CENTRE OF DOCUMENTATION, RESEARCH AND EXPERIMENTATION ON ACCIDENTAL WATER POLLUTION

715, Rue Alain Colas, CS 41836 - 29218 BREST CEDEX 2, FRANCE
Tel: +33 (0)2 98 33 10 10 – Fax: +33 (0)2 98 44 91 38
Email: contact@cedre.fr - Web: www.cedre.fr

Sea & Shore *Technical Newsletter n°36*

2012-2

Contents

• Spills

Multiple spills caused by Hurricane *Sandy* (Arthur Kill, New Jersey, US)

The spills recorded in the second half of 2012 in offshore, port and inshore waters only resulted in low to moderate pollution, generally a few dozen to a few hundred tonnes of pollutant. To the best of our knowledge, only one incident exceeded 1000 tonnes.

This was a leak, which occurred on 29th October, of over 1,100 m^3 of diesel in two tributaries (Woodbridge Creek and Smith Creek) to the Arthur Kill, a waterway separating Staten Island (New York, US) from mainland New Jersey. The leak occurred from two tanks at an oil storage facility (Motiva Enterprises LLC) located in Sewaren, damaged by flying debris caused by the hurricane resulting from tropical cyclone Sandy, which also caused the retention areas to become flooded.

The response, conducted jointly with the local and federal branches of the different agencies involved, was coordinated by the US Coast Guard (USCG) within a unified command specially established to handle the consequences of this hurricane (Hurricane Sandy Pollution Response Unified Command -HSPRUC). The incident mobilised the aerial surveillance resources of the Atlantic Strike Team (USCG) and, given this urbanised shoreline, required air quality monitoring to be implemented.

Three specialised companies were contracted to conduct clean-up operations which involved around 200 people, large quantities of skimming and pumping equipment (vacuum tanks, pumps, skimming heads etc.), a few low-draught recovery barges, sorbents and over 5,000 m of floating booms.

Some thirty oiled birds were placed at a rehabilitation facility as a presumed consequence of this spill. Operations were made difficult due to the areas to be cleaned being cluttered with debris (oiled to various degrees) generated by the hurricane.

Containing oil released from a storage facility at the refinery affected by Hurricane Sandy (Arthur Kill Waterway, Linden, N.J.) (Source: NOAA)

This hurricane also caused other smaller spills in the Arthur Kill Waterway, from various oil facilities (refineries) situated on its banks, including:

- a 37 m^3 spill of biodiesel from damaged tanks at the Kinder Morgan Energy Partners terminal (Carteret, New Jersey) whose retention tanks were also flooded.
- a leak of around 30 m^3 of an unspecified oil, caused by an electric failure of equipment within a refinery (Phillips 66) in Linden (New Jersey), flooded with seawater.

Typhoon and containers: shoreline pollution by plastic pellets (Hong Kong)

On 23rd July 2012, off the southern coast of Hong Kong, Typhoon Vincent caused 6 containers to become dislodged on the deck of a China Shipping Container Lines Company cargo vessel. The containers fell overboard, releasing 150 tonnes of white plastic pellets or "nurdles" (with a diameter of <5 mm and used for the industrial manufacture of various objects) transported in sacks. Five of the containers fallen overboard were rapidly recovered but plastic pellets, part of which had escaped from the torn sacks, the rest still contained within the sacks, washed upon on the shores (in particular of Lamma Island).

The cargo owner, State-owned company Sinopec Corp., covered the response costs and sent 120 of its own staff on-site while recruiting several hundred volunteers to conduct clean-up operations.

These operations were carried out manually, and occasionally using industrial vacuum systems. The company set up a 10 million Hong Kong dollar clean-up fund.

On 5th August, the authorities announced that around half of the pellets spilt had been recovered (i.e. over 50 tonnes, in sacks or loose).

Although we do not have knowledge of the final official account of clean-up operations, in October environmental associations reported residual pollution of beaches on the southern coast of Hong Kong (based on photos of plastic pellets still visible along the high tide line on sandy beaches, or in the form of accumulations between boulders on rocky shores).

Pollution in a port following the explosion of a chemical tanker (*Bunga Alpinia*, Labuan, Malaysia)

On 26th July, the Malaysian-registered chemical tanker *Bunga Alpinia* (gross tonnage: 25,709, built in 2010) was being loaded with a cargo of methanol, in the Petronas chemicals methanol terminal on the island of Pulau Enoe, near Labuan (Malaysia), when it suffered a fire resulting, according to theories broadcast by the press, in the ignition of vapours due to a lightning strike.

26th July: the chemical tanker Bunga Alpinia after exploding when berthed in the Petronas Labuan terminal (Source: DR/MaritimeTraffic.com)

The fire was followed by a violent explosion, tragically killing 5 members of the crew and, by destroying the ship's structure, releasing unassessed quantities of diesel and probably methanol into the port's waters (an estimated 6 tonnes of cargo had been loaded onto the vessel), as well as extinguishing waters resulting from fire-fighting efforts (by the Labuan Fire & Rescue Department).

The explosion also damaged port infrastructures, including one of the methanol silos, and caused the island's only electrical power plant, located near to the terminal, to have to be shut down.

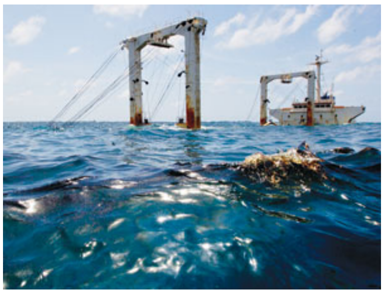
Recurrent spills in the North Sea

On 24th August, in the North Sea off Aberdeenshire (Scotland), a crack in a subsea pipeline operated by Talisman Energy resulted in an offshore leak of around 13 m^3 of crude oil. The faulty section of pipeline, which runs between the offshore Galley field and the company's *Tartan Alpha* platform, was isolated and depressurised, thus stopping the leak. This was a small spill which dispersed naturally, not requiring any response operations at sea.

Six days later, a larger sheen was detected, only a few kilometres away, during aerial surveys conducted by Talisman Energy. Given the appearance of and area covered by this new spill, the quantity of oil at the surface was estimated at between 30 and 130 m^3. Despite their proximity, no link was identified between these two events, and the analysis of oil samples taken in situ confirmed that they were of different origins. An enquiry was conducted by the Department of Energy and Climate Change (DECC) to determine the source of this second spill – apparently a one-off incident – however it was not able to be identified.

