How unique was the strong marine snow-associated accumulation of oil on the deep seabed during the Deepwater Horizon blow-out?

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Introduction

Large amounts of marine snow were observed during the Deepwater Horizon (DwH) oil spill which formed aggregates with oil, particulate matter (PM) and (phyto)plankton. These aggregates subsequently sank resulting in persistent toxic deposits on the deep seabed[1].

The Dutch C-IMAGE team studies the effect of oil spill dispersants on marine snow formation, and benthic accumulation & persistence of oil toxicity. This poster describes a meta-analysis of subtidal sediment contamination for 52 large historical spills (>10,000 t) to examine whether oily marine snow deposits were reported and whether dispersant application could be related to this so-called MOSSFA mechanism (Marine Oil Snow Sedimentation & Flocculent Accumulation). Also other parameters enhancing oil sedimentation were evaluated.

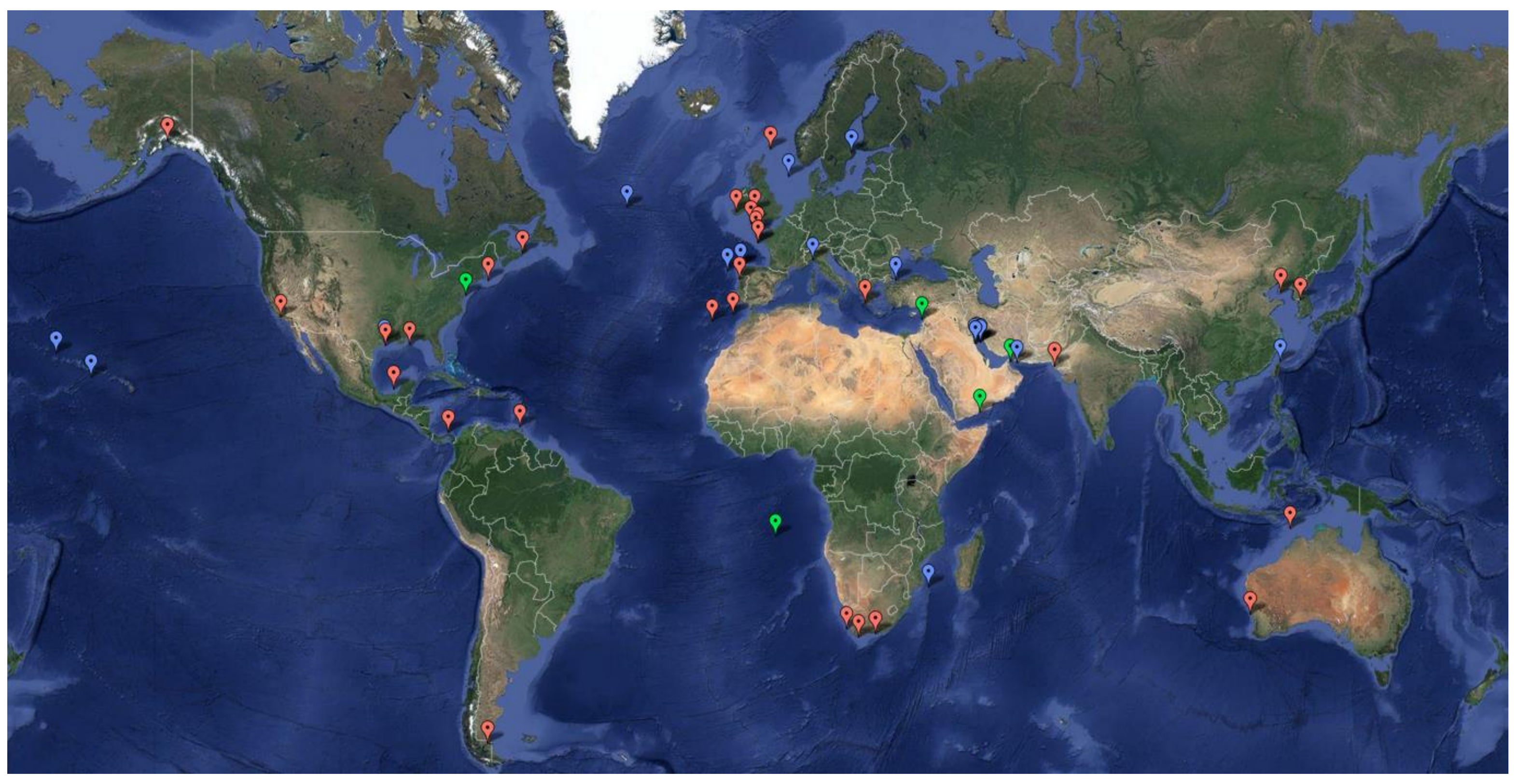

Figure 1: Selected 52 historical oil spills of >10,000 t from 1958 to present. The marker colour indicates whether dispersants were applied (red), not (blue) or unknown (green).

