mosby observed the plume at 200 meters depth on the echo sounder, and at 0821 – the first sighting of oil on the sea surface was reported from *Far Grip*.

Two series of underwater sampling was conducted with the Rosette sampler deployed from Johan Hjort with guidance from the echo-sounder images. The first started at 0800 and covered a depth range from 100 to 500 meters – the second started at 0940 and covered a range from 10 to 250 meters. For lack of ROV images – the echo sounders on both research vessels were used actively for monitoring of the subsea plume and the cloud of rising oil droplets. While Johan Hjort concentrated on operating the Rossette sampler – Håkon Mosby circled the discharge vessel to monitor the development of the subsea plume. Recordings of the echo sounder data were saved for later analysis by IMR.

At 0950 – the Norwegian surveillance aircraft arrived at the site and started to guide the workboat through the surface slick. At this time, this was the only aircraft available while the various other surveillance airplanes had left to attend to other tasks. The workboat continued subsea monitoring and surface oil sampling until 1620, with two returns to *Johan Hjort* – the first at 1200 to change crew, the second at 1440 to deliver oil samples.

The SFT aircraft stayed in the area until 1120 on the first flight – and returned at 1605 for a final surveillance of the crude oil slick. At 1630 – the pilots on SFT aircraft concluded that the remaining surface slick would dissipate in short time and represent no serious treat to the marine environment. On that basis – Chevron on behalf of the JIP decided that no attempts to recover the oil would be required. The on-site SFT representative had no objections to this decision.

Workboat launched from Johan Hjort *to monitor crude oil slick.*

Workboat in crude oil slick

Picture from SFT aircraft. Research vessels in crude oil slick.

Inside SFT's surveillance aircraft. View of the radar image of the crude oil slick.

3.3.5 LNG discharge

The natural gas discharge was planned as the last experiment to avoid serious setbacks caused by possible blockage of the exit nozzle due to hydrate formation. Preparations for the discharge of LNG and seawater were started at 0940 when the WROV crew decided to launch the ROV from *Far Grip*. Full rate discharge of LNG and seawater was reported and continued until 1247.

More LNG was remaining for this experiment than planned since the cryogenic pump had actually been pumping at only 70% of the design rate. For this reason, the discharge period could be made considerably longer than the planned one-hour duration. In this period, the ROV took video shots of the rising bubble plume and close ups of gas bubbles – trying to detect hydrate formation. At the same time – *Håkon Mosby* circled the discharge vessel to monitor the plume with the echo sounder.

3.4 Recovery of discharge unit and instruments

After the gas discharge was finished – *Håkon Mosby* assisted *Far Grip* in the recovery of the discharge platform, while *Johan Hjort* recovered the ADCP mooring from the seabed. Thursday June 29 at 1625, as the recovery of the equipment was finished and the slick was declared not recoverable – the vessels departed the experimental site.

Overview of aft deck on Far Grip with NOFO oil recovery vessel seen in background. Picture taken during LNG discharge.

3.5 Return to harbor and demobilization of vessels

After the last experiment was finished Thursday June 29, *Johan Hjort* made a final biological survey in the area before it departed at 2000 the same day on transit to Kristiansund to allow SINTEF personnel to disembark and to unload equipment before returning to Bergen. The vessel arrived in Kristiansund the next morning (Friday June 30 at 0950) and departed at noon the same day for Bergen where it arrived Saturday July 1 at 0830.

Håkon Mosby returned directly to Bergen, while *Far Grip* headed for Kristiansund to unload the power pack for the high pressure pump on request from Schlumberger.

Far Grip arrived in Kristiansund harbor Friday June 30 at 0500 and departed at 0840 the same day for transit to the ASCO base at Tananger, where it docked Saturday July 1 at 0825. The vessel departed from the base Sunday June 2 at 0150 after demobilization of the discharge equipment and cleaning of tanks, and arrived in Mongstad terminating the charter at 1400 the same day. By the time of arrival in Mongstad – *Far Grip* had been on charter for 11 days and 9 hours, consuming a total of 145 m^3 bunker oil.

4 FIELD OPERATIONS IN BRIEF

As the previous review have shown – all major operations, including mobilization of vessels, deployment of discharge arrangement and experimental discharges were all carried out according to plan, although with some delay due to a few technical problems and weather.