Sinking of an abandoned ship: the case of the *Thermopylae Sierra* (Panadura, Sri Lanka)

On 23rd August, the Cypriot bulk carrier *Thermopylae Sierra* (155 m, gross tonnage of 15,612, built in 1985) was caught in a violent storm, causing it to spring a leak and sink in waters scarcely 20 m deep, less than 6 km from the western coast of Sri Lanka. Before sinking, the ship (with its cargo of steel) had been anchored for 3 years off Panadura (around 25 km south of Colombo, the capital) following a detainment order issued by a Sri Lankan court, due to a still unresolved conflict over the payment of taxes and port fees[1].



The wreck of the Thermopylae Sierra, with scatterings of bunker fuel (Source: officerofthewatch.files.wordpress.com)

Following this decision in 2009, the 350 tonnes of fuel oil contained in the bunker tanks of the *Thermopylae Sierra* were pumped out, with the exception however of a remainder of around 75 tonnes, which began to gradually be released in the coastal waters after the vessel sank.

This incident thus caused discontinuous oilings of the nearby shore, and the authorities mobilised 500 volunteers organised into small groups to manually clean up the affected areas situated along a 50 km stretch of coastline (socio-economically sensitive, with many tourist resorts, including the beaches of Negombo for instance).

Controversy rapidly arose over the perception and anticipation of the environmental risks by the authorities: the crew had abandoned the ship which slowly but surely began to deteriorate, resulting

[1] (and, according to sources, over the crew's wages)

in the leak which ultimately caused the *Thermopylae Sierra* to sink. In this respect, according to the Ministry of Environment, the vessel could have been towed to a shipyard in the east of the island (Trincomalee) however the owned had obtained a court order preventing it from being towed.

Be that as it may, in late November 2012, the press reported the authorities' decision to refloat the wreck (whose bridge and cranes were jutting a few metres out of the water) under calmer weather conditions hoped for in January 2013. The Commercial Court of Colombo ruled that the ship was to be dismantled, allowing its debts to be paid off (including to the crew) by selling the materials and equipment for recycling.

• Review of spills having occurred worldwide in 2012

Oil and HNS spills, all origins (*Cedre* analysis)

• Volumes spilt

In 2012, Cedre recorded 33 spills involving volumes of over 10 m^3, for which sufficient information was available for statistical analysis. Almost half of these spills occurred in inshore waters, one third offshore and just under 1 in 5 (18%) occurred in ports (Fig. 1).

Despite a similar annual number of spills as for the period 2004-2011 (approx. 20 to 30), 2012 showed the lowest total quantity of oil and other substances spilt by far (Fig. 3). This is the result of the small size of the spills having occurred, which totalled less than 4000 tonnes compared, generally[2], to a few tens of thousands to one hundred thousand tonnes (estimations obtained using the same approach since 2004) (Fig. 3).

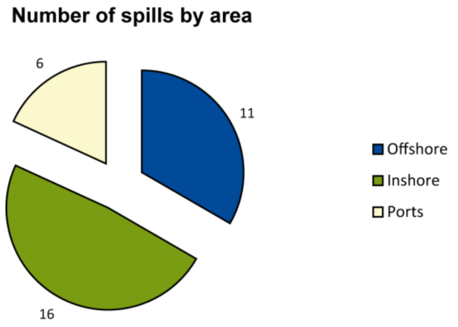


Figure 1

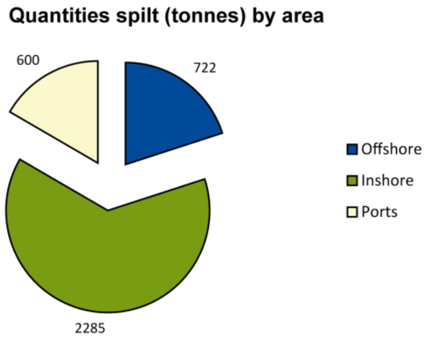


Figure 2

The majority of the quantities spilt in 2012 were (> 60 %) released in inshore waters (Fig. 2), mainly due to the consequences of Cyclone Sandy on the eastern coast of the United States in October (see above) and the incidents involving the vessels *Tycoon* and *Karakumneft* (see LTML n°35).

Roughly equal quantities, around 20 % of the annual total, were spilt offshore (mainly due to the *Elgin* platform incident in the North Sea, off Scotland) and in ports (including a spill of a few m^3 of a water/process water mixture in an open-top pit next to the Grand Canal of the port of Le Havre).

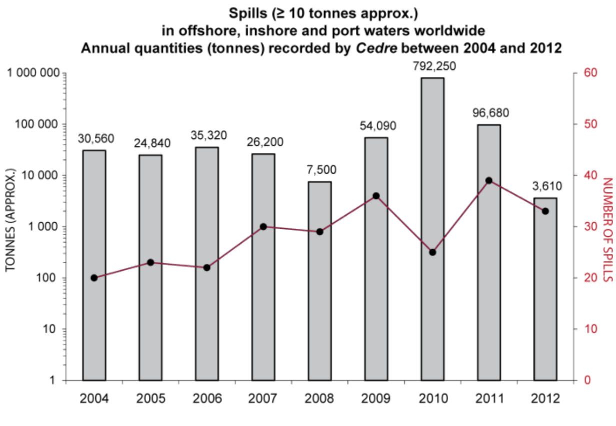


Figure 3

[2] With the exception of 2010, whose balance was mainly dominated by the major pollution caused by the Deepwater Horizon blowout (see LTML n°29-30), and 2008 (which showed the lowest total quantity spilt to date, with less than 10,000 tonnes).

• Spill locations

Figure 4. *Location of oil and HNS spills (≥ approximately 10 tonnes) offshore and inshore in 2012 recorded by Cedre.*

• Spill causes

Analysis of the distribution of spills by cause shows that in 30 % of cases the cause is **unknown or unspecified** (Fig. 5). These cases (half of which concerned offshore oil facilities or subsea pipelines) make up 20 % of the total spilt (Fig.6). This lack of detail, in addition to the patchy nature of certain information on the volumes involved, necessarily affect this analysis.

The most frequently reported events were vessel **strandings and groundings**: representing 30 % of incidents (Fig. 5), they are the 2nd highest contribution (23 %) to the total volume spilt in 2012 (Fig. 6), mainly due to the grounding of the *Tycoon* in early January (see LTML n°35).

