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Environmental effects monitoring at the Terra Nova offshore oil development (Newfoundland, Canada): Program design and overview

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ABSTRACT

An environmental effects monitoring (EEM) program was developed by Suncor (formerly Petro-Canada) in 1997/98 to assess effects of the Terra Nova offshore oil and gas development on the receiving environment. The Terra Nova Field is located on the Grand Banks approximately 350 km southeast of Newfoundland (Canada), at approximately 100 m water depth. The EEM program was developed with guidance from experts in government, academia and elsewhere, and with input from the public. The EEM program proposed by Suncor was accepted by Canadian regulatory agencies and the program was implemented in 2000, 2001, 2002, 2004, 2006, 2008 and 2010, with pre-development sampling in 1997. The program continues to be implemented every two years. EEM includes an assessment of alterations in sediment quality through examination of changes in sediment chemistry, particle size, toxicity and benthic invertebrate community structure. A second component of the program examines potential effects on two species of commercial fishing interest: Iceland scallop (*Chlamys islandica*) and American plaice (*Hippoglossoides platessoides*). Chemical body burden for these two species is examined and taste tests are performed to assess the presence of taint in edible tissues. Effects on American plaice bioindicators are also examined. A final component of the program assesses potential effects of the Terra Nova development on water quality and examines water column chemistry, chlorophyll concentration and physical properties. The papers presented in this collection focus on effects of drill cuttings and drilling muds on the seafloor environment and, as such, report results on sediment quality and bioaccumulation of drilling mud components in Iceland scallop and American plaice. This paper provides information on drilling discharges, an overview of the physical oceanography at the Terra Nova Field, and an overview of the field program designed to assess environmental effects of drilling at Terra Nova.

1. Introduction

The Terra Nova Field was discovered in 1984 by Suncor (formerly Petro-Canada) and is the second oil field to be developed on the Grand Banks of Newfoundland, off Canada's East Coast. The Field is located approximately 350 km southeast of St. John's, Newfoundland, 20 km southeast of the Hibernia and 30 km southwest of the White Rose developments, in approximately 100 m of water (Fig. 1). The Hebron Field, located 5 km to the north of Terra Nova, was not developed at the time this paper was published. Development drilling began at Terra Nova in July 1999 and production began in 2002. Terra Nova wells have been drilled in five excavated drill centres from semi-submersible rigs, with subsea completions and production directed to a floating production, storage, and offloading (FPSO) facility, via flow lines (Figs. 2 and 3). Fishing activity is excluded from the area around

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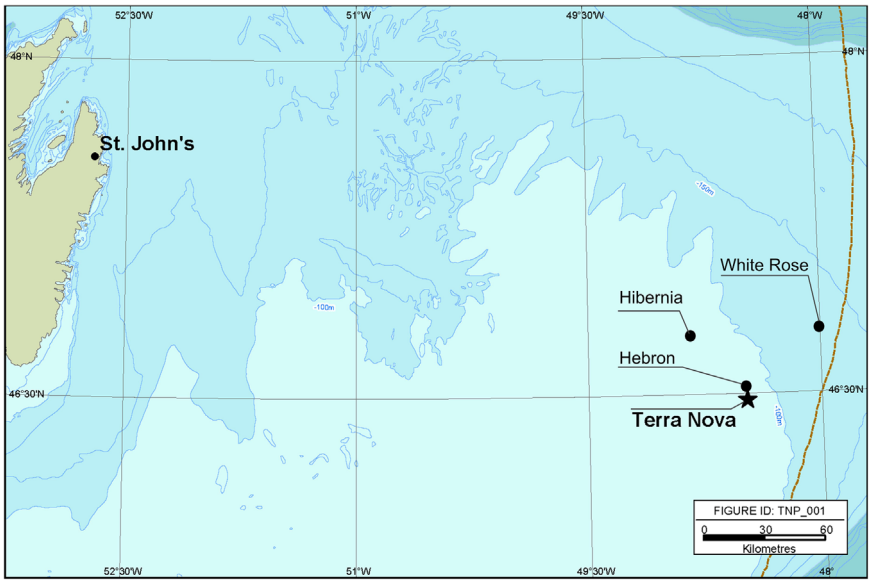

Fig. 1. Oil developments on the Grand Banks (Newfoundland, Canada). The Hebron Field was not developed at the time this paper was published.