A lot of redundancy was built into the monitoring program to allow for unforeseen events as well as adverse weather conditions. So - in spite of some operational problems and equipment failure, the major objectives of the experiment were fulfilled. While the ROV on Håkon Mosby failed at an early stage – the behaviour of the underwater plumes was also monitored by the ROV operated from the discharge vessel as well as by echo sounders onboard the two research vessels. These observations will be valuable for evaluating simulation models for deepwater leaks or blowouts. The echo sounder measurements combined with sampling of the water column for chemical and biological properties turned out to be a promising approach for surveillance of underwater plumes from deepwater leaks or blowouts. The echo sounder images also showed that the gas plumes would dissipate before reaching the sea surface – probably due to dissolution of gas in seawater. This is an important observation relevant for the safety aspects of drilling and operating in deep waters.

Observations from sampling boats and surveillance airplanes demonstrated that oil from the discharges of marine diesel and crude oil formed surface slicks that expanded with time into substantial slicks as diminishing droplets arrived at the sea surface. Patches with thicker oil were water-in-oil emulsions formed were observed in the crude oil slick. These observations are strongly relevant for oil spill contingency planning and environmental risk assessments.

A brief chronological summary of the major events during the field operations is presented in the following table, while a detailed chronological log of the different stages of the field operations is given in appendix B.

Date	***Time***	***Event***	***Comments***
June 21	0500	Supply vessel Far Grip on charter	Far Grip departs Mongstad on transit to the ASCO base in Tananger for mobilization.
June 22	2100	Research vessel Johan Hjort departs from Bergen harbor.	Johan Hjort heading for experimental site to conduct biological survey prior to experiment.
June 23	2400	Johan Hjort arrives in the experimental area	Reports to Far Grip one hour later
	2240	Mobilization in Tanager finished on schedule	Far Grip heading for the CCB base at Ågotnes, Sotra.
June 24	1645	Loading of crude oil and LNG finished on schedule	Far Grip heading for experimental site
	1700	Mobilization of Håkon Mosby finished on schedule	Håkon Mosby heading for experimental site
	2000	Johan Hjort departs experimental area temporarily	Johan Hjort heading for Kristiansund to pick up SINTEF crew and equipment
June 25	0945	Johan Hjort arrives Kristiansund harbor	JIP observers, SINTEF personnel and lab container loaded on Johan Hjort
	1700	Johan Hjort departs Kristansund	

Date	*Time*	*Event*	*Comments*
	1855	Arrival of Far Grip in the experimental area	Vessels arrived about three hours after schedule due to strong Northernly winds
	1930	Arrival of Håkon Mosby	
	1930	Work ROV launched from Far Grip to inspect sea bed	Depth 844 m – sea bed consisted of clay with a few cm thick soft top layer.
	2345	Start of deployment operation	Transfer of tow wire from Far Grip to Håkon Mosby
June 26	0230	Discharge platform at sea bed	Discharge platform deployed through moon pool on Far Grip with assistance from Håkon Mosby. Visual observations made with WROV during deployment.
	0300	Deployment operation finished 3 hours after schedule	Håkon Mosby deployed tow wire, rope and acoustic release with floats for later retrieval.
	0430	Håkon Mosby deploys ADCP on sea bed	Contact problems reported with ADCP.
	0800	Johan Hjort back in experimental area	Vessel arrives with JIP observers, SINTEF personnel and equipment picked up in Kristiansund
	1650	Far Grip starts preparations for discharge of nitrogen and dyed seawater	Communication problems with ADCP and entanglement of OROV caused delayed start of the first experiment.
	1810	Liquid nitrogen pumped at full rate	Temporary problems with power supply to high pressure sea water pump
	1947	First experiment finished	Nitrogen pumped for two hours with variable rate due to temporary overheating problems with power generator for the high-pressure sea water pump. Due to the serious delay of the first experiment – the marine diesel discharge was postponed until next morning.
June 27	0620	Preparations for marine diesel experiment started	OROV launched from Håkon Mosby. Problems with the video transmission lines were reported shortly after and the ROV had to be recovered due to damaged video cable.
	0838	Full rate pumping of diesel and LNG	Experiment commenced after some minor problems with high-pressure pump.
	0930	All pumps stopped - discharge finished	Experimental discharge of marine diesel and LNG conducted successfully.
	0935	Oil spotted on sea surface	Workboats from Johan Hjort starts monitoring surface slick
	1012	First aircraft on site	SFT's surveillance airplane first on site – followed by airplanes from Germany, France, Denmark, Netherlanss and UK.
	1230	Workboats return to Johan Hjort due to adverse sea conditions	Next experiment postponed due to adverse weather conditions
	1800	NOFO oil recovery vessels starts to arrive on site	Oil recovery vessel (ORV) Northern Commander arrives at 1800, ORV Troms Skarven arrives at 2200, and ORV Far Sun comes later in the night..
June 28		Experiments postponed until next day	Adverse sea conditions prohibits launching of workboats and ROV's. All surveillance airplanes, except the SFT aircraft leave site. NOFO oil recovery vessels determined to wait for crude oil discharge.