Adverse weather conditions, with in particular the part-destruction or submersion of several oil facilities on the coast and in the ports of New Jersey (east coast of the US) in October due to Hurricane Sandy, led to several oil spills or releases of other substances (in particular the loss of containers of plastic pellets overboard in China - see above). It is likely that many of the small spills having resulted from Hurricane Sandy have not been detailed in our sources of information, possibly leading to an underestimation of the contribution of weather conditions to the total annual volume spilt; this category nevertheless represents the largest share for 2012 (38 %; Fig. 6).

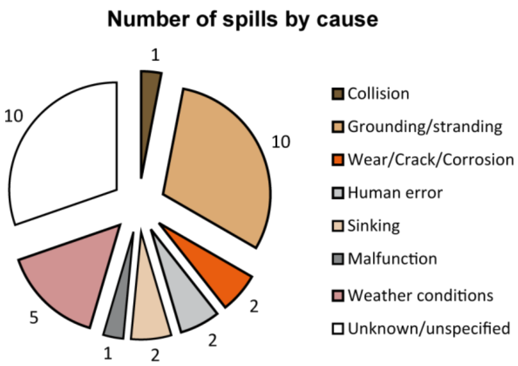


Figure 5

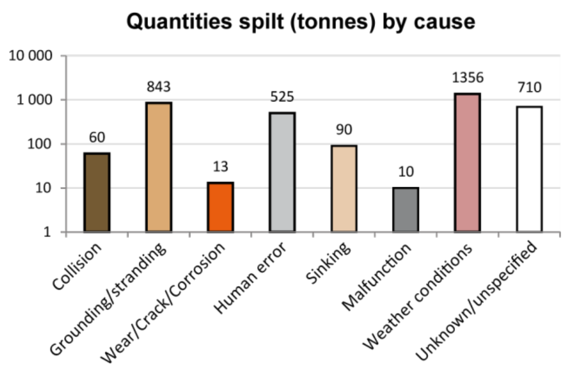


Figure 6

The other types of events identified were each responsible for a maximum of 6 % of the significant incidents recorded in 2012. They represent minor contributions (< 100 tonnes) to the total annual quantity spilt (with the exception of **human errors**, which represented a total of approximately 525 tonnes, i.e. 15 % of the sum total).

• Substances spilt

Among oil spills - representing around 85 % of cases in 2012 - the most frequently spilt substances were **various IFO grade fuel oils** (intermediate to heavy) (25 % of spills in 2012), followed by **white oils** (18 % of cases) and **crude oils** (around 15 % of cases) (Fig. 7).

In 2012, three spills (i.e. 9 % of cases) of **condensates**, of which few spills have been reported in previous years, from offshore facilities (1 subsea pipeline, and 2 cases of oil platforms - including the *Elgin* platform in March which was the most significant spill) and, more marginally, 1 incident involving **biofuels** (biodiesel, from a terminal hit by Hurricane Sandy in New Jersey) were recorded.

In terms of quantities, oil again represents the main proportion (75 %) of the total spilt, a contribution largely dominated by white products (42 % of the annual total), followed by the other categories (condensates, then intermediate and heavy fuel oils and finally crude oils) (Fig. 8). The white products category was mainly composed of diesel, principally due to an incident involving 2 tanks at an oil storage facility in New Jersey damaged by Hurricane Sandy.

Few ship-source oil spills of 10 tonnes or more were identified in 2012 (around a dozen), half of which involved bunker fuel. The few spills reported were relatively minor and only the grounding of the cargo ship *Tycoon* (January) and of the container ship *Bareli* (March, Chinese province of Fujian) resulted in spills of around 100 tonnes of bunker fuel.

2012 saw few spills of **hazardous and noxious substances** (HNS) of over 10 m^3. The main such spills, in the **mineral/bulk** category, were a 260-tonne spill of phosphorite caused by the grounding of the *Tycoon* in Australia (see LTML n°35), and a 500 m^3 **process water** spill (from a metal plant) in an open-top pit next to the Grand Canal of the port of Le Havre.

Finally, an incident involving 150 tonnes of plastic pellets in China in July was identified (see above).

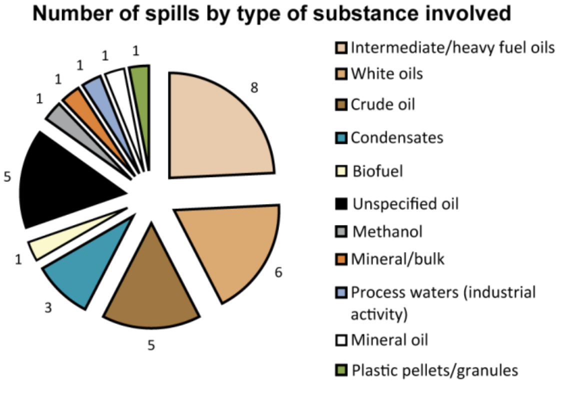


Figure 7

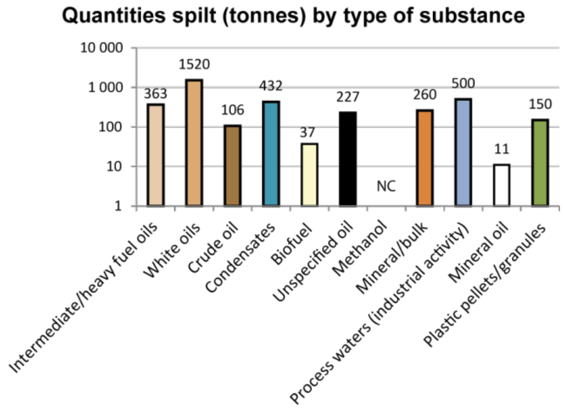


Figure 8

Ship-source oil spills in 2012: ITOPF statistics

The 2012 statistics provided by the International Tanker Owners Pollution Federation (ITOPF) on ship-source oil spills once again confirmed the downward trend of major spills by ships observed from one decade to the next since the 1970s.

No large spills (over 700 tonnes according to ITOPF's terminology) were recorded in 2012, marked by 4 moderate spills (7-700 tonnes). While this is not the lowest annual number of spills recorded by the organisation (2011 holds this record), it is far lower than the annual mean for each of the previous four decades.

The total quantity of oil spilt by ships in 2012 was however the lowest on record, estimated at around 1000 tonnes.

