Marine Pollution Bulletin 111 (2016) 402–410

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

The value of offshore field experiments in oil spill technology development for Norwegian waters

Liv-Guri Faksness *, Per Johan Brandvik, Per S. Daling, Ivar Singsaas, Stein Erik Sørstrøm

SINTEF Materials and Chemistry, NO-7465 Trondheim, Norway

ARTICLE INFO

Article history:
Received 1 April 2016
Received in revised form 14 July 2016
Accepted 25 July 2016
Available online 13 August 2016

Keywords:
Oil spill
Field experiments
Weathering
Oil spill contingency
Arctic

ABSTRACT

The blowout on the Ekofisk field in the North Sea in 1977 initiated R&D efforts in Norway focusing on improving oil spill contingency in general and more specifically on weathering processes and modeling drift and spreading of oil spills. Since 1978, approximately 40 experimental oil spills have been performed under controlled conditions in open and ice covered waters in Norway. The importance of these experimental oil spills for understanding oil spill behavior, development of oil spill and response models, and response technologies are discussed here. The large progress within oil spill R&D in Norway since the Ekofisk blowout has been possible through a combination of laboratory testing, basin studies, and experimental oil spills. However, it is the authors' recommendation that experimental oil spills still play an important role as a final validation for the extensive R&D presently going on in Norway, e.g. deep-water releases of oil and gas.

1. Introduction

The oil and gas exploration on the Norwegian Continental Shelf started in the 1960s and the first field, Ekofisk, was in production from 1971. In April 1977, an oil well blowout occurred at the Ekofisk Bravo platform that lasted for seven days. An estimated volume of 13,000 tons of oil was released to the sea, the largest blowout in the North Sea to date. Fortunately, the blowout caused less damage than feared. The oil slick dissipated before reaching land, with a large portion having been evaporated and dispersed naturally (Audunson, 1977). However, the debate on its possible environmental impact had started. The focus on oil spill related R&D in Norway prior to the Bravo blowout in 1977 was limited. This incident initiated a large R&D effort in Norway focusing on modelling of oil drift, mechanical recovery offshore, and weathering processes in marine oil spills. Already in 1978, the first set of large experimental oil spills in Norwegian waters was performed to verify the findings from the Ekofisk blowout (Sørstrøm et al., 1978).

This paper is focusing on selected large scale field experiments performed in Norway over the past 35 years, both in open and ice covered waters. The process from planning to accomplishment of a field trial is long. During the last decade, the requirement from the Norwegian authorities has become stricter regarding documenting the necessity for carrying out experimental oil discharges. The process starts with a dialog with the pollution authorities as early as possible in order to communicate the scope of work and the objective of the field trials, as well as requirements regarding location of the field trial and criteria for oil release. It is the Norwegian Environment Agency that issues the discharge permits on the Norwegian Continental Shelf.

Some of the most significant field experiments performed in Norway for understanding oil spill behavior, development and improvement of dynamic oil spill and response simulation model tools, and oil spill countermeasures will be summarized and discussed. The objective is to document the value of performing field experiments to develop and improve oil spill models, and to verify new knowledge and technology development. Table 1 gives an overview of some of the most important field experiments, which mainly have been funded by the oil industry, but also by the Norwegian authorities (e.g. Norwegian Coastal Administration and Norwegian Environment Agency). NOFO (Norwegian Clean Sea Association for Operating Companies) has since the 1980s performed field trials, more or less on an annual basis, with the last ones performed in 2015. These trials have contributed considerably to technology development, but will not be addressed here. More information regarding the NOFO field trails can be found on www.nofo.no.

The progress within oil spill related R&D has taken place over the past 35 years through a combination of laboratory testing, basin studies and controlled field trials, and has formed the basis for the continuous development and refinement of dynamic oil spill and response simulation model tools. These tools are used today in connection with e.g. Environmental Risk Assessment, Oil Spill Response Analysis and Net Environmental Benefit Analysis (NEBA). The series of >40 experimental field releases (typically 2–50 tons of oil for each release) have been crucial in the validation of the scientific documentation and in gaining operational experiences, which today is implemented in the oil spill contingency plans in Norway. However, much of this research is

* Corresponding author at: SINTEF Materials and Chemistry, Environmental Technology – Oil Spill Research, NO-7465 Trondheim, Norway.
E-mail address: livgurif@sintef.no (L.-G. Faksness).

http://dx.doi.org/10.1016/j.marpolbul.2016.07.035
0025-326X/

Table 1
Selected field experiments in Norwegian waters (from 1978 to 2011).