Date	*Time*	*Event*	*Comments*
June 29	0345	Preparations started for conducting crude oil discharge from 0600	Sea conditions declared acceptable for conducting crude oil discharge
	0510	Sea conditions prohibits deployment of WROV	ROV observations could not be made during crude oil discharge.
	0714	Crude oil experiment started	Crude oil pump started. LNG and crude oil pumped at full rate at 0723
	0810	LNG and diesel discharge stopped	Cryogenic pump switched to LIN. Marine diesel supply exhausted.
	0821	Crude oil reported on sea surface	Surface slick monitored by workboat from Johan Hjort. The MOB boat from Far Grip could not be launched due to sea conditions (swell).
	0950	SFT aircraft on site	Guiding workboat
	1047	Starting preparations for experiment #4, discharge of LNG and sea water.	Pumping LIN. WROV going down to discharge platform to observe plume and gas bubbles.
	1108	Full rate LNG	Last experiment started
	1247	LNG discharge stopped	End of last experimental discharge
	1420	Recovery of discharge platform started	Far Grip assisted by HåkonMosby
	1625	Far Grip and Håkon Mosby depart experimental site	SFT aircraft has declared slick not recoverable
	2000	Johan Hjort departs site	Heading for Kristiansund
June 30	0500	Far Grip arrives Kristiansund	Unloading power pack for high pressure pump
	0950	Johan Hjort arrives Kristiansund	Unloading laboratory container and SINTEF personnel
	1300	Johan Hjort departs Kristiansund	Heading for Bergen
	0830	Håkon Mosby arrives in Bergen	Unloading OROV
July 01	0825	Far Grip arrives in Tanager	Unloading equipment and cleaning oil tanks
	0830	Johan Hjort arrives in Bergen	Cruise finished for IMR
July 02	0150	Far Grip departs from Tanager	Heading for Mongstad
	1400	Far Grip arrives in Mongstad	End of charter

APPENDIX A: PARTICIPATING VESSELS AND CRUISE MEMBERS

Function	***Far Grip***	***Håkon Mosby***	***Johan Hjort***
TAC Representative		1 Cort Cooper, Chevron US	
Project supervisor	1 Bob Watson, Norsk Chevron		
Safety officer	1 Roger Tailby		
Response Officer	1 Odd Arne Follum, Norsk Hydro		
DeepSpill Camera man	1 Steve Kane		
SINTEF cruise coordinators	1 Hans Jensen, SINTEF	1 Øistein Johansen, SINTEF	
Discharge system supervisor	1 Kenneth Maribu, Schlumberger		
CST operators	4 Schlumberger		
LNG/LIN operators	2 Stein Inge Lien, Marintek Harald Haltstrand		
ROV operators	3 OCEANEERING	4 ARGUS	
Subsea monitoring	1 Henrik Rye, SINTEF	1 Alf Melby, SINTEF	
Workboat # 1(SINTEF)			2 Per Dahling Ivar Singsaas
Workboat #2 (SINTEF)			2 Per Johan Brandvik Frode Leirvik
SINTEF Lab container			1 Kirsti Almås
Cruise leader IMR		1 Bjørn Serigstad	1 Tor Knutsen
Oceanographic data aqui.		1 IMR	
Plankton trawling			2 IMR
Chemical analysis			1 IMR
Acoustics			1 IMR
Ornitholog			1 Nils Røv, NINA
DeepSpill JIP observers		1 Mary Boatman, MMS 1 Paul Broussard, Texaco	1 Arne Myhrvold, Statoil 1 Bela James, Equilon
External observers			
Norwegian Pollution Control Authority, SFT	1 Jørn Harald Andersen		
NOFO			1 Kari Stokke
CO_2 experiment		1 Arvid Sundfjord, NIVA	

APPENDIX B: LOG FROM FAR GRIP

Compiled on site by Hans Jensen, SINTEF. Time in Norwegian local time.