For further information:
http://www.itopf.com

• Summary of illegal discharges

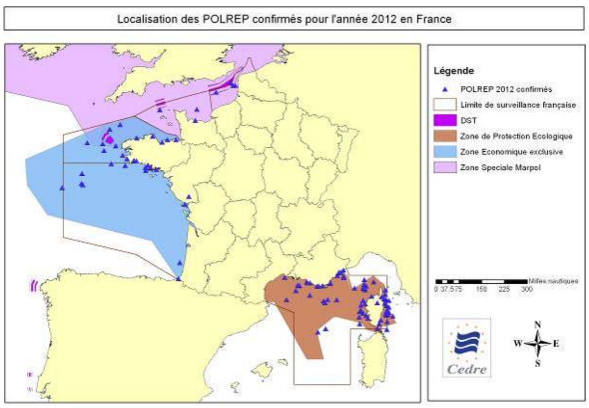
Pollution reports: analysis of 2012 POLREPs (mainland France)

Since 2000, Cedre has been drawing up, upon request by the French authorities (*Secrétariat Général de la Mer*), an annual summary of POLREPs (Pollution Reports) in the waters under

French jurisdiction, which are submitted by the Maritime Rescue Coordination Centres (MRCCs) - directly until 2010 and since then via the French maritime database Trafic 2000. Through comparison of the 2012 results with previous data, certain major trends can be observed for the past decade, despite inter-annual variation in observation pressure (e.g. number of hours of overflights, periods and areas covered).

The analysis of 2012 data shows:

- a total of 113 confirmed POLREPs, confirming the downward trend described in previous years (141 in 2011, 397/year on average for the period 2000-2011)[3]
- the distribution of the majority of POLREPs off the Mediterranean coast, where 65 % of reports were made in 2012
- that, like previous years, oil was the most frequent category of pollutant with a confirmed presence in 70 % of POLREPs
- that, again in 2012, the origin of the discharge was only determined for a small proportion of reports, estimated at 18 % of confirmed POLREPs.



Location of confirmed POLREPs in 2012 in France (Source: Cedre)

The spatial distribution of reports between France's different coastlines is consistent with previous years (concentration of POLREPs along the shipping routes in the Channel - Ushant and Casquets traffic separation schemes - and the Mediterranean - Genoa-Barcelona, Genoa-Valencia and Genoa-Strait of Messina routes). The Mediterranean, and in particular around the Corsican coasts, remains the French coastline from which the majority of POLREPs originated in 2012.

Throughout the year, the number of reports issued on a monthly basis was more stable than on average for the 2000-2011 period, with a peak in reports in August (around 20 per month), this summer variation being connected to the Mediterranean.

Based on the 55 confirmed oil POLREPs for which information was available on the surface area, the average slick surface area was calculated to be approximately 3 km², similarly to in 2011 (compared to an average of just over 5 km² the previous decade). The Bonn Agreement oil appearance code, provided for 34 of these POLREPs, meant that the reported spills could be situated within a range of 1 to 8 m^3, i.e. a range similar to that of 2011.

For further information:
Cedre report R.13.12.C "*Analyse et exploitation des POLREP reçus au Cedre pour l'année 2012*".

• Response preparedness

Emergency mobilisation in remote areas: Total E&P Joslyn Ltd Spill Response Trailer

The company Canadyne Technologies Inc., based in Vancouver (British Columbia, Canada), which offers various resources and services in the field of oil spill response, was recently awarded a contract with the oil company Total E&P Joslyn Ltd[4] for the development of a specially equipped trailer that can be rapidly mobilised in an emergency to respond to a spill in a remote area.

The Spill Response Trailer, finalised in 2012, (with, according to the manufacturer, a length of 9 metres and a total laden weight of less than 7 tonnes[5]) is designed to contain a whole range of containment and recovery resources (floating booms, skimmers, pumps, hoses and power packs), as well as a stock of products ranging from PPE to sorbents, within a confined space.

Images of the Spill Response Trailer

The company plans to propose such trailers, as part of its product

[3] excluding the *Erika*, *Tricolor* and *Prestige* spills.
[4] (subsidiary of Total E&P Canada, specialised in exploration and production from Alberta's Athabasca oil sands)
[5] 14,000 lbs GVW

range, produced to order according to client specifications. *(Source: Canadyne technologies Inc.)*
For further information:
http://www.canatec.com/

• Response techniques and resources / research and innovation

Recent technological developments

In 2009, in partnership with the Norwegian Coastal Administration (NCA), the Norwegian Clean Seas Association for Operating Companies (NOFO) initiated a wide-ranging NOK 30 million (€3.6 million) research and innovation project (Oil Spill Response 2010)[6], to fund 20 projects, notably relating to: offshore oil containment and recovery, chemical dispersion, remote sensing and finally inshore and on-land response.

Since this vast and ambitious project was launched, much progress has been made, regularly presented at international events (including for instance, in 2012, the Interspill conference and exhibition), and newly developed equipment has been released on the market. This gives us the opportunity to review a few concepts which are currently being finalised, if not already on sale, considered promising by the programme's initiators.

• Containment and recovery in strong current

In this chapter, mention can be made of the **Marine Oil Spill Sweeper** (MOS Sweeper), developed by Maritime Development Group AS (MDG, part of the Egersund Group). The Marine Oil Spill Sweeper is a containment and recovery system for floating oil and can be deployed by a single vessel using a paravane[7]. Composed of a V-shaped formation of a series of deflection booms, the MOS Sweeper is designed to be towed in order to deflect and gradually concentrate the oil at the apex of the system - like a funnel[8]- where it is recovered and transferred to a vessel.

Left: the MOS sweeper during testing at Ohmsett (top) and at sea (bottom); Right: overall diagram of the concept - concentration of the oil towards a skimmer/pump set (Source: NOFO)

Among its claims, this system is quick to deploy (approximately 15 minutes) and its design, by reducing splash-over, means it can be used offshore in high current (up to 3 or even 4.5 knots) and in waves of up to 5 m for the MOS Sweeper 50.

