# Study on Oil Spill Response Technology in Cold Water Condition
## - Lessons learned from Exxon Valdes and Deepwater Horizon -

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### Abstract

This oil spill in cold water conditions study started in 2017 to collect information and review various researches on spill response technology. This paper describes the lessons learned from the past two oil spill events: Exxon Valdes in 1989 and Deepwater Horizon in 2010. In the aftermath of the Exxon Valdez spill in Prince William Sound, Alaska, and the Deepwater Horizon oil spill in the Gulf of Mexico, only 15 to 25 per cent of the oil was effectively removed by mechanical methods. Despite numerous clean-up efforts, including mechanical recovery and in situ burning, it was tiny bacteria in the water that carried out the bulk of the clean-up operation. Since up-to-date information exchange for the development and implementation of the oil spill technology is important, international collaboration of research is indispensable.

**Key words:** Arctic, oil spill, oil budget, cold ocean, Exxon Valdes, Deepwater Horizon.

### Introduction

In cold ocean environments with sea ice present, oil-spill cleanup is technologically difficult since spilled oil remains under/between sea-ice cover and harsh environmental conditions. Figure 1 shows a spilled crude oil in pack ice off the Canadian East Coast in 1986[1].

In the aftermath of the Exxon Valdez spill in Prince William Sound, Alaska, and the Deepwater Horizon oil spill in the Gulf of Mexico, only 15 to 25 per cent of the oil was effectively removed by mechanical methods using booms and skimmers and burning off the spilled oil.

Fig.1 Spilled oil in pack ice off the Canadian Coast[1].

### Exxon Valdes Oil Spill

On March 24, 1989, the oil tanker Exxon Valdez struck Bligh Reef in Prince William Sound, Alaska, spilling more than *11 million gallons* of crude oil.

Three methods were tried in the effort to clean up the spill[2]:

- Burning
- Mechanical cleanup
- Chemical dispersants

A trial burn was conducted during the early stages of the spill. A fire-resistant boom was placed on tow lines, and two ends of the boom were each attached to a ship. The two ships then towed the boom away from the slick and the oil was ignited. Because of unfavorable weather, however, no additional burning was attempted in this cleanup effort.

Shortly after the spill, mechanical cleanup was started using booms and skimmers. Thick oil and heavy kelp tended to clog the equipment. Repairs to damaged skimmers were time consuming. Transferring oil from temporary storage vessels into more permanent containers was also difficult because of the oil's weight and thickness. Continued bad weather slowed down the recovery efforts.

A trial application of dispersants was performed. Because there was not enough wave action to mix the dispersant with the oil in the water, the Coast Guard representatives at the site concluded that the dispersants were not working and so their use was discontinued[3]. Figure 2 shows a cleanup operation checking gunk trapped by a floating boom after the spill.

Fig.2 Cleanup operation: gunk trapped by a floating boom[4].

## Deepwater Horizon Oil Spill

On April 20, 2010, the oil drilling rig Deepwater Horizon, operating in the Gulf of Mexico, exploded and sank resulting in *210 million gallons* of oil flowed from the damaged well. It was the largest spill of oil in the history of marine oil drilling operations.

The oil budget of the Deepwater oil spill accident is shown in Fig.3 which is based on calculation made July 2010[5]. Only 25% of the oil was effectively removed by mechanical methods and 75% was potentially being biodegraded.

- *Removed (25%)*: direct recovery from the well (17%); in situ burning (5%); skimmed (3%).
- *Environment (75%)*: chemically dispersed (16%); naturally dispersed (13%); evaporated or dissolved (24%); *other (22%)*.

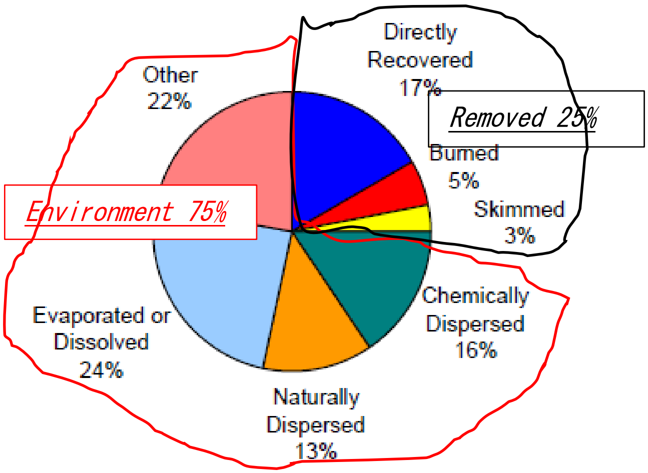

Fig.3 Oil budget of the Deepwater Horizon oil spill[5].