Date/ time	*Location*	*Comment*
23 June		
0830	Stavanger	MOB. Checked with Sture about potential lockout. Nothing new. We decide to have all crude loaded on truck today. Called Total Transport and ordered the second tank truck. All crude should be loaded as early as possible this afternoon. Later repeated order by fax.
1000		Tank truck arrived for filling LIN tank.
		Frode Narten, DnV called to inform he is the standing in case Ingolf Jensen is late for inspection of experimental setup today. Phone 90028053.
1130		Started to fill LIN.
1330		Called Total Transport. Their 2. truck has a broken axle. They are trying to fix it. They are calling Sture between 1500 and 1600 to decide when to start the filling of crude.
1330		Bob: Marintek has a few small leaks on their equipment. These leaks might be large enough to fail the pressure test.
1350		We have checked with the ship's electrician whether it is possible to have the power cables for the cryogenic pump and the WROV connected to separate electric sources on the ship. This could only be done if the cable for the cryogenic pump is run through open doors to the engine room. After discussing with Øistein, Cort and Roger, we continue to use the same outlet for both consumers. To minimize the risk of power failure, the winch for the WROV should not be started during pumping with LIN or LNG:
1430		Service on a turbo charger for the main engine will probably be finished about 1700.
1440		1 coiled tubing has been tension tested to 7.5 tons without problems. The other has not been tested so far due to a leakage in a hydraulic hose. This hose is being repaired. According to Schlumberger they can do the rest of the work after leaving Stavanger.
		The length of coiled tubing is 1200 m and 1250 m, respectively.
1440		Oceaneering still has some more to do before testing the WROV in the water.
1455		The tank truck left after finishing the filling of LIN.
1520		Marintek is waiting for the freshwater pump to get started with the high pressure testing.
		The remote operated safety valve is unknown to the Schlumberger supervisor (Kenneth Maribu). He has been asked to call Snorre Furberg. This is not according to plans accepted by DnV.
1530		Total Transport called and confirmed that they will be filling two tank trucks at Sture trerminal 1900 hrs tonight.

Date/ time	*Location*	*Comment*
1900		DnV representative checked the setup. According to the DnV survey report, we have been granted the permission to use the setup, with comments like: Several certificates from Schlumberger are missing. Certificates for the two Oceaneering containers are missing. Check valve for seawater on main deck, but not installed. missing grounding on 1 Oceaneering powerpack. After the survey report was finished, Schlumberger brought the certificates and presented them for the DnV representative. The Oceaneering certificates will be faxed both to DnV, Stavanger, as well as to the FAR GRIP.
1930		Gunnar J. Kvale from KON Sertifisering A/S accepted the Oceaneering winch equipment after a load test.
2030		The cryogenic pump has been tested. One of three pistons is ok, one is not working, and the third is not working correctly. Problem likely due to moisture that has frozen. The manufacurer's two representatives will follow the ship to CCB and try to fix the problem.
		The ship is waiting for an express parcel, arriving at 2153 from Horten.
2243	Leaving Stavanger	Parcel arrived, and the ship is leaving for CCB, ETA 0730.
2340		Contact with J.Hjort that arrived the experiment area an hour ago. 10 m/s nly wind, 2-3 m max waves, few seabirds.
2355		Contacted Total Transport, their two tank trucks are waiting at CCB with the crude.
24 June		
0735	Arrival CCB	Arrived CCB. LNG truck on site.
0745		Contacted tank truck company to start filling.
0845		Lab report re. crude and crude sample received, quality accepted..
0845		Captain FAR GRIP, B.Watson and H. Jensen go to Marineholmen for a meeting with captain on Håkon Mosby
1200		Back on Far Grip again. Cryogenic pump fixed. Another test of the pump before filling LNG.
1600		H.Mosby reay to leave Bergen.
1620		All LNG filled. Ready to leave CCB.
1635	Leaving CCB	Outside CCB, starting to get the wire through the moon pool.
1645		Wire ready, started transit to experiment area.
1700		Received request from J.Hjort to stay in the experiment area for another 4 hours. They are also requesting a certified welder to seafasten the lab container.
1750		Granted J.Hjort 3 hrs. more so far. Checking for welders.
1900		Safety brief in the messroom, walk through the deck area.
2340		Contact with J.Hjort. They are on their way to Kr.sund, only some fulmar (havhest), very few other birds.
2330		Lunchtime on Far Grip.
25 June		
0720	N6246' E 0504'	Nly wind 10 m/s. Speed 10.5 knots, overcast.

