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°37*

2013-1

Contents

- Spills 2
  - Collision of the container ship *Florida* and bunker fuel spill (East China Sea) 2
  - Pollution in an estuary and chemical dispersion: the *Pemika* (Phuket Province, Thailand) 2
  - Spill of light oil in inshore waters: *Sureste 700* (New Zealand) 2
  - Submerged pollution: sinking of the *Nesa R3* (Sultanate of Oman, Arabian Peninsula) 3
- Response preparedness 5
  - Towards a European dispersant aerial application service? 5
  - Korea: designation of a national organisation in charge of impact assessment 5
- Recovery 6
  - Viscous pollutants: evaluation of the use of self-propelled skimmers 6
  - Recovery barges and automatic separation/transfer system 6
  - Recovery vessel with integrated Elastec X30 oleophilic discs 7
  - Pumping viscous pollutants: evaluation of offloading pumps 7
- Research 8
  - Korean experimental facilities: in situ mesocosms 8
- In situ oil detection/monitoring 9
  - Oil in Water Monitoring Buoy 9
  - SHOAL project: robot prototypes for in situ pollutant monitoring 9
- Remediation 10
  - First year of the European project Kill-Spill 10
- Impact 11
  - *Rena* spill: environmental impact report 11
  - Impacts of the *Hebei Spirit* spill on macrobenthic communities 11
  - Development of a system to track rehabilitated oiled birds 12
- Containment 12
  - Containment/protection in strong current: Current Buster 6 12
  - R&D: aerial response containment system 13
- Statistics 14
  - Statistical analysis of spills 14
- Legislation/convictions 14
  - *Deepwater Horizon*: legal proceedings 14

• Spills

The first half of 2013 saw very few significant spills, with the quantities recorded hardly ever reaching 10 m^3, and very rarely 100 m^3.

Collision of the container ship *Florida* and bunker fuel spill (East China Sea)

During the night of 18th to 19th March, around 220 km off Shanghai and from the mouth of the Yangtze River (China), the UK-registered container ship *Florida* lost around 610 tonnes of bunker fuel at sea, from a fuel oil tank cracked due to a collision with the Panama-flagged bulk carrier *Chou Shan*.

The container ship was transporting 1,500 containers (of which 70 to 80 contained hazardous substances) and over 5,000 tonnes of fuel. Still sailing despite structural damage, once the leak had been stopped the vessel was able to reach a mooring point close to the Yangshan container terminal (port of Shangai).

Following an evaluation of the condition of the vessel and of the potentially resulting risks (explosion, fire, etc.), the ship was allowed to enter the port to unload its containers and have the fuel removed from its tanks, before being taken to a shipyard for repair.

At sea, spill response actions were initiated on the day after the incident occurred by the Shanghai Maritime Safety Administration, apparently mobilising 7 vessels and 1 plane for around 1 week.

A year after the incident, the conclusions of the Marine Accident Investigation Branch (MAIB) identified communication problems due in part to "inappropriate use of VHF" with respect to the procedures established by the International Chamber of Shipping (ICS) and to incomplete translation of communications between the second officer and the officer of the watch of the *Florida*.

For further information:
http://www.maib.gov.uk/cms_resources.cfm?file=/CMACGMFlorida_Report.pdf

Pollution in an estuary and chemical dispersion: the *Pemika* (Phuket Province, Thailand)

During the night of 21st to 22nd March in Thailand, the fishing vessel *Pemika* sank, for an unspecified reason, in the estuary of the Tah Chin Klong River, near the harbour of Koh Sirae (Phuket Province), releasing part of the contents of its load of drums containing heavy fuel oil (representing a total volume of around 20 m^3 according to the Phuket Marine Police).

At this stage, the spill had spread over an area of around 0.4 ha within the estuary. The authorities in charge of the response (Royal Thai Navy and the Thai Marine Police Division), with logistical support from PTT (public oil company, providing boats, equipment, response products, etc.), opted to spray chemical dispersants on the spill, despite its small volume (initially estimated at 2 m^3 then 10 m^3 by the Phuket Marine Office) and its location close to the shoreline.