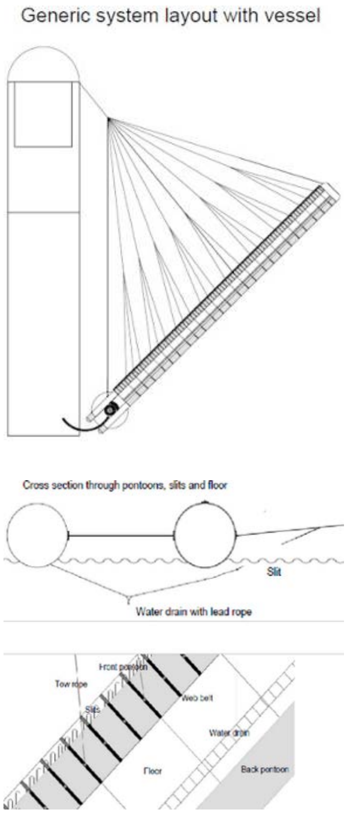
With a 50 m swath width, from which it gets its name, the MOS Sweeper 50 has a recovery rate of up to 400 m^3/h (in the unspecified test conditions used at Ohmsett)[9]. The sweeper exists in various sizes (30, 15 and 7.5 m), always suitable for strong currents but in coastal waters, ports, estuaries or even continental waters. Also designed to be operated from non-specialised vessels, the design is identical, only a few elements (notably the outrigger procedure) are adjusted.

For further information: http://www.egersundgroup.no/index.cfm?id=405640.

The **OilShaver**, developed by the companies Åkrehamn Trålbøteri and Husen AS, which was a candidate in the Wendy Schmidt Oil Cleanup X Challenge[10] (finishing in 4th position, demonstrating a rate of 460 m^3/h with 90 % selectivity), is also a dynamic system which can be deployed by a single vessel.

---

[6] See LTML n°25
[7] The ORC Ocean BoomVane for the MOS Sweeper 50 and the Egersund Trål paravane for the other models (MOS Sweeper 7.5, 15 and 30).
[8] An idea similar to that of Dynapol, designed by the French company EGMO in the early 1980s, in order to concentrate the pollutant towards an EGMOPOL barge.
[9] The MOS Sweeper 50 features a DESMI Giant Octopus oleophilic brush skimmer together with a high flow rate Archimedes screw pump at the apex of the system.
[10] Competition launched by the private foundation X Prize, with support from Shell, following the Macondo well blow-out (Gulf of Mexico, spring 2010), the aim being to promote the emergence of more efficient offshore recovery equipment than that used in response to this spill, considered disappointing.



It is composed of 2 parallel inflatable pontoons, linked together with ropes (with a maximum distance of 2 m for the offshore version and which can be adjusted according to the sea state). It is towed alongside the vessel, using a rope arrangement attached to a single point at the front of the vessel. These ropes, of varying lengths, carry the strain of the system so as to ensure the correct configuration, as the vessel moves forward[11], by forming a 45° angle in relation to the hull (see diagram on the left).

A floor extends under the system to form the 'shaving' system. It is connected to the external pontoon and extends in front of the inner pontoon (before the effect of the bow wave can disturb the water flow). A series of slits runs along the leading edge to skim the surface of the water.

The oil concentrated between the 2 pontoons is naturally channelled towards a collection device at the end of the system (made of aluminium and designed to provide rough oil/water separation) which almost touches the vessel's hull. From here it is transferred to a storage capacity using a centrifugal fish pump[12] and flowing via a relatively short hose thanks to this design. The collection device should also be equipped with a skimmer (unspecified), not featured in the initial prototypes, to improve the system's selectivity (and also probably reduce the weight of this part of the system which currently weighs between 600 and 1000 kg).

The whole of the system (pontoons and floor) is made of neoprene-coated polyester[13]. The OilShaver is claimed to be operational at up to 5 knots if the sea is not too rough.

***Left**: Testing the OilShaver, deployed using the Norwegian Coast Guard vessel KV Barentshav, during the NOFO "Oil On Water" 2012 exercise (Source: NOFO); **Right**: close-up of the near end of the device, oil collection device (made of aluminium) carrying the pump used to transfer the oil to the storage capacity (Source: www.oilshaver.com)*

Like the MOS Sweeper, the OilShaver has undergone tests at experimental facilities (Ohmsett between 2010 and 2012), but also at sea, notably during the latest editions of the annual exercise organised by NOFO in the North Sea: when the results were released in 2013, the MOS Sweeper appeared to be in the process of being incorporated into NOFO's spill response equipment stockpile, while the OilShaver required further adjustments (2013 was in theory to be its last year of development before being released onto the market).

For further information: http://www.oilshaver.com/

[11] The prototype tested in June 2013 during the NOFO exercise had a swath width of 26 metres.
[12] 12" Karm pump by Norwegian manufacturer Karmoy AS (http://www.karmoy-winch.no/fishpumps.htm)
[13] Technical fabric provided by French company Pennel & Flippo (http://www.pennel.fr)

Testing of a HISORS in a basin (Source: NOFO)

The High Speed Oil Recovery System (**HISORS**) concept involves the manufacturers FRAMO and DESMI, based on the observation that, while many offshore booms are produced by different brands worldwide, all of them reach an efficiency limit in currents (or at trawling speeds) of over 0.7 knots. HISORS consists in adding several rows of perforated barriers to a conventional boom, gradually dissipating the current from the opening to the apex of the boom.

This system can therefore be adapted to conventional booms, in order to allow significantly higher towing speeds, and thus improve slick handling rates without however compromising the boom's containment performance. The parameters required to provide this system with the greatest efficiency, determined through fluid mechanics calculations and tests at different scales, were still being established in 2012 (in particular through experimentation in a test basin in Denmark). The motivation behind these efforts lies in NOFO and NCA's interest in improving the performances of the offshore booms they already own. To be continued...

As a reminder, a **HISCORS** (High Speed Continuous Oil Recovery System) project involving collaboration between a marine technology laboratory[14] of the University of Southampton and the manufacturer Vikoma aimed to identify Weir Boom[15] deployment configurations which would be liable to enable efficient oil recovery in strong current and strong waves. Tests and calculations have been conducted using model versions at NCA, but we are not aware of any full-scale testing at sea.

- ### Ship-borne dispersant spraying system

The **BoomVane Spray** was developed by the company ORC (with the participation of Ayles Fernie). This ship-borne dispersant spraying system is based on the Swedish firm's paravane (BoomVane) and, for this purpose, is equipped with a mast used to extend a hose fitted with nozzles between the vessel and the BoomVane. The idea is to provide an alternative to classic rigid beams, which is easily adaptable and can be deployed from vessels also equipped with mechanical recovery equipment - so as to have the option of these two response options. A model with a 25 m swath width (using the classic Ocean BoomVane) is already available on the market, designed for coastal use by small vessels.

BoomVane Spray prototype being tested at sea (Source: NOFO)

A prototype of the offshore model with a 50 m swath width is currently being studied (developed in 2012, it required a large paravane to be designed - tested the same year during the NOFO exercise). The company Elastec/American Marine, which also holds an operating license for the product, manufactures and markets the BoomVane Spray (as well as the range of paravanes developed by ORC).