Date/ time	*Location*	*Comment*
1123	6332 0503	Distributed UHF radios to Schlumberger, Oceaneering, Safety Officer. Weather is improving, 13 knots nly wind.
1300		Trying to send fax request regarding bird count to Johan Hjort.
1633	6433 0457	Heading towards N65 E04:50. Expecting approximately 800 m at this position. Wind nly 13 knots.
1855	N 6500 E 0450	Far Grip in experiment position. Stops to go on DP for 15-20 min. before diving to seabed.
1920		DP stabilized. WROV can dive to the seabed any time now.
1932		WROV in the water.
2000		WROV passing 600 m depth.
2030		WROV at about 840 m.
2120		844 m depth. The seabed consists of clay, soft layer is a few cm thick. We are satisfied with seabed conditions. The WROV is starting to ascend. Will go to 30-40 m depth to wait for deployment operation.
2120		Schlumb. has a problem with the depth meters. This is likely due to all the splashing from the moon pool during transit. Will try to dry it and solve the problem.
2230		WROV on deck.
2345		Shot line to H.Mosby for transfer of tow wire.
26 June		
0015		Starting to deploy CT to 10 m depth.
0025		Discharge platform at 10 m.
0035		WROV in the water, not sufficient visibility to observe platform.
0108		Discharge platform at 50 m.
0114		Discharge platform at 75 m.
0119		Discharge platform at 107 m.
0132		Discharge platform at 240 m.
0146		Discharge platform at 400 m.
0155		Discharge platform at 500 m.
0204		Discharge platform at 600 m.
0215		Discharge platform at 703 m.
0228		Discharge platform at 820m.
0231		Paid out 26 m CT after bottom indication on CT tensiometer.
0243		WROV searching at seabed for discharge platfor.
0306		Schlumberger and Oceaneering allowed shutting down for the night. Håkon Mosby deploying tow wire, rope and acoustic release with floats. OROV requested to go i the water at 0700 to confirm that platform is positioned correctly.
0355		WROV on deck.
0430		Håkon Mosby deploys the ADCP just SE of Far Grip, position N 64:59.79' E04:50.31'.
0700		Some problems with data transfer from ADCP.
0745		H.Mosby moves closer to deploy the OROV.
0800		MOB boat from Far Grip leaving for J.Hjort. Brings fresh weather forecasts to H.Mosby.
0845		Requested Response Officer to communicate with NOFO to be on site.
0915		OROV estimates to be down at bottom at 1000.
1000		Toolbox meeting for N2 release. Finished 1026.

Date/ time	*Location*	*Comment*
1100		OROV has seen the CT on the bottom. Cannot reach all the way to the discharge platform. Started to follow its own cable to see whether it is entangled in the CT.
1100		Two persons over to J.Hjort to try to fix the ADCP, worst case bring it to the surface.
1200		OROV cleared from the CT. The Far Grip moved 15 m to Starboard to lift the CT off the bottom.
1220		Aircraft coordinator contacted. The 6 aircraft are keen to fly. BW informed that the m.diesel spill is at least 2 hours delayed. Surface sampling personnel want to get started with the diesel spill as close to plan as possible. Håkon Mosby accepts that ADCP is only recording internally during the diesel spill.
1335		MOB boat out.
1335		Håkon Mosby has a transponder that will reach 2000 m out. This transponder is transferred to Far Grip for attachment on the WROV.
1355		MOB boat in.
1415		The ADCP is now operational. We are waiting for the OROV to observe the platform at the bottom.
1500		WROV ready to go in the water. OROV got stuck, probably in the CT.
1510		WROV in the water.
1620		OROV got away from the CT and is on its way back to the H.Mosby. WROV on its way down to inspect the platform.
1627		BW called Alun to inform about the situation.
1640		WROV confirmed that discharge platform is perfectly placed on the seabed.
1650		Starting pump for heat exchanger. Starting seawater pump.
1756		Can see a cloud coming out of discharge nozzle.
1806:30		Starting up LIN pump, Release #1.
1807:30		Pumping 70 % N2, pressure rising.
1810:40		75-80% N2.
1811		Full rate N2.
1812		Overheating motor for high pressure (HP) pump.
1813		N2 rate reduced to 50% to save LIN.
1815:50		N2 out at seabed, 78% of full rate.
1817		Opened doors to improve cooling rate for HP pump motor.
1822		OROV moving in towards platform from NE, 700 m off.
1824		N2 rate up to 100%. J.Hjort 200-300 m to W.
1826		Qceaneering: Cryogenic pump motor creates lots of noise on sonar image.
1828		N2 rate 100%, 80 bars pressure.
1830		Requesting H.Mosby and J.Hjort to go on channel 67 if they need to discuss.
1831		Cooling down HP pump motor before starting up again.
1842		WROV back at the disharge platform.
1843		Starting seawater (HP) pump again.
1847		Seawater at 996 l/min.
1848		1000 l/min.
1856		Stopped releasing N2.
1857		Request from H. Mosby to continue pumping LIN.
1900		OROV at 705m and ascending, 180 m NE of discharge platform.
1905		WROV starts ascending. N2 ready again, seawater and Rhodamin ready to be pumped.
1907		Pumping Rhodamin and seawater.