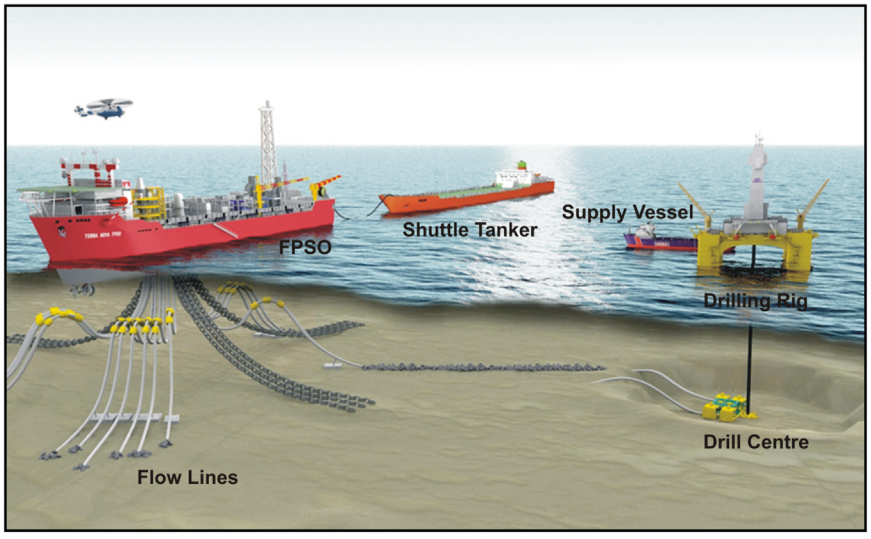

Fig. 2. Terra Nova Oil Field schematic.

the four drill centres surrounding the FPSO to protect subsea infrastructure. By the end of October 2010, 34 wells and sidetracks had been drilled in these drill centres. Drilling at three delineation wells has been suspended/abandoned and now 28 wells are being used for different production activities: 16 for oil production; 3 for produced gas injection; and 9 for water injection. One oil production, one gas injection well and one water injection well have been plugged and abandoned. Proven probable reserves of oil at Terra Nova are 506 million barrels (8.1×10^7 m^3). Between January 2002 and January 2014, 5.58×10^7 m^3 of oil and 1.5×10^{10} m^3 of gas had been produced (Natural Resources Canada, 2014).

The bi-products generated in largest quantity during drilling of oil and gas wells from offshore platforms are drill cuttings and drilling muds (also called drilling fluids) (Neff, 2005). Produced water, comprised of naturally-occurring formation water in oil reservoirs and injected water to maintain reservoir pressure, is the largest by-product originating from oil production operations (Neff et al., 2011). The collection of papers that follows focuses on environmental effects of drilling discharges at the Terra Nova Field. This paper provides information on drilling discharges; an overview of the physical oceanography at the Terra Nova Field; and an overview of the sampling program designed to assess environmental effects of drilling at Terra Nova. Specific results of the sampling program are described in Mathieu et al. (2011), DeBlois et al. (2014-a, 2014-b), Paine et al. (2014-a, 2014-b) and Whiteway et al. (2014).

2. Drilling discharges

Drill cuttings are crushed formation rock from well holes. Drilling muds are used to facilitate the drilling process (e.g., cooling the drill bit, stabilizing the well hole and transporting the cuttings to the surface) (APPEA (Australian Petroleum Production and Exploration Association), 1998; Smit et al., 2007; Neff, 2008). They are mixtures of natural or modified clays and/or polymers, weighting agents and smaller amounts of other solid and liquid chemicals in water, or a non-aqueous continuous phase (Neff, 2008). Drill muds may have a continuous phase of freshwater, seawater or a salt brine (water-based drilling muds: WBMs), a refined petroleum product (oil-based drilling muds: OBMs), or a synthetic organic liquid (synthetic-based drilling mud: SBMs)