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Real time observation system for monitoring environmental impact on marine ecosystems from oil drilling operations

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ABSTRACT

Environmental awareness and technological advances has spurred development of new monitoring solutions for the petroleum industry.

This paper presents experience from a monitoring program off Norway. To maintain operation within the limits of the government regulations Statoil tested a new monitoring concept. Multisensory data were cabled to surface buoys and transmitted to land via wireless communication. The system collected information about distribution of the drilling wastes and the welfare of the corals in relation to threshold values.

The project experienced a series of failures, but the backup monitoring provided information to fulfil the requirements of the permit. The experience demonstrated the need for real time monitoring and how such systems enhance understanding of impacts on marine organisms. Also, drilling operations may improve by taking environmental information into account. The paper proposes to standardize and streamline monitoring protocols to maintain comparability during all phases of the operation and between drill sites.

1. Introduction

1.1. Background

Impact of human activity in the marine environment is of increasing concern worldwide (see e.g. Crain et al. (2009)). Oil companies are experiencing increasing attention from governments as well as from Non-Governmental Organisations (NGOs) on risks and the potential disastrous impacts on the environment at various temporal and spatial scales. Catastrophes like the Exxon Valdez oil spill in Alaska and Deepwater Horizon blowout in the Gulf of Mexico receive much attention, with their impacts being both instantaneous and long term (Schmidt, 2012). In contrast, there has been less attention given to the smaller and less voluminous spills and discharges of drilling waste associated with current drilling operations (Neff, 1987), with published work often focusing on oil-based drilling processes (Daan et al., 1994, 1996; Santos et al., 2010) superseded by water-based drilling in European waters today (Neff, 2005;Trannum et al., 2010; Gates and Jones, 2012; Larsson et al., 2013a,b). Further, the methodologies used in impact studies are often based on traditional sampling strategies where data are collected with various sampling platforms and sensors giving substantial temporal gaps. Little emphasis is given on integration of information between time periods of investigation, thus limiting the possibility to separate the impacts from overall natural variation in an area. The Norwegian Environment Agency has prepared a general guidance document on how monitoring of the seabed around drilling sites should be performed (ANON, 2011). However, lack of standardisation of monitoring techniques in accordance with present knowledge and advances in technologies, precludes comparison of the situation before drilling, during drilling, during production and post production. In addition to making identification of impacts from time series difficult, comparison of impacts between regions or drill sites is also made more problematic by not taking advantage of advances in knowledge and technology (Purser and Thomsen, 2012).

Autonomous and cabled observatories are receiving increasing attention in marine science and have been demonstrated as capable platforms for collecting data remotely, and increasing insight into the functioning of remote marine ecosystems (Barnes et al., 2008; Best et al., 2013; Taylor, 2009). Such cabled systems are

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expected to become an important tool in marine monitoring and management (Aguzzi et al., 2012; Godø et al., 2005; Haugan, 2010; Horne, 2005). The availability of such cabled platforms has catalysed the development of subsea operating instrumentation and sensors, including 'lab on a chip' systems, with *in situ* chemical analysis capability. With increasing frequency, the granting of petrochemical exploration or extraction licenses is accompanied by the requirement that the company carries out new techniques for the investigation or monitoring of the habitats surrounding a drill site. Combining licence requirements for monitoring with technical routine monitoring seems a sensible and efficient way of exploiting the advances in observatory technology for environmental monitoring. Deploying sensor systems for marine environmental monitoring in conjunction with the field's infrastructure should be possible if operational constraints are taken into account. However, during the pre and post production phases cabled infrastructure is lacking at drill sites, and any pre and post baseline studies must be replaced by autonomous instrumentation for the drilling and production periods.

Statoil was given a permit to start production drilling on the Morvin field off Mid Norway in 2009 (Fig. 1), and initiated an associated environmental monitoring program. Here we describe the use of a subsea observatory and network of three moorings tailored for real time monitoring. The Institute of Marine Research (IMR) participated in the EU funded project HERMES (Hotspot Ecosystem Research on the Margins of European Seas (Grehan et al., 2009)) and chaired the supplementary project 'Hermes lander'. This project established a coral reef observatory (Godø et al., 2012b), which was the basis for the observatory technology chosen for the Morvin monitoring program (Tenningen, 2011). Further, a network of three moorings with current and turbidity sensors with real time transfer of key environmental data was established by Metocean Services International PTY LTD. The operational and technological details of this deployment, combined with the data collected during the monitoring program, forms the basis of this paper.