Date/ time	*Location*	*Comment*
1912		WROV trying to observe N2 on its way up.
1916		N2 spent: about 1/3 of the tank, i.e. about 1 hour full rate pumping.
1921		Stopping N2 release for today.
1929		WROV at 600m.
1943		Pumping Rhodamin and seawater for 15 min. more.
1947		OROV does not need more, Shutting down seawater and Rhodamin.
2000		WROV on deck.
27 June		
0620		OROV in the water.
0649		MOB-boat (Blue boat) requested at J.Hjort 0900.
0708		WROV at 50 m.
0710		OROV returns to Mosby with video problems.
0720		Marintek requests HE-water.
0740		Safety Officer: Everything ready for release.
0741		WROV TMS in place at seabed.
0748		S/w pump started, start pump LIN.
0756		Full rate LIN, 47 bars.
0759		N2 release starts (out at discharge platform).
0800		10.7 C gas, 80 bar pressure.
0800		Starting diesel feeding pump.
0803		Pulsating flow out at seabed. Diesel feeding pump stopped.
0807		Fire alarm in cement room.
0809		Reduces to 50% LIN.
0814		Seawater feeding pressure stopped.
0816		Reactivated alarm. It went off immediately again. (Later it proved to have a short circuit due to salt water spray from the broken pipe).
0820		A lot of seawater in the cement room.
0823		Trying to feed diesel to HP pump.
0826		Schlumberger had a problem with manifold on deck (valve closed when expected to be open).
0827		Trying to pump diesel again.
0828		Starting HP pump again, increasing pressure (Release #2 starting).
0829		Pumping diesel, 660 l/min.
0829		850 l/min.
0833		Diesel out from template.
0834		Starting to switch to LNG.
0838		Full rate LNG.
0842		Sampling done in water colomn???
0847		LNG pumping quite all right.
0852		Tank sensor reports 50% diesel pumped (underestimated).
0913		MOB-boat in the water.
0916		WROV working from seabed to 50 m above.
0923		Stops LNG, switching to LIN.
0928		Stops pumping diesel (tank empty). Pumping rate very accurate.
0930		Stops pumping LIN, Release #2 finalized.
0934		Blue boat ready and in position.
0935		Diesel observed on the surface towards NE.
0942		All pumping relating Release #2 finalized at Far Grip.
0947		Diesel on surface, probably 1-5 mm thickness.
0953		WROV permission to go to surface.

Date/ time	*Location*	*Comment*
1000		Red boat reports logging on two channels.
1006		Wind 25 knots N-ly.
1012		LN-SFT on site.
1039		Work conditions are becoming marginal due to wind and waves. LN-SFT confirms that slick is gone when oil is passing Far Grip.
1104		Red boat most upwind. Measuring oil, but has no oil on the surface.
1235		Next release postponed until tomorrow due to wind and waves.
28 June		
0620		New weather forecast. Probably not able to do the third spill until after midnight when the significant waveheight is predicted to reduce to 2.0 m.
		All the aircraft except LN-SFT will leave today, so will the aircraft coordinator. LN-SFT has no IR/UV scanner operational.
1030		After discussion beetween the vessels it is clear that both Deepspill and NOFO plan to stay in the area to carry out the experiments early morning tomorrow, weather permitting.
29 June		
0345		Wind 20 knots, sea has come down. We go for release at 0600.
0430		M.tek starts to cool down cryogenic pump.
0505		Received ADCP-data from J.Hjort, seabed to 340 m. Current around 5 cm/s towards S. From H. Mosby reported an average of 20 cm/s in E-ly direction.
0509		Too much heave for WROV. Used 8.5 l Rhodamin the other day.
0520		Radio report from the ornitologist: Max 5 flying seabirds (fulmar) observed, No swimming seabirds observed. Conditions well within limits in the spill permit.
0530		In case current conditions still are as measured at 0500 and the oil is rising with the same speed as the diesel spill, the crude oil will surface about 290 m out from Far Grip in direction 113 degrees.
0548		H.Mosby in position about 350 m in direction 110 degrees.
0609		N2 at 60 bars, going towards 80 bars.
0615		Pumping LIN. J.Hjort circles around Far Grip, echosounder sees N2 on W side.
0628		J.Hjort behind F.Grip at port side, sees N2 at 700 m, traces at 650 m.
0637		Stop N2.
0656		Order to start Release #3. Weather allows MOB-boat from J.Hjort to work in the slick. MOB-boat on F.Grip not allowed.
0700		Pumping full rate N2, 30 bars. Full rate seawater 1000 l/min.
0706		Seawater 1000 l/min., 169 bars.
0707		Starts feeding pump crude.
0710		N2 reduced to 50% while waiting for crude.
0714		Starting to pump crude with HP pump.
0715:20		1000 l/min crude, 184 bars.
0720		Starts switching to LNG.
0723		Full rate LNG.
0734		LN-SFT is planned to be on site at 1000, Daling is requesting to have it on site 0930.
0737		Gas pressure 81 bars, 10 C.
0744		Crude 186 bars, 1000 l/min.
0810		Stops LNG, switching to LIN.