For further information: http://www.elastec.com/oilspill/dispersant/boomvanespray/index.php

- ### Remote sensing

OceanEye, a remote sensing system (developed by Maritime Robotics AS) for detecting floating oil by both day and night, is a small helium-inflated balloon which provides a relatively high observation point (maximum altitude of 140 m). It has a payload capacity of 3 kg, partly reserved for its cameras: high definition video and uncooled infrared[16], whose images are transferred live by radio to the vessels present on site. It has a range of around 7 km (4 nautical miles) at 120 m altitude.

Imagery (visible and IR) acquired by OceanEye (Screenshot/Source: NOFO)

---

[14] Wolfson Unit for Marine Technology & Industrial Aerodynamics
[15] Weir model already produced by Vikoma; See http://www.vikoma.com/marine-products/containment-booms/weir-boom
[16] (less expensive, requiring less maintenance, and with a theoretically longer life time than cooled models)

This compact system with its small footprint (120 x 80 cm on the ground[17]; 1.60 m high) means that it can be installed on very small vessels for deployment in shallow waters (e.g. rivers, etc.).

Testing OceanEye offshore (Source: Maritime Robotics)

OceanEye was tested and finalised in 2012 and 2013 during NOFO exercises at sea, during which it attracted great interest from international participants according to the Norwegian cooperative, with results ranking it as a "good operational tool" in conditions of low visibility (fog, dark, etc.).

The device was first marketed in the 2nd half of 2013[18].

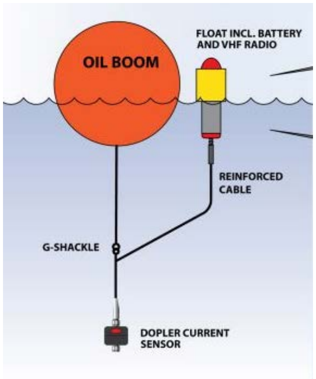
Deployment from a small vessel (Source: Elastec)

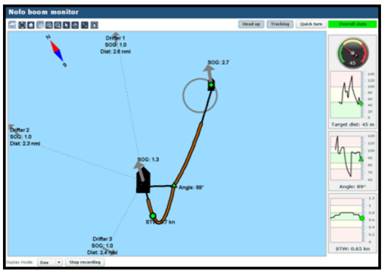
For further information:
http://www.maritimerobotics.com/products/oceaneye/
http://www.elastec.com/oilspill/oceaneye/

- **Operation support tools**

In addition to projects relating to containment equipment, mention can be made of the **Boom Monitoring System** (jointly developed by Salford Electronic Consultants Ltd and Aanderaa Data Instruments AS), developed in response to the need felt by NOFO for a tool to directly control and optimise the efficiency of containment in conditions of restrictive visibility (in particular in winter, for northern countries such as Norway).

It is based on the use of the Aanderaa doppler log system which, when fixed to the base of a boom below the skirt, measures the speed of travel. This data, transmitted by VHF and processed in real time by specialised software (in this case coupled with the GPS coordinates taken at various points on the vessels and booms), can be used to directly adjust operations to ensure a better configuration. This equipment is now marketed by Aanderaa.





Left: Diagram of the doppler fitted to a floating boom (Source: Aanderaa); Above: View of the interface providing an onboard display of the data processed by the Salford Electronics software (Source: NOFO)

For further information: http://www.aanderaa.com/applicationsdetail.php?Oil-Spill-Recovery-5

View of the TCMS interface (Source: Aptomar)

In terms of operational management of remote sensing data, the Norwegian firm Aptomar has developed a software programme, recently marketed (under the name of **Tactical Collaboration Management System** or **TCMS**), capable of integrating and summarising via a specific interface all the data obtained from the various sensors, of which there are often many, deployed in an offshore response area.

For further information:
https://www.aptomar.com/solutions/tcms-tactical-collaboration/

- **Inshore response**

Other aspects of the Oil Spill Response 2010 project relating to inshore response have resulted, or may be liable to result in the near future, in the release of new innovating equipment or services, in various fields of spill response. Particular mention can be made of:

- **Remote sensing and mapping of shoreline pollution**:

The firm Aranica AS has developed an **Unmanned Aircraft System** (UAS) comprising an automated airframe and its associated implementation system (image capture and

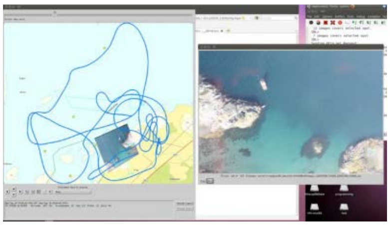
[17] equivalent to that of a EUR-EPAL standard pallet
[18] distributed in America by Elastec/American Marine.

processing). The aircraft is compact and weighs around 30 kg. It can be launched from a mobile ramp and can cover over 400 km (range of 4 hours). After landing, the photographs (vertical) are integrated in a geographic information system (GIS) and assembled as a mosaic for subsequent analysis. Its operational assets (surveillance at very low altitude and in low light/visibility conditions) appear to have been demonstrated through various exercises (with varied sensors, e.g. IR) (for further information: http://www.aranica.com/).

- **Deployment on difficult access shores:**

The manufacturer H. Henriksen Mekaniske Verksted received funding to develop various types of response equipment suitable for the difficult access conditions at certain sites (e.g. shallow waters, or remote areas).

- o An initial project targeted the development of a light, compact skimmer which could be easily handled by 1 or 2 people without requiring lifting equipment. The result was the oleophilic rope skimmer **Foxtail Mini VAB 1-6** which, with its aluminium structure and equipped with a small 2-stroke engine, constitutes the smallest model (60x40x75 cm and weighing 33 kg) proposed by the manufacturer, and was added it to its Foxtail range after test phases conducted by NCA
  (for further information: http://www.hhenriksen.com/Inventory/Navision/OF002291).
- o A prototype of a work platform resulted in the release of the **Foxbarge 40**, designed to transport and unload personnel and equipment at remote shoreline sites. It is composed of an aluminium catamaran (in principle non-submersible - the floats are foam-filled), fitted with an unloading ramp, and whose 2 outboard motors can be remote controlled. The aim is to ensure relatively easy deployment, while finding a compromise between a sufficiently large deck area (60 m²) and a compact design enabling it to be stored and transported in a standard 40-foot container.
  (for further information: http://www.hhenriksen.com/Inventory/Navision/OG025276).