The lack of updated standards and international agreements on how to monitor and assess impact on the physical and biological environment which may be caused by oil and gas drilling activities was underlined by Purser and Thomsen (2012). Their overview of present practice demonstrates the need for systematic and scientifically acceptable approaches, the utilisation of adequate sampling and observation technologies and the design of monitoring strategies most suitable for assessing the risk and impacts of the habitat categories that may potentially be exposed to waste materials such as drill cuttings or drilling muds.

In this paper we follow up the monitoring strategy perspective presented by Purser and Thomsen (2012) and combine it with the basic ideas, the technological challenges and the operational experience acquired during the Morvin environmental monitoring program. We emphasize the uniqueness of the habitat of the Morvin location and the need for basic understanding of its physics and biology in order to tailor a technology solution that meets the requirements of the permit. The operational challenges, failures and successes, and obtained results are given attention (lessons to learn). The overall experience is used to extract factual information about concepts, technology, and operational requirements for next generation of real time monitoring systems, required for responsible drilling activities, and the need for a targeted development program to secure functional systems tailored to the uniqueness of the particular habitats encountered at future drilling locations. Included in these considerations are recent technological advances and experiences. The overarching objective is to stimulate the discussions and interactions among scientists and between science and industry on technology and concept developments that are needed to satisfy the requirements for sustainable management of the marine environment and its resources.

1.2. The area, its biology, regulations and the drilling operation

The Morvin field is located at the western shelf break of the Halten Bank northwest of Trondheim (Fig. 1). The depth is ~360 m and several coral reefs are scattered in the area. The Halten Bank is a traditional fishing ground with the bottom habitat including several deep water *Lophelia pertusa* coral reefs (Mortensen et al., 2001). These habitats are vulnerable to human activities such as trawling (Fosså et al., 2002) and the potential negative impact from

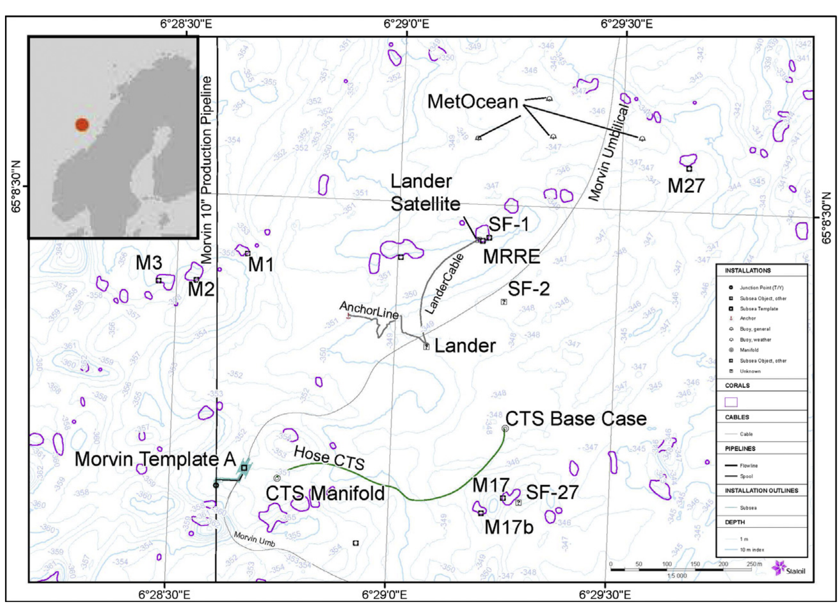

Fig. 1. The location and its topographic features and oil installations including the fixed sampling locations (overview picture given in upper left corner). The three buoy symbols named 'MetOcean' which are located at same latitude mark the position of the three current rigs. The position named 'Lander' show the position of the instrument platform and 'Lander satellite' show the position of the camera at the MRRE coral reef. The positions of the three sediment traps are marked SF-1, SF-2 and SF-27. 'CTS Base Case' marks the discharge point. The various coral reefs are marked with letters and names. Map contributed by Statoil.