Date/ time	*Location*	*Comment*
0811:30		Lost crude oil feeding pressure (pump sucks air), switching to seawater. Pumping 5 m3 seawater to evacuate crude.
0813		Full pressure N2.
0816		H.Mosby observes plume at 200m in E direction.
0818		Stops pumping seawater, stops LIN. Release #3 finalized.
0821:30		From F.Grip reported ”brown emulsion” behind H.Mosby. Sampling boat guided to area.
0824		LIN tank depressurized.
0844		Red boat: Oil surfacing fresh, very thin slick.
0845		H.Mosby profiling ADCP from NE through the slick.
0930		Starting to pressurize N2.
0940		WROV in the water.
0950		LN-SFT on site.
1000		Guiding Red boat from LN-SFT.
1020		Expects to be ready to start pumping LIN approx. 1040.
1047		Starts pumping LIN, Release #4.
1049		Starting to pump seawater, no Rhodamin.
1050		Seawater 500 l/min.
1051		WROV in and out again from the plume.
1052		25 bars pressure N2. A cloud coming out of discharge platform, dirty seawater in the tanks????
1059		Red boat reports emulsion a distance from the surfacing area. Has been sampling based on good guiding from LN-SFT.
1105		Full rate LIN.
1106:30		Switching to LNG.
1108:30		Full rate LNG.
1126		About 6000 l LNG left in tank. Full pumping rate proves to be 0.7 Sm3/s.
1247		Release #4 finished. WROV to go to TMS, and then to surface.
1251		H.Mosby requested to trigger the acoustic release for the towing wire.
1259		WROV at 680 m.
1307		Starts to pump LIN.
1321		Stopped to pump LIN.
1326		Red boat to the north of slick, reports that individual droplets still are surfacing.
1334		WROV on deck.
1420		Starting to recover discharge equipment.
1625	Leaving for Kr.sund	LN-SFT declared slick not recoverable. Far Grip has recovered all equipment and is sailing towards Kristiansund to unload a power pack on request from Schlumberger.
30 June		
0500	Kr.sund	Vessel in Kristiansund harbor.
0840		Leaving Kristiansund, heading for Stavanger to demobilize all equipment.
1330	Ålesund	Short stop in Ålesund.
1 July		
0115	Bergen	Passing the Sotra bridge.
0825	Stav.	Docked at the ASKO base in Tananger for demob.
0900		Welders arrived.

Date/ time	*Location*	*Comment*
1308		Called Alf Nilsen, JM Consult to ask whether welders were supposed to leave for lunch before the job is done. All mob activity stopped due to this. Supervisor not here. Welders arrived during phone call.
1330		Called Alf Nilsen again to inform that only three welders returned. Supervisor requested to get back to make sure work is done.
1500		Tank cleaning personnel on board to start work.
1600		Welders finished and left ship.
2030		Methanol tank vented – personnel with air supply entered tank to clean.
2 July		
0150	Dep. Stav.	Leaving Stavanger for Mongstad after finishing tank cleaning.
0950	Bergen	H.Jensen leaving Far Grip at Flesland.
1400	Mongstad	Far Grip charter ended.