Map of shoreline pollution: screenshot of the interface for processing/summarising the data obtained by UAS (Source: NOFO)

*Foxtail Mini lightweight skimmer (**left**) which can be transported by a single person (**right**) (Source: hhenriksen.com)*

Foxbarge 40 unloading catamaran (Source: hhenriksen.com)

A prototype of an amphibious vehicle powered by Archimedes screws was developed by Team Innovation Trondheim (who intend to market it under the name **Oil Spill Fighter**). The aim was to produce a robust vehicle capable of travelling both across potentially ice-infested waters and across particularly difficult terrain (e.g. soft substrates, snow cover, etc.) to conduct tasks including boom deployment (towing capacity in water of 0.6 tonnes) and equipment transport (e.g. waste evacuation) in remote areas, shallow waters or areas with a high tidal range.

The prototype of the amphibious Oil Spill Fighter (inset: the model version) Source: NOFO

The proposed vehicle is 4.5 m long by 2.4 m wide and weighs 1.2 tonnes. The efficiency of this design is said to extend to potential applications beyond spill response.

The Oil Spill Fighter in fact uses a longstanding concept of motor power, apparently forgotten but which regularly resurfaces, some examples being the Armstead Snow Motor vehicle in 1924 in the United States (http://vimeo.com/2638558) and the ZIL Screw Drive Vehicle in Russia (http://youtu.be/1uynmApjhWI)

For further information:
http://teaminnovationtrondheim.com/
http://teaminnovationtrondheim.com/TIT/Welcome.html
video illustrating the concept (model): http://www.nrk.no/trondelag/vant-pris-for-livbat-1.6748602)

- **Shoreline clean-up**:

Two projects focused on systems designed to treat hard shoreline substrates by spreading and recovering loose sorbents (fibres, shavings, granules, etc.), a strategy perceived as an efficient alternative to manual recovery in certain conditions:

- A prototype with a large capacity and high treatment rate, based on a vacuum truck transported by a barge and adapted to increase its range to up to 20 m (using hoses, operated by a crane from the barge) was shown to be efficient[19]. This system was developed by Vacumkjempen Nord-Norge, a company specialised in pumping which now offers this service in Norway.
- The **Mechanical Oil Spill Equipment (MOSE)** project resulted in the development of a lightweight system (less than 10 kg), able to be operated by a single person. It aims to optimise the efficiency of sorbent use, in addition to its spreading, by promoting contact with the oil prior to recovery, the idea being to limit the quantity of sorbent material required. The shape and dimensions of the device (developed by the Norwegian firm Kaliber Industridesign) are similar to those of a floor polisher. It has a head fitted with rotary brushes used to mix (without generating any spray) the sorbent particles with the oil on the surface to be treated. Alternatively, via a system of hoses, the MOSE device can spread then recover the sorbent particles by suction. Following shoreline spill response exercises, the MOSE device was included in the list of satisfactory equipment meeting the NOFO efficiency criteria for oil recovery on hard substrates (rocks and infrastructures).

Vacuum system (Vacumkjempen Nord-Norge) for spreading and suction of loose sorbents on oiled shorelines (Source: NOFO)

The MOSE TB 2.0 in action on a rocky surface (source: NOFO)

It is manufactured and marketed by MOSE Innovation.

The sorbent supply (compressed air) and pumping systems were developed by Mercur Maritim.

(for further information: http://www.faqs.org/patents/app/20130206172; http://moseinnovation.com/product-category/mose-response-kits).

These two devices are reminiscent of the Vacuna 1000, developed through a previous Norwegian research and innovation programme launched in the 1980s (TOBOS 85) which was a small pneumatic industrial vacuum cleaner with 2 functions: pressurised spreading of sorbent material (pine bark) then suction of pollutant/sorbent agglomerates (this equipment was distributed by the Norwegian firm Mercur Subsea at the time).

• Preparedness for response in cold environments

Arctic response: recent reviews and projects in progress

In late November 2012, the US Arctic Research Commission (ARC)[20] and the US Army Corps of Engineers (ACE) jointly published a white paper entitled Oil Spills in Arctic Waters, reviewing the current research projects in this field. The document specifically concerns the United States (activities of bodies such as MMS, NOAA, USCG, etc.) in terms of strategies, response resources and currently knowledge of the fate and impact of oil. However it also more widely lists the international programmes in progress initiated by various entities: public structures, private

[19] tests during a shoreline exercise in autumn 2010.

[20] Federal agency whose role is to define the US policy in terms of scientific research on the Arctic environment, and to promote this research in collaboration with the relevant federal agencies (e.g. National Science Foundation). It includes representatives of scientific research (institutes, universities, etc.) but also of industrial firms interested in working in this area.

institutes, NGOs, industry (Alaska Clean Seas, various JIPs...), etc.

The document lists the commonly identified recommendations in terms of future research work, focusing on:

- Improvement in the performance of mechanical recovery equipment - including indirectly - with the assessment of the potential benefit of chemical herders.
- Further investigation of in situ burning assessments, increasingly perceived as a potential strategy in such contexts.
- The development of various remotely operated or autonomous devices, to overcome the limits of response by personnel, imposed by the climate (temperature, daylight hours, etc.).
- The development of recovery techniques for oil trapped under ice, primarily measurement and mapping tools for recoverable accumulations.
- Development of knowledge on the efficiency - and potential impacts - of chemical dispersion in Arctic environments (since Deepwater Horizon, these aspects also include subsea dispersion).

