Kill•Spill

Integrated Biotechnological Solutions for Combating Marine Oil Spills

Deliverable D1.7

Report on Future Trends in Combating Oil Spills

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1 Introduction / Background

Kill•Spill is a European funded seventh framework programme project focusing on the development of highly efficient, economically and environmentally viable solutions for the clean-up of oil spills caused by maritime transport or offshore oil exploration and related processes.

The aim of the project is to develop novel biotechnologies with a reduced ecological impact for the clean-up of oil spills, to limit the use of non-environmentally friendly solutions. This encompasses the development of biosensors to monitor hydrocarbon degradation, as well as novel dispersants, absorbents, combined microbial and additives formulations, multifunctional bioremediation agents, and tools for sediments decontamination. The impact and toxicity of the developed products will be assessed, and they will then be validated in mesocosms and on real oil spills.

Work Package 1 (WP1) is the in depth analysis of current knowledge and identification of technological gaps. This includes a study of future trends in combating oil spills; Task 1.3. The objective of this task is to watch carefully the scientific literature over a four year period (2013 to 2016) to identify new products, technologies and future trends in oil spill response in deep sea environments and any potential ramifications on typical sea surface oil spills.

It is considered that this paper should be read against a background of global, international and local events over the past decade which may have had a bearing on oil spill combating spending, research and development.

Possibly the most significant event from a funding perspective was the financial crisis of 2007 – 2008; this led to the 'great recession' between 2007 and 2009 which most economies are still recovering from today. It was reported in January 2016, by the International Monetary Fund, World Economic Outlook – Update, that in 2015 that global economic activity remained subdued with the majority of countries focusing on reducing their nation debt and expenditure.

One significant area of influence is lower prices for energy. Oil and gas prices continued to fall in 2015 and in less than a year companies have seen a 50 percent drop in revenues; this resulted in a cut in capital expenditure, deferment of major projects and a cut in operating expenditure. The oil price remains unstable due to a mixture of political reasons.

Another notable factor was highlighted by Susannah Musk, ITOPF, in her paper entitled 'Trends in Oil Spills from Tankers and ITOPF non-tanker Attended Incident'. She states "The average number of spills between 2002 and 2011 is approximately half of that in the period between 1992 and 2001". She goes on to say "There are many factors that have contributed to the overall decline in the volume and frequency of spills from ships in marine waters, but it is most likely to be the combination of implementation and enforcement of conventions and regulations, training, assessments and communications, and development of technology". In the ITOPF Annual Review 2015, Chairman's Statement, said "ITOPF's oil spill statistics for 2014 showed that the downward trend in large oil spills from tankers is continuing, halving each decade since the 1990s until it is now less than two per year".

From a local perspective in America the focus on research is on the repercussions of the response to the Deepwater Horizon oil spill in 2010. On 24 May, 2010, BP announced a commitment of up to $500 million over 10 years to fund an independent research program to study the impact of the oil spill and its associated response on the environment and public health in the Gulf of Mexico.

Bearing in mind that over the last four years research funding has almost certainly been restricted due to the worldwide financial situation; the oil industry cut back in expenditure and deferment of major projects; the continuing downward trend in large shipping accidents and the 'directed' research in the USA **the overall current and probable future trend in oil spill response is 'no change'** – let hang on to what we've got.

Notwithstanding the above there have been some developments which could influence the future of response. In America the Environmental Protection Agency (EPA) has proposed a change to dispersant regulations. In Norway technology development programmes, 'Oil Spill Response 2010' has been completed and 2015 is going ahead. The new focus area for 2015 is the challenges that could be met further north on the Norwegian Continental Shelf; cold climates and ice infested waters. For the European Union (EU) the Kill•Spill project has entered its final year. The focus of the project is the development and promotion of alternative technologies and products that could be used on oil spills in a more environmentally friendly way whilst maintaining efficiently. Other EU funded marine pollution projects can be found on the website cordis.europa.eu (Community Research and Development Information Service.

2 Developments in Oil Spill Response Preparedness

Recent developments in oil spill response preparedness include the following:

The International Association of Oil and Gas Producers and IPIECA Oil Spill Response - Joint Industry Project (IOGP–IPIECA OSR-JIP) (2012 to 2014) has produced a recommended practice for a **Common Operating Picture (COP).** The computing platform based on Geographical Information System (GIS) technology provides a single source of data and information for situational awareness, coordination, communication and data archival to support emergency management and response personnel and other stakeholders involved in or affected by an incident.