Meta analysis of 52 large historical oil spills

Overall four mechanisms were reported resulting in vertical oil transport to sub littoral sediments (Table 1). However, the extensive marine snow formation and the greatly enhanced sedimentation rate as observed during the DwH spill were not reported in any of the historical oil spills reviewed. In one spill, though, comments suggest a MOSSFA mechanism could have occurred. From these historical oil spills it could not be extracted what conditions and responses induce the MOSSFA mechanism. However, it should be noted that benthic studies were performed in only half the spills examined and sampling methods were often unsuitable for the detection of thick oily marine snow deposits.

Table 1: Specific mechanisms for oil sedimentation in offshore areas extracted from the meta-analysis of 52 oil spills >10,000 tonnes. Examples are given of oil spills where the mechanism was specifically reported.

Oil sedimentation mechanism	Specific process involved
1. Shoreline erosion	Transport of contaminated shore and intertidal sediments to offshore areas
2. Interaction of oil with particles	Turbulence near sediment
	River discharge of particulate matter
	Atmospheric particle input
	Deliberate particle application
3. (Changing) physical properties of oil	High density oil (originally or due to conditions)
4. Association of oil with (remains of) organisms	Agglomeration with marine snow
	Contaminated zooplankton faecal pellets

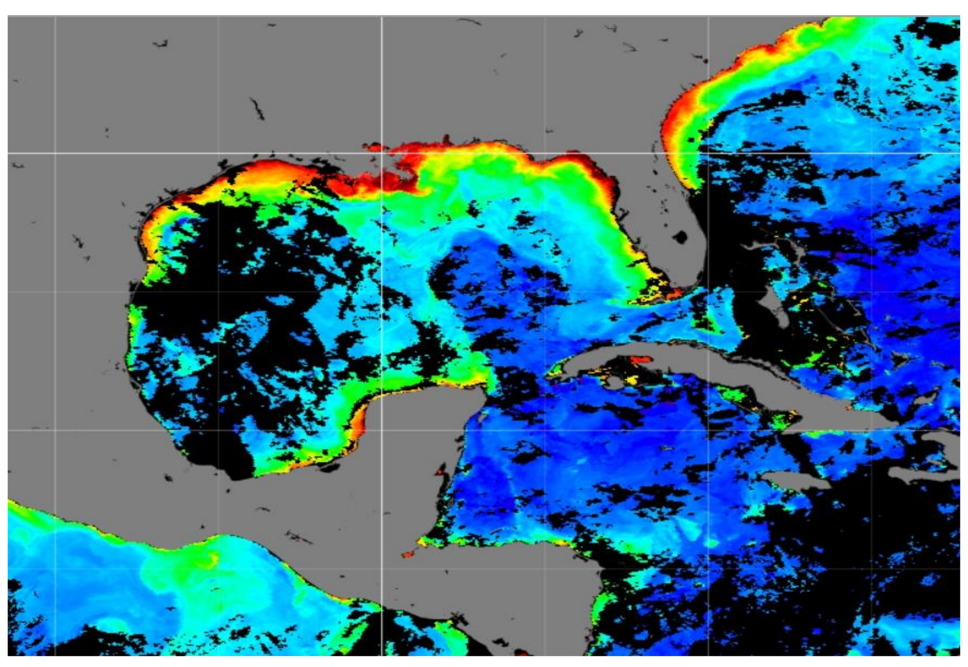

Figure 2: Chlorophyll-a concentration in the Gulf of Mexico during the Deepwater Horizon oil spill. *(Source: Narangerel Davaasuren, IMARES)*

Table 2: Characteristics of the Deepwater Horizon blow-out spill that may have favoured the MOSSFA mechanism.

Spill characteristics	Response characteristics	Spill location characteristics
Blowout spill at 1500 m depth	Dispersant quantity: 1.8 million gallons	Vertical sediments of the canyon walls (bath tub effect[1])
Duration: approx. three months	Injection of dispersants into the deep-water oil plume	Communities of oil-degrading bacteria
Oil volume: 4.9 million barrels	In situ burning of oil reducing the oil's buoyancy	Discharge of high loads of particulate matter by the Mississippi river
		Suspended bottom sediments associated with the blowout
		High phytoplankton biomass
		Atmospheric input of particles

How unique was the DwH MOSSFA mechanism?

The persistent toxic layer on the deep seabed in the Gulf of Mexico was possibly due to the relatively unfortunate combination of conditions (Table 2). Better understanding of the main drivers involved in the MOSSFA mechanism including enhanced marine snow formation is greatly needed, to enable better informed oil spill response decision making in the future. A selection of historical spills is proposed for (re)analysis of subtidal sediment cores to unravel the conditions that induce the MOSSFA mechanism. The characteristic conditions during the DWH blowout occurred in different combinations or were absent in the proposed spills. It is advised to also apply biomarkers that can characterise and quantify the biological material in the cores, in addition to the chemical and physical parameters. Such research may also provide an indication of the recovery process to be expected for the oily marine snow deposits on the DwH spill sediments.

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