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Aerial Surveillance and Ground-truth Monitoring of Light Crude Oil / Condensate Slicks during Full-scale Field Experiments - Behaviour and Effect of Response Options

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Introduction and objectives

An increasing number of light crude oils and condensates, with a wide span in physico-chemical properties, are coming into production on the Norwegian Continental Shelf (NCS). The international trade and transport of such light crudes and condensates carries the potential for accidental releases, as the recent "Sanchi" incident in the East China Sea demonstrates.

The research project *"Formation and behaviour of thin oil films and evaluation of response methods including HSE"* (hereafter-called TOF project) was a 3-year R&D project (2014-2017) led by SINTEF Ocean and funded by the Research Council of Norway and the oil industry. The TOF project aimed to acquire knowledge to provide more efficient and safe oil spill response to releases of condensates and light crude oils that may lead to thin oil films on the sea surface. In this context, we define thin oil films as spill scenarios leading to initial releases of oil slicks in thicknesses range of > 5µm < 200-300 µm i.e. film thicknesses that may have potential for environmental effects on resources such as sea birds. This thickness range corresponds to codes 3 and 4 of the Bonn Agreement Oil Appearance Correlation (BAOAC).

A total of 8 different light crude oils and condensates, all in production on the Norwegian Continental Shelf, were characterized in the laboratory and tested in basins as a part of the TOF project. The different oils and their simulated weathered residues exhibited a wide range of physicochemical properties. One of these oils was selected for further studies in the field as a part of the annual NOFO (Norwegian Clean Seas Association for Operating Companies) "Oil on Water (OOW) field trials" in the North Sea in June 2016. Three experimental slicks, each of 10m^3 of Åsgard Blend (a condensate/light crude oil blend) were released onto the sea surface under controlled conditions. The purpose of these field experiments was to:

- Document the behaviour of these light oils when spilled at sea.
- Assess the efficacy of different response methods in mitigating such oil slicks.
- Document the potential risk of human exposure to the VOCs (Volatile Organic Compounds) evaporating from the slicks during response operations.

A Norwegian Coast Guard vessel released the oil (Figure 1-A) and a response vessel employed different response methods including low-dosage dispersant application followed by artificial turbulence using high-capacity water flushing bow booms, and mechanical dispersion using Fi-Fi (Fire Fighting) monitors (see Figure 2 A and B). A variety of platforms were used to monitor the behaviour of the oil on the sea surface, the VOCs in the air and the oil in the water under the oil slicks. These included:

- Marine surveillance aircraft from Finland, the Netherlands and Norway. Quadcopter drones were also used to obtain aerial video and air sampling.
- An USV (Unmanned Surface Vessel) deployed an Aerostat equipped with Visible/IR video and sampling boats with instrumentation for measuring VOC in the air (Figure 1-C)
- The oil slicks on the sea surface were sampled to determine oil layer thickness and the physicochemical properties of the oil as they changed due to ‘weathering’ at the sea surface. The water column under the slicks was monitored for oil-in-water concentrations and dispersed oil droplet size distributions. (Figure 1-D).