Other oil and gas industry recommended practices include using an Incident Command System (ICS), the Tiered Response Concept and carrying out a Net Environmental Benefit Analysis (NEBA).

The **Tiered Response Concept** is highlighted in the Cleaner Seas article dated December 2014 "Historically oil spill response has been directed towards the corporate level of oil companies, and specifically the shipping sector. Now the response structure is changing, with more focus being given to the business unit led, upstream exploration and production sector. In addition downstream parts of the industry are also now paying more attention to oil spill preparedness and response. **One trend now becoming apparent is that the oil companies are reducing their internal oil spill expertise partly through downsizing and retirement.**

Around 20 years ago the industry and government developed a structured method to prepare for and respond to oil spills of any size; called the Tiered Response Concept".

Bonn Agreement BE-AWARE: One of the strategic aims of the Bonn Agreement Action Plan 2013-2016 is to ensure the organisation of optimum response capacities for oil pollution.

The further development of response capacities should be based on risk assessments, gap analysis and regional and sub-regional approaches: Thus it is essential to assess the alternatives to ensure that investments in future response and risk reducing technologies deliver the optimal effect at the regional and sub-regional scale.

The BE-AWARE I project, which ran from 2012-2014, assessed the risk of oil pollution from spills including the likely, between 2011 and 2020. In order to assess which methods and technologies that would be most effective in reducing and responding to oil pollution it was clear that further analysis was required.

BE-AWARE II modelled the outflow of oil from the spills predicted in BE-AWARE I for ten different response or risk reducing scenarios, taking into consideration the hydrodynamics of the North Sea region. This was combined with an analysis of the environmental and socioeconomic vulnerability of the region to assess the impact of the different scenarios. Based upon these, and the cost of implementing the measures, risk management conclusions were developed for each of the five project sub-regions.

MESOCOSM ARCTIC: This project, conducted under the Joint Industry Programme (JIP) and led by the Norwegian Institute Akvaplan-niva, involves several teams from France, Norway, and the United States.

The aim is twofold: to study the fate and impact of oil spills in the polar environment and to assess the impact of two response techniques (chemical dispersion and in situ burning). The project was launched in May 2014 and its experimental phase began in late January 2015 with the installation (at -20°C!) of 8 mesocosms in the ice on the Svea site in Svalbard, Norway.

The stage of the project consists in regularly taking core samples of ice and water samples up until June 2015. Three sampling campaigns were implemented, one in February, the second in March and the third in May, with a total of over 400 samples taken. The project will finish by the end of 2016.

METANE Project, 2011-2014: METANE (modelling underwater gas/oil blowout and LNG leak) is an extension of the BLOW OUT project and aimed to extend the IT model developed in the BLOW OUT project to underwater oil leaks. The long-term aim is to obtain a comprehensive IT system to describe the behaviour of gas or oil in the marine environment in the event of accidental discharge.

The BLOW OUT Project, 2011-2013, (modelling of subsea natural gas and LNG leaks) was set apart by its focus on a more safety-related issue than environmental issue, by investigating incidents relating to underwater natural gas leaks, in the deep sea environment, or inshore subsea LNG discharge.

MOST Project, 2012-2013: In order to implement oil spill response equipment as efficiently as possible, it is essential to be able to predict how the slick formed will drift and evolve at the surface, i.e. whether it will fragment or not, and to estimate the quantities of drifting oil in order to determine the resources required for response operations at sea and/or on the shoreline.

The aim of MOST (Mapping Oil Spill drifT) is to improve decision support for the definition of the response strategy to be implemented, by significantly improving the processing technique for images obtained by remote sensing in the field. The idea is to develop an IT tool to analyse these images based on a new protocol designed to accurately outline drifting slicks (more accurate information on their shape and therefore their surface area), to geolocate them (dimensions repositioned on a map) and, as far as possible, estimate their thickness. This information is then sent to Météo France for use as input data for the MOTHY drift model.

3 Oil Spill Response - New Products and Technologies

There are several options available to respond to oil spilt **at sea**. They can be considered in three broad strategies; containment and recovery, in-situ burning and dispersant application.