APPENDIX C: SURFACE AND SUBSEA MONITORING

C1: Monitoring and sampling during the Marine Diesel release (June 27th)

0600	ADCP-measurements received
0630	ADCP-results forwarded to Far Grip
0815	Release N_2
0830-0930	Release of Marine Diesel and LNG
0930	Start tracking (in transects) the plume by Echo-sounders (very visible)
0930	Workboats on the water (rough weather !)
0940	Surface oils (most "Rainbow") observed on the water about 400-500m NE of Far Grip
0950-1200	**Surface sampling ("Blue" Workboat).** Mostly Oil film thickness measurements were performed. General thin oil films (mostly Rainbow and "metallic, i.e. < 50 µm), means too thin for oil sampling. A total of 4 pad samples, 6 Teflon-net samples and 1 surface oil sample taken. Generally, it was difficult to perform oil film thickness measurements due to rough weather. One sampling series was co-ordinated with the German Aircraft. The surface sampling was cancelled at 1200, due to workboat failure
0930-1330	**Subsurface sampling ("Red" Workboat).** *In-situ* UVF-measurements were carried out at 1 and 8 m depth. Transects were carried out both across and along the slick. Significant response of dispersed oil was obtained. A total of 8 water samples (each sample consisting of 1x 1L and 3x25 ml) for analysis of TPH, VOC and SVOC in water, and for UVF-response calibration.
0920	**CTD/UVF/Rosette monitoring (series 1, station 491):** No water sampling, the plume was missed.
1100-1115	**CTD/UVF/ Rosette monitoring (series 2, station 492):** A total of 8 water samples (each sample consisting of 1x 1L and 3x25 ml) were taken at 300, 250, 200, 150, 140, 100, 50 25 and 10 m depth. Response was observed on the UVF.
1445-1500	**CTD/UVF/ Rosette monitoring (series 3, station 493):** A total of 7 water samples (each sample consisting of 1x 1L and 3x25 ml) were taken at 400, 300, 200, 100, 75, 25 and 10 m depth. Response was observed on the UVF.
1930	Visual observation of oil still resurfacing (sheen /rainbow, i.e. <5 µm) in position N65.00.55/E004.52.74 (i.e.1.3 Nm NE of Far Grip)
Additional	**CTD/UVF/ Rosette monitoring (series 0, station 488), Blind samples taken June 26:** 3 water samples (each sample consisting of 1x1L and 3x25 ml) were taken at 800, 500 and 300m depth.

C2: Monitoring / sampling during the crude oil release (June 29th)

0400	ADCP-measurements received
0500	ADCP-results forwarded to Far Grip
0700	Release N_2
0720-0815	Release of Crude Oil and LNG
0730	Start tracking (in transects) the plume by Echo-sounders (very visible)
0750	Workboat on the water. Only one workboat was in operation this day. The workboat consisted of 2 SINTEF personnel operating the sub-surface UVF/ water sampling, and 2 SINTEF personnel doing oil film thickness and surface oil sampling.
0822	The first surface oils (most "Rainbow") observed on the water about 300-400 NE of Far Grip
0800	**CTD/UVF/Rosette monitoring (series 1, station 500):** A total of 6 water samples (each sample consisting of 1x 1L and 3x25 ml) were taken at 500, 450, 400, 300, 200 and 100 depth. The samples were taken in the plume, co-ordinated to the Echo-sound response.
0940	**CTD/UVF/ Rosette monitoring (series 2, station 501):** A total of 6 water samples (each sample consisting of 1x 1L and 3x25 ml) were taken at 250, 200, 100, 50, 25 and 10 m depth. Response was observed on the UVF.
0800-1630	**Subsurface and surface sampling ("Red" Workboat).** Extensive sampling and monitoring was carried out. *In-situ* UVF-measurements carried out at 1 and 8 m depth. Transects were carried out both across and along the slick. Between the transects, surface and oil film thickness sampling were taken both at stations where oil came up to the surface and on surface weathered oil downwind the slick. The workboat was partly guided to sampling stations by the LN-SFT when the aircraft was on site: 1st. Series: 0955-1120 2nd. Series: 1605-1630. The following samples were taken: 10 pad samples, 1 Teflon-net sample and 8 surface oil samples A total of 5 water samples (each sample consisting of 1x 1L and 3x25 ml) were taken for water TPH, VOC and SVOC characterisation in the water and for UVF-response calibration.
1630	**Sampling monitoring terminated. SFT aircraft declared the remaining surface emulsion not recoverable.**
2130	**Debriefing meeting at Johan Hjort**