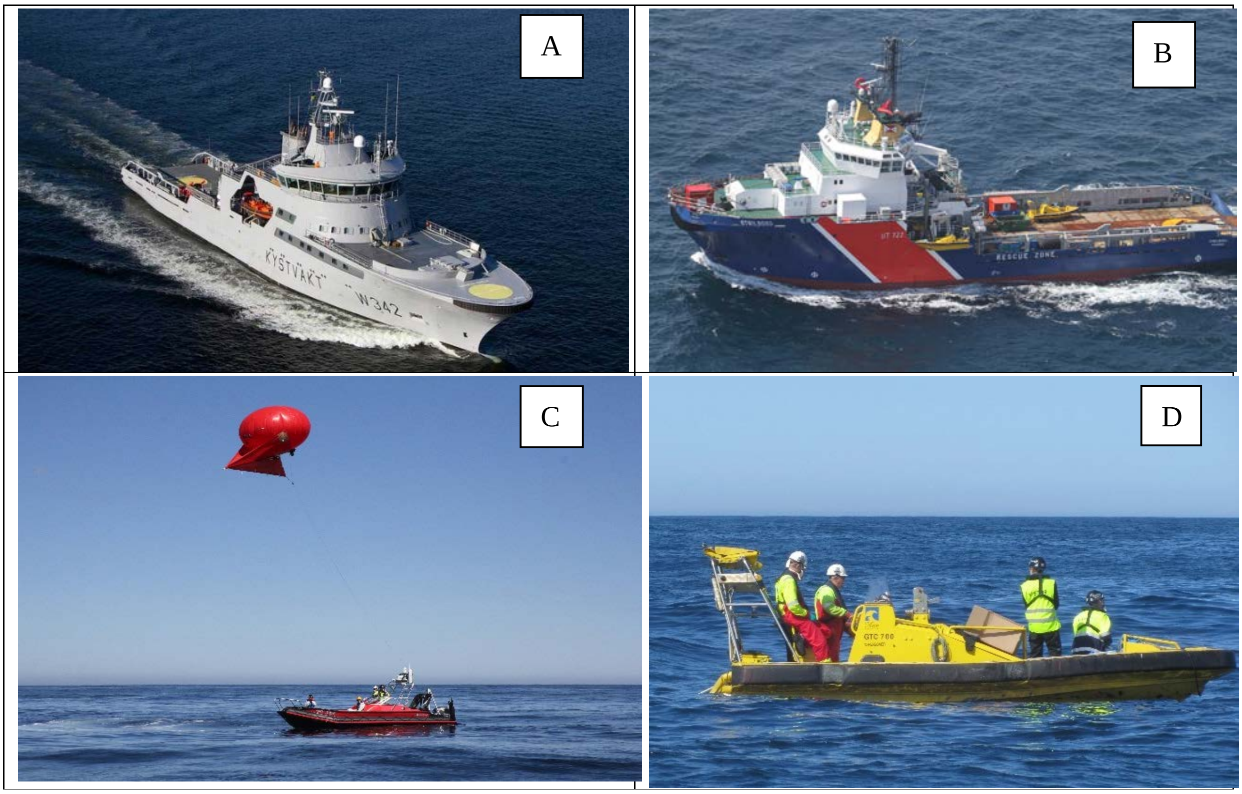

Figure 1 Vessels involved in the TOF- experiments: A):KV Sortland (Releasing oil), B): MS Strilborg (Response vessel) C): Air Sampling boat (USV) with Aerostat, D): Sampling boats (MOB boats for oil on surface and water column).

Figure 2: A: Response systems installed on MS Strilborg (low-dosage dispersant application followed by artificial turbulence using high-capacity water flushing bow booms
B: Mechanical dispersion using Fi-Fi monitors on thin oil films

Main Results

A lot of good data was acquired from the various monitoring platforms during the two-day field trial. Comprehensive planning and good prevailing weather conditions allowed three of four planned experiments with Åsgard Blend to be conducted.

The spreading and weathering behaviour of spilled Åsgard Blend was documented in both non-breaking (< 5 m/s wind speed) and breaking wave conditions (> 5 m/s wind speed). The oil was released to produce an initial average oil thicknesses of 200 to 500 µm. Measurements were made of the total volatiles (TVOC) concentrations in the air and the plumes of volatile compounds were also detected remotely by IR sensors on the aircraft and Aerostat during and short time after release. Approximately 50 vol.% of the light crude / condensate blend evaporated in the first 2 to 3 hours on the sea. The initial spreading behaviour of the oil was in accordance with the modelled spreading behaviour. With time, the oil residue on the sea surface became re-distributed as areas of relatively thin oil (approximately 0.1 mm thick or less) and smaller areas of relatively thick oil (approximately 1 mm thick). After about one hour on the sea surface, the reference slick (control – no treatment) had ceased spreading and formed narrow bands of thick oil residue (1 to 2 mm) containing > 80% of the oil volume within < 20 % of the IR-detectable slick area. This narrow bands of thick oil retained a similar area and, although was distorted by the prevailing wind and currents, was maintained for many hours on the sea. The relatively thin oil spread and appeared to produce an increasing area of visual and UV detectable sheen. This sheen (<1 µm) is considered not to cause any harmful environmental effect e.g. on seabirds.

Three novel response techniques: (i) low-dosage dispersant treatment, followed by (ii) high-capacity water flushing from bow-mounted boom, and (iii) water flushing by using Fi-Fi monitors were tested.

Low dosage dispersant application followed by high-capacity water boom flushing 0.5 to 1 h after the dispersant treatment was found to be effective. The majority of oil in the slick was dispersed as small oil droplets (70 to 100 µm VMD) in the water column. Even very low dispersant treatment rates (DOR 1:300 to 1:400 for the thickest oil) were sufficient to disperse this light crude oil. Only a thin oil film remained after the dispersant treatment.

Despite being tested under less than optimal conditions, water flushing by using Fi-Fi monitors was effective (see Figure 2-B). The oil was allowed to weather on the sea in breaking waves for 3 to 4 hours before treatment. The experiment indicated that water flushing can effectively mechanically disperse low viscosity oils before the oil has started to become semi-solid.

The response techniques tested in the field clearly show the potential for developing operational response strategies with high encounter rates to significantly reduce the persistence of light crude oils /condensates under on the sea in calm conditions.

References

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