The selection of the most appropriate strategy will depend on many factors, including; the response resources available, the national and local regulations on oil spill response, the spill scenario and the physical and ecological characteristics of the area impacted by the spill.

On 28 January 2014 (updated on 09 September 2014) EMSA published the Action Plan for Response to Marine Pollution from Oil and Gas Installations which gives the pollution response measures for accidental releases originating from **offshore installations** as the following:

- Well capping and containment – the well is capped with the assistance of specialised equipment for the purpose of controlling the flow of oil and a containment system is used to direct the released oil toward storage or disposal facilities;
- Mechanical recovery – oil is collected and removed from the water surface and disposed of onshore;
- Dispersant application – oil is chemically treated and dispersed in the water column;
- In-situ burning – oil is burned on the water surface, with most of the carbon released into the atmosphere, while minimum residues remain in the water;
- Monitor and evaluate – this option involves close monitoring and constant evaluation of the spill, taking into account the particularities of the spill and the environmental conditions

3.1 Containment and Recovery

Containing floating oil within booms for recovery by specialised skimmers is often seen as the i deal solution to a spill at sea as this aims to physically remove oil from the marine environment. As a result, it is the primary at-sea response strategy adopted by many governments around the world. The most important characteristic of a boom is its capacity to contain or deflect oil and this is largely determined by the boom's behaviour in relation to water movement and sea conditions. It should be flexible enough to conform to wave motion yet sufficiently rigid to provide a barrier so as to retain as much oil as possible. Standard booms are typically not capable of retaining oil against a relative water current of more than 0.7 knots at right angles to the boom, irrespective of boom size or construction. A recent development has been boom arrangements specifically constructed to work in moving water or towed behind a vessel and where available, can prove effective in areas with relatively strong water currents.

MOS Sweeper System

Using the laws of hydrodynamics, the V-shaped multi-barrier MOS Sweeper collects oil efficiently, allowing higher speed and better manoeuvrability. The oil can be pumped directly to storage on the vessel, allowing for uninterrupted operation. The system is operated from a single vessel, such as traditional trawlers.

Able to operate at a speed of 4.5 knots and in up to 5 meter waves, the fast deployment makes the MOS Sweeper ideal for use in rough conditions and as a rapid response to oil spills. It uses an integrated pump that transports the oil directly to the towing vessel, allowing for continuous collection and recovery of oil spills at up to 400m3 an hour.

In 2009 the Norwegian Clean Seas Association for Operating Companies (NOFO) and the Norwegian Coastal Administration (NCA) launched the technology program “Oil Spill Response 2010” aimed at dealing with the challenges of oil spills from fields near the coast and overcoming rougher conditions. As part of the program the MOS Sweeper was approved for funding as a key project within oil recovery technology. The concept proved itself through several tests both at sea and in controlled settings, making use of the OHMSETT test facility in New Jersey twice. Constantly improving the system, combined with the oil-on-water exercises, has made the MOS Sweeper an effective and reliable system.

Norway is one of few countries benefiting from full-scale offshore oil-on-water exercises, organized annually by NOFO. This provides a unique ability to test, understand and improve oil spill recovery. During the 2015 exercise the MOS Sweeper has achieved a record high 96.4% oil spill recovery rate.

Lamor Sternmax

The Sternmax is a high capacity advancing Arctic skimmer designed to separate oil from the drifting ice with a high recovery rate of 230 m^3/h (1013 gpm). The 28 brush wheel skimmer system has two oil transfer GTA 115 pumps and an ice and oil separating grate that collect oil with excellent ice handling capabilities in harsh Arctic climatic conditions.

Oil Trawl

The Oil Trawl is a fast current system, designed to collect a wide range of oil emulsions spread over larger areas. The system tackles effective flow rates of four to five knots using a paravan/trawl-door that can be operated with one vessel.

FORCE 7

In line with current trends in offshore drilling, which are increasingly moving operations towards the arctic seas, FORCE 7 project developed a new approach for oil spill recovery based on the use of advanced technical textiles with controlled oleophilic and hydrophobic properties and special multilayer design, capable of absorbing up to 2 times their own weight for each cycle, with oil recovery efficiency over 90%.

A downsized mop skimmer prototype has been operated and demonstrated in real conditions in February 2015 on the sea near Cardiff bay. A small fishing vessel hosted the equipment onboard, giving evidence of the optimal equipment integration flexibility.