In a few areas of the estuary, site protection measures were taken by laying containment booms, however these booms were partially dismantled by vessels in the area. Water samples were taken to detect any possible contamination and were analysed by the Pollution Control Department in Bangkok. According to the authorities, response operations were complete after 3 days, with only sheen remaining around the wreck thereafter. No mortality was reported among the wildlife in the estuary.

An investigation was initiated to determine liability for the incident; the authorities indicated that the owner of the fishing vessel would not necessarily be liable, as the boat had been "hired" to transport fuel oil...

Spill of light oil in inshore waters: *Sureste 700* (New Zealand)

Late at night on 27th April, the 58-m long fishing vessel *Sureste 700* struck a rocky shoal as it searched for a mooring point in an inlet off Stewart Island (New Zealand). After hitting the rocks, the vessel released 23 m^3 of marine diesel into the sea from its fractured fuel tanks. The ship – which remained stable with its engine still operating – rapidly moved around 50 km offshore to reduce the risk of oiling the coast and to assess the situation at dawn. The incident was reported to Environment Southland, who conducted aerial surveys the morning after the spill, over the incident location and the mooring point of the *Sureste 700*. No significant pollution was visible, as this light oil very rapidly dispersed under the prevailing sea and weather conditions (strong waves and 30 knot winds blowing in an offshore direction) without threatening the shoreline.

Submerged pollution: sinking of the *Nesa R3* (Sultanate of Oman, Arabian Peninsula)

On 19th June, in the Gulf of Oman, the tanker *Nesa R3* (856 GT, Saint Kitts and Nevis flag) was waiting for a pilot around 2.5 km off Port Sultan Qaboos (Muscat, Sultanate of Oman), for which it was bound with its cargo of 840 tonnes of bitumen, when a chain of unspecified events (an investigation is currently underway) caused a leak onboard the vessel. A mayday call was issued, but the *Nesa R3* had a severe starboard list and sank 20 minutes later in waters 65 m deep, with its cargo and around 5 tonnes of marine diesel onboard. Nine of the 10 crew members were evacuated to safety, but the master lost his life when the ship sank. Bitumen began to escape from the wreck in the form of drifting slicks which rapidly washed up on the shore, along a 40-km stretch of steep coast which is difficult to access. According to the International Oil Pollution Compensation Funds (IOPC Funds), over 250 tonnes of bitumen were released into the environment[1].

To mitigate the potential effects of the spill on the many sensitive habitats (e.g. coral) and economic activities (in particular fishing and tourism) in the affected area, the Oman Government, through the Ministry of Environment and Climate Affairs (MECA), rapidly activated its national Action Plan for Combating Oil Spills. The emergency response included the following actions:

- setting up a National Contingency Committee (NCC) comprising representatives of the government and port authorities, in charge of identifying and implementing the resources required to survey the vessel and monitor the spill. Upon request from Oman, the Technical Committee was provided with assistance by the Marine Emergency Mutual Aid Centre (MEMAC, a regional intergovernmental agreement for cooperation in case of marine pollution),
- the deployment of boats to conduct surveys of the oil at sea (Sultan Qaboos Port authority and the central government),
- contracting of two foreign response companies with a base in Oman, for shoreline clean-up operations, under the supervision of the Technical Committee.

The substance spilt was grade 60/70 bitumen[2], which is a viscous pollutant, heated for transport (122°C), with a density close to (if not higher than) that of seawater (between 1.01 and 1.06 compared to 1.025). When the substance came into contact with the seawater, the immediate cooling caused it to solidify into relatively cohesive patches. These patches, which were large and thick in places during the first few days, tended to be partially submerged and drift towards the coast, or even to sink, and to break up into tarballs. Given this specific behaviour of the pollutant, and due to the lack of ad hoc resources available, no