## Spilled Oil Clean-up in the Arctic

In this section, we cite a recent study on spilled oil clean-up in the Arctic by L. Vergeynst (2018)[6].

***1. Low temperatures slow down biodegradation.***

Cold oil is more viscous, which prevents it from being broken up into small droplets in the sea. This causes a problem for oil-eating microbes, which only consume oil when it is dispersed into small droplets.

***2. Sea ice prevents oil dispersion.***

Where there is sea ice, there are fewer or no waves, preventing the breakup of the spilled oil into small droplets.

***3. Few nutrients to sustain oil-eating bacteria.***

The Arctic is generally an environment with very low amounts of nutrients such as nitrogen and phosphorus. Since the oil does not contain any nitrogen or phosphorus, oil-eating bacteria thus need to find nutrients in the water, which is not an easy task in the nutrient-poor Arctic oceans.

***4. Marine algae and glacier debris may form a “dirty blizzard” of oil.***

During the Deepwater Horizon oil spill, marine algae, known as phytoplankton, and other particles stuck to the oil droplets and sank to the seafloor, forming a “dirty blizzard.” During the Arctic spring and summer, massive phytoplankton blooms occur and glaciers release suspended mineral particles. Their amounts can be magnitudes of order higher than in the Gulf of Mexico.

***5. Midnight sun makes oil more toxic.***

The long hours of sunlight may help the microbes to break up oil molecules into smaller pieces. However, it may also make the oil compounds more toxic for aquatic organisms.

***6. Arctic has not yet adapted to dealing with oil spills.***

The Arctic is still a very pristine environment and we are currently trying to figure out whether the microbial populations present in the Arctic already ‘know’ how to degrade oil compounds.

## Japanese Contribution for the Arctic Oil Spill?

As a conclusion, the authors would like to see the international network collaboration on the oil spill prevention technology.

Figure 4 shows a network of experts participated actively in the Arctic Oil Spill Response Technology Joint Industry Programme (JIP). The JIP was initiated in 2012 under the auspices of the International Association of Oil and Gas Producers (IOGP), and completed in 2017. Global expertise included 39 contractors in ten countries: Canada, U.S.A, Norway, Denmark, Finland, UK, Germany, France, Netherlands, and Israel[7].

Since any oil spilled in the Sea of Okhotsk may drift to the coastal areas of Hokkaido and cause damage to the marine environment and economy of this area, continuous studies and information collection of current progress of oil spill research are indispensable for Japan. The Engineering Advancement Association of Japan (ENAA), the University of Tokyo (Prof. Hajime Yamaguchi) and Hokkaido University (Prof. Kay I. Ohshima) started a six-year program, “A Study to Predict Spilled Oil Behavior in the Okhotsk Sea Under

Sea Ice Conditions," in 2003. This project established the numerical modeling of the ice-spilled-oil rheology and the ocean circulation of the Okhotsk Sea[8, 9].

As shown in Fig.4, there was no contribution to the JIP from the Asian countries which will reap the benefits from the northern sea route and the oil/gas industry. Since up-to-date information exchange for the development and implementation of the oil spill technology is important, international collaboration of research is indispensable.

Fig.4 Network of experts participated in the JIP[7].

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## Summary in Japanese

### 和文要約

# 氷海域における流出油対策技術
# －2大流出事故から学ぶこと－

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1989 年のエクソンバルディーズ号の座礁による原油流出事故と 2010 年にメキシコ湾で発生した Deepwater Horizon 爆発事故による原油流出事故における流出油回収の実態から、流出油の多くは海水に取り込まれ、長期間に微生物により分解されると考えられる。しかしながら、北極海では低温、海氷の存在による低波浪、夏期の長期日射、微生物の低繁殖などにより油の分解が抑制されると考えられている。今後、北極海航路や氷海での石油天然ガス開発による経済的恩恵を受けると考えられる我が国は、流出油問題に関する国際的な研究への参加が望まれる。