Year	Location	Amount of oil	Objective/monitoring
1978	Tromsøflaket	25 tons crude	Drifting, spreading, weathering
1982	Haltenbanken	100 tons crude	Drifting, spreading, weathering
1982	North Sea	7 × 2 tons crude	Drifting, spreading, weathering, dispersant application from boats
1983	Oslofjord	21 × 0.1 ton	Small scale dispersant effectiveness screening testing. Validation of laboratory testing
1984	North Sea	6 × 10 tons crude	Drifting, spreading, weathering, dispersant application from aircraft. Gave unique documentation of dispersant working mechanisms
1985	Haltenbanken	4 × 10 tons crude	Drifting, spreading, weathering, natural vs chemical dispersion
1989	Haltenbanken	30 tons crude	Drifting, spreading, weathering followed over 3.5 days
1991	Haltenbanken	3 × 20 tons crude	Drifting, weathering, satellite monitoring
1993	Barents Sea	26 tons crude	Marginal ice zone: drifting, spreading, weathering, oil in ice monitoring
1994	North Sea	3 × 15 tons crude	Drifting, spreading, weathering, dispersant application from helicopter
1995	North Sea	3 × 15 tons crude	Surface release. Drifting, spreading, weathering, dispersant application from boat and helicopter
1995	North Sea	1 × 25 tons crude	Underwater release-pipeline simulation: spreading, drifting, weathering
1996	North Sea	2 × 15 tons crude	Surface release. Drifting, spreading, weathering, dispersant application from helicopter (Response 3000)
1996	North Sea	1 × 43 tons crude and gas	Underwater release-blowout simulation: spreading, drifting weathering
2000	Norwegian Sea	2 × 60 tons crude and diesel	Underwater blowout simulation from 850 m depth
2008	Barents Sea	0.7 ton crude	Response technology: testing of skimmers, booms, herders in ice
2009	Barents Sea	20 tons crude, 5 tons IF30 emulsion	Response technology: testing of skimmers, dispersant application, ISB, satellite monitoring. Drifting, spreading, weathering, MetOcean, oil-ice-water interactions

published in grey literature and technical reports that are becoming difficult to access for the general public.

The SINTEF approach for development and verification of new oil spill technology is illustrated in Fig. 1. It typically starts with a large number of laboratory experiments to understand the basic theory. The next step is laboratory experiments in a larger scale that may include testing in basins of different sizes, with the final verification of the applied technology typically taking place in a field experiment. This R&D strategy was followed in the SINTEF Oil in ice JIP (summarized in Sørstrøm et al., 2010): A large number of small- and medium-scale tests were performed under controlled conditions in the laboratory facilities at SINTEF Sealab in 2006. These tests were run with a number of combinations of oil types, ice conditions, temperatures and other important parameters that affect the behavior of oil as well as the possibilities for efficient oil spill countermeasures with the various available techniques. Important parts of the test program were carried out at the outdoor test facilities at the Svea Research Station (Svalbard) in 2006 and 2007, and lastly, two offshore field experiments were conducted in the marginal ice zone in the Barents Sea in 2008 and 2009 (Sørstrøm et al., 2010).

2. Drifting and spreading of oil

Knowledge about oil spill drift and spread has been developed through a number of field trials starting in 1978 with the first large scale experiment on Tromsøflaket in the Barents Sea and followed up with a large number of experiments thereafter (Table 1). During the first experiments the existing basic knowledge on this subject was quite limited, but they gave valuable insight into how the oil behaved and served as a basis for further developments within the field of oil spill research and response technology development.

As mentioned above, the first large scale experimental oil spill in Norwegian waters was performed on Tromsøflaket in 1978, releasing 25 tons of Ekofisk crude oil (Sørstrøm et al., 1978). The key activities during this set of field experiments were observation and mapping of the oil slick, both by ship and from air. During the experiment that

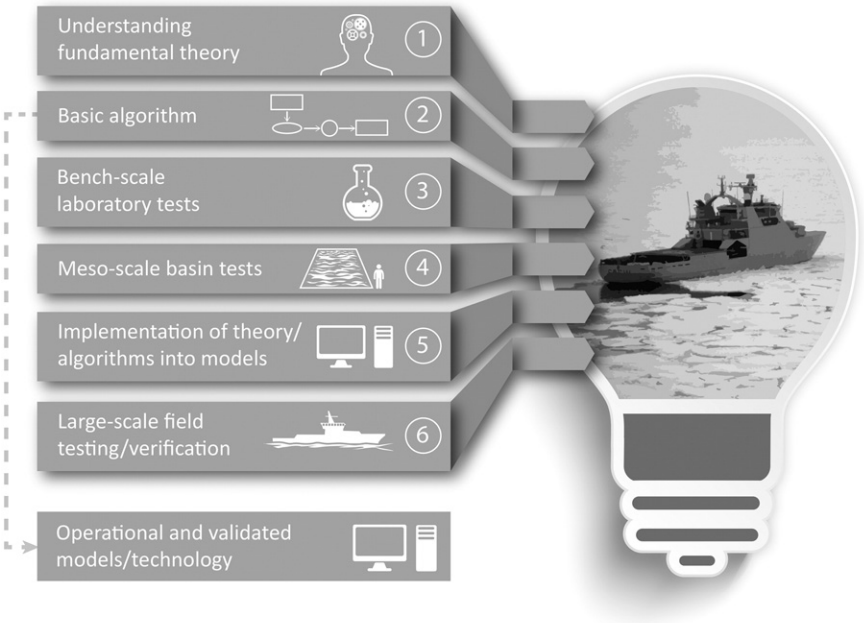

Fig. 1. Experimental concept: from basic theory to applied technology.