Results of advanced numerical models developed in the project could be successfully verified during the trial, confirming dynamic behaviour prediction and enabling full correlation with the oil sorption characteristics of the advanced textile structure characterized in a confined tank.

Outside the period covered by this report but considered worthy of note are the skimmers developed during the '**Wendy Schmidt Oil Cleanup X CHALLENGE' – 2010 to 2011**. In the competition born out of frustration of oil cleanup technology used in the Gulf oil spill, Elastec/American Marine Company deployed a system that slurped oil in the test tank at a rate of 4,670 gallons (17,677 liters) per minute, with an efficiency of 89.5 percent. (Only 10.5 percent of the oily mix in the recovery tanks was water). Giant grooved discs that skimmed oil at more than three times the industry standard; to win the top prize of $ 1 million. The second prize of $300,000 went to Norway's Team Nofi, which deployed V-shaped flexible boom to capture 2,712 gallons (10,266 liters) per minute and an efficiency of 83 percent. None of the other teams achieved the competition minimum recovery rate, so the $100,000 third prize was not awarded, and will be returned to the X PRIZE Foundation for further contests focused on marine and ocean environmental issues. But the third and fourth place teams, OilShaver of Norway and Team Koseq of The Netherlands, both achieved recovery rates and efficiency rates in excess of the 2,000 gallons per minute and with efficiencies of about 90 percent.

3.2 In-situ Burning

In-situ burning is the term given to the process of burning floating oil at sea, at or close to the site of a spill. In order to undertake burning, the oil must be concentrated and an ignition source applied. Burning oil at seas has, in ideal conditions, the potential to remove relatively large amounts of oil from the sea surface. In EU waters in-situ burning has been tested in response to the Torrey Canyon incident in 1967.

In-situ burning was considered successful during the *Deepwater Horizon* where following technique development, 411 controlled burning operations, in favourable weather conditions, enabled 42,000 m^3 of oil to be dispersed into the atmosphere (5% of the estimated total).

The International Association of Oil & Gas Producers (IOGP) Arctic Response Technology Joint Industry Programme (JIP) Tests Herders, In-Situ Burning for Arctic Oil Spill Response: Formed in 2012, the JIP has been examining the effectiveness of oil spill response technologies. In April 2015, JIP scientists conducted tests in Fairbanks, Alaska of the first operational combination of the aerial application of herders and in-situ burning, where herders are applied to an oil slick by manned helicopters. The study – which sought to validate the use of herders by manned and robotic helicopters – found that herders are effective in the open sea and in fresh and marine waters for addressing oil spills. It also found that herders are effective with or without the presence of ice, up until the point that breaking waves are present. Five successful tests were conducted over a 10-day period, including cleaning of the tank between tests. Each test took between 10 and 20 minutes from start to completion. The trials took place in a purpose-built, above ground, fully-lined, 8,400-square meter simulated ice basin at the Poker Flat Research Range.

Herding agents can thicken oil slicks in sea ice concentrations of up to 70 percent of ice coverage and in temperatures as low as -17^{o} C, providing favourable conditions (slick thickness) for effective ignition and in-situ burning without the need for containment booms. Experimental burns in open water in the Barents Sea have achieved 80 to 90 percent oil consumption.

The combined aerial response maximizes the use of resources while minimizing the number of workers required to remove a surface slick from the marine environment, where it can do the most harm. The combination also makes the response safer by reducing exposure of people responding to marine operations such as boom deployment and recovery under challenging conditions.

3.3 Dispersant

Dispersant use in the USA - Regulations

The Congressional Research Service paper, dated 17 April 2015, entitled "Deepwater Horizon Oil Spill: Recent Activities and Ongoing Developments" states: Dispersants received considerable attention during the Deepwater Horizon oil spill response. During the 2010 oil spill, responders used, in aggregate, 7,600 m^3 of dispersants on both the surface water and (for the first time) at the site of the uncontrolled well approximately 5,000 feet below the surface. While dispersants have proven effective in breaking up the oil on the surface, stakeholders raised questions about the fate of the dispersed oil and the chemical dispersants and their short and long term environmental impacts.