In terms of response in cold environments, mention can be made of the activities of 2 recent major JIPs (Joint Industry Programmes) on this issue:

- The Oil Spill Recovery in Ice JIP: in 2012 this programme, together with the American Petroleum Institute (API), published a review, entitled Spill Response in the Arctic Offshore[21], on the challenges, issues and results of the R&D advocated by – and at the disposal of – the oil industry. It provides an inventory of the currently available resources (newly and specially developed, or derived from 'classic' resources), ranging from those devoted to pollutant detection and monitoring to shoreline protection and clean-up techniques, without forgetting in situ burning, dispersion (both chemical and mechanical), containment and recovery.
- The Arctic Oil Spill Response Technology JIP: launched in January 2012, in the wake of the previous programme, at the instigation of the International Association of Oil & Gas Producers (OGP). Funded by 9 international oil companies[22], it is one of the largest R&D programmes in the field, whose projects come under 7 key points:
  - **Chemical dispersion**, with projects focusing on: (i) developing a **numerical model** to predict the behaviour of a dispersed oil plume that develops under ice – the aim being to assess the potential to re-form a new slick[23]; (ii) assessing the effectiveness of chemical dispersant and fine particle spreading, through experimentation in test basins and field validation trials, with the ultimate aim of developing **regulations** in this field for various geographical regions, according to the properties of the oil, the ice cover, the mixing energy, etc.[24] Cedre is contributing to this project by conducting an experimental assessment, in its flume tank, of dispersion efficiency under various conditions, in particular in terms of mixing energy.
  - For **decision support**, a review of existing literature in terms of the **environmental impacts** (direct or indirect) of oil spills in the Arctic, to identify the elements required to conduct a relevant NEBA (Net Environmental Benefit Analysis).
  - **Modelling of the trajectory** of oil spilt in variable conditions of ice cover.
  - Extension of the use of existing technologies to iced environments and conditions of low visibility, in terms of **oil remote sensing and mapping** - a project divided into 2 parts, one devoted to surface detection equipment and the other to subsurface detection[25].
  - Identification and ranking of priority issues (e.g. technical limitations, etc.) in terms of **mechanical recovery in cold environments**, and existing resources, in order to

[21] Drawn up by consultants SL Ross Environmental Research, DF Dickins Associates, and Polaris Applied Sciences.

[22] BP, Chevron, ConocoPhillips, Eni, ExxonMobil, Shell, Statoil, North Caspian Operating Company, Total.

[23] This project has thus far produced a review published in October 2013 which can be downloaded from the following address: http://www.arcticresponsetechnology.org/wp-content/uploads/2014/02/Report-1.4-Fate-of-Dispersed-Oil-under-Ice.pdf

[24] Two reviews have been published on this issue since late 2013: http://www.arcticresponsetechnology.org/wp-content/uploads/2013/10/Report%202.1%20-%20DISPERSANT%20TESTING%20UNDER%20REALISTIC%20CONDITIONS.pdf; and http://www.arcticresponsetechnology.org/wp-content/uploads/2013/10/Report%202.8%20-%20STATUS%20OF%20REGULATIONS%20AND%20OUTREACH%20OPPORTUNITIES%20IN%20DISPERSANT%20USE.pdf

[25] Two reports, published in October 2013, can be mentioned in relation to these 2 aspects: http://www.arcticresponsetechnology.org/wp-content/uploads/2013/10/Report%205.1%20-%20SURFACE%20REMOTE%20SENSING.pdf and http://www.arcticresponsetechnology.org/wp-content/uploads/2013/10/Report%205.2%20-%20CAPABILITIES%20FOR%20DETECTION%20OF%20OIL%20SPILLS%20UNDER%20SEA%20ICE.pdf

promote the development of new systems, or improve those already available.

- **In situ burning** (ISB), through various actions including: (i) a review; (ii) a comparative assessment of operational methods of implementing ISB (from aircraft, vessels, etc.) and research into the most appropriate ignition techniques; (iii) an experimental approach (and field validation) of the benefit of chemical herders for ISB.
- The development of validation tests in the natural environment, requiring authorisations to release real oil.

For further information:
http://arctic.gov/publications/white%20papers/oil_spills_2012.html
http://www.api.org/environment-health-and-safety/clean-water/oil-spill-prevention-and-response/spill-response-in-arctic-offshore
http://www.arcticresponsetechnology.org/about-the-jip

Equipment testing in Arctic conditions: large-scale exercises north of Alaska

In August 2012, the US Coast Guard (USCG) and the US Department of Defense jointly organised a 3-day exercise on spill response preparedness in ice-infested waters, within the Arctic waters of the State of Alaska (Point Barrow). A remote area, over 900 km from the closest port, was deliberately chosen in order to address the logistical difficulties inherent to response in Arctic waters. A buoy tender (68 m long) supported by a tug and a barge for supplying the necessary logistics were used.

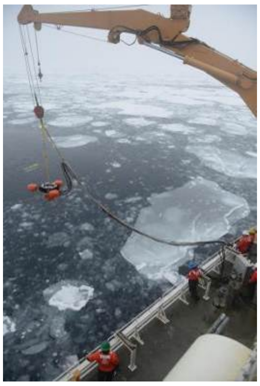
The tests focused on the deployment of all the resources required for the offshore recovery chain: booms, skimmers, pumps, storage capacities.

The following aspects were assessed: for containment, the deployment capacity of a NOFI Current Buster 600 by a USCG buoy tender; for recovery in ice-infested waters, the deployment of an oleophilic brush skimmer DESMI Polar Bear, already adopted by the USCG for response in the Great Lakes.

Skimmer deployment exercise with a DESMI Polar Bear, using a crane from the buoy tender Sycamore (Source: USCG)

In September 2013, the USCG Research and Development Center (RDC), in addition to testing containment and recovery equipment, also assessed oil detection techniques during a second exercise (Operation Arctic Shield 2013) held in the Beaufort Sea.

These tests, reflecting the current strong focus of North American efforts on the Arctic theme, mobilised the icebreaker *USCGC Healy* (130 m long) and involved many staff from other agencies (e.g. NOAA, BSEE) and research laboratories (e.g. University of Alaska, Woods Hole Oceanographic Institute -WHOI). They aimed to investigate remote sensing using various carriers, including an unmanned aircraft system (UAS) *Puma* (by the US manufacturer AeroVironment), an unmanned underwater vehicle (UUV) *SeaBED* and a remote operated vehicle (ROV), but also various detectors for detecting and measuring the oil thickness below the ice.



*Spill response exercises in the Beaufort Sea: deployment of a 360° oleophilic brush skimmer (DESMI Helix - **Left**), a UAV operated by WHOI (**middle**), retrieval of a NOAA UAS after a sea landing (**right**) (Photo source: USCG)*

Finally, NOAA took this opportunity to deploy the Arctic version of its Environmental Response Management Application (ERMA[26], a tool first exploited in an emergency context following the Macondo blow-out in the Gulf of Mexico in 2010), an online geographic information system (GIS) enabling the real time integration and display on a map of various data (data obtained from various

[26] See http://response.restoration.noaa.gov/maps-and-spatial-data/environmental-response-management-application-erma/arctic-erma.html

sensors, information on environmental sensitivity, operations in progress, extent and concentration of the ice, etc.). This type of system is currently expected to become an efficient decision support tool, meeting the need for information and coordination between the variety of potentially numerous response personnel.