The paper goes on; The Fate of Oil - Following the containment of the Macondo well in July 2010, satellite data began to reveal decreasing daily quantities of oil on the ocean's surface. In November 2010, the federal government released a peer-reviewed publication that provided an estimate of what happened to the oil. The study concluded that approximately 50% of the oil had evaporated, dissolved, or been effectively removed from the Gulf environment through natural and human activities. Thus, at the time of the study, a substantial portion—over 390,000m^3—remained, in some form, in the Gulf: in 2011 the residual oil remaining was estimated at 26% - 202,000m^3

Subsequent research has offered some insights into the fate of this "remaining" oil. Some research suggests that microbial organisms (bacteria) consumed a considerable amount of the oil in the water column. Other studies claim to have found evidence indicating that a considerable amount of the oil settled on the sea floor. Suffice to say there is a considerable difference in opinion in 'academic circles' about behaviour, fate and effects of the crude oil that was released from the subsea well; some basic facts are still not known with certainty.

The research is ongoing however the current situation in the USA regarding the use of dispersant is as follows: the use of oil spill dispersants is regulated by the US EPA (Environmental Protection

Agency). Subpart J of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) describes the rules that govern the use of dispersants, other chemical and biological agents, and other spill mitigating substances when responding to oil discharges into US waters.

In January 2015, the EPA published a proposed rule that would comprehensively revise Subpart J. The proposed rule addressed many aspects of dispersant use including:

- Revised and extended testing for effectiveness (efficacy) and toxicity.
- Monitoring required during dispersant use. This would include water sampling and analysis and ecological monitoring for effect that could be caused by dispersant or dispersed oil.
- Supplemental testing, monitoring and information that might be required if dispersants were to be used.

The proposed rule invited comments from the public and other interested parties by 22 April 2015. The Federal Register web-site shows that 81,973 comments had been received. Many were from members of the public who were firmly against dispersant use. Other had different views. According to the API (American Petroleum Industry) in their 100-page long response:

"Although the EPA claims that it seeks to "*encourage the development of safer and more effective spill mitigating products, and would better target the use of these products to reduce the risks to human health and the environment*" and "*ensure that On-Scene Coordinators (OSCs), Regional Response Teams (RRTs), and Area Committees have sufficient information to support agent preauthorization or authorization of use decisions*," the proposed rule has the practical effect of treating dispersants as toxic and either prohibiting or discouraging their use."

The EPA is still considering the comments that it received on the proposed rule. **It is considered that whatever the revision is made to Subpart J will reflect on the use of dispersant worldwide.**

Boeing 737 Dispersant Spraying Prototype

In the UK the project to develop a Boeing 737 oil spill dispersant capability took a major step forward in late 2013 with the successful testing of a prototype spray system on board a Boeing aircraft in the USA.

The flight trials allowed various configurations to be tested as the design phase moved towards its conclusion.

RVL, the company undertaking the project, has said "once the system is fully approved for use in the USA and Europe the system will initially be used to provide 'last resort' capability for the UK Maritime and Coastguard Agency in dealing with oil pollution in UK waters". It is understood that the system will be operational in early 2017.

Boeing 727 Wide Area Aerial Dispersant Delivery

For many years, wide area aerial dispersant delivery was achieved using the Hercules L-382 aircraft; and although the aircraft remains a highly versatile and effective platform, they are not as widely available as they once were and with significant increases in maintenance costs and demands elsewhere from within the aviation industry, other options were investigated. Boeing's triple engine 727 was identified as a suitable alternative due to its high power to weight ratio, cargo capacity, robust design, central engine position and low capital cost. Since then, a project by UK, based T2 Aviation on behalf of Oil Spill Response Limited (OSRL) to convert two 727s has been underway. The successful completion of this jet conversion will mark a global first for both the oil spill response and aviation communities alike. The 727 will have the ability to house the Tersus dispersant spray system which has a capacity of 15,000 litres. The planned delivery of the project is the first quarter of 2016.

4 Comment

It is considered that this report covers a range of probably the most important developments in **at sea oil spill response** products and technologies over the last four years, found in the scientific literature and numerous other sources. There will inevitably be some that have been missed – for which the author apologises. The most obvious omission is new products and technologies covering the 'shoreline' protection and clean up. However as given in the ITOPF response techniques guide; 'The techniques available for shoreline clean-up are relatively straightforward and do not normally require specialised equipment'.

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Joe Small, GCL, joe.small@gortonconsultancy.com. Joe is the leader of the WP1 group. He is currently a consultant to IMO, IPIECSA, IOC and the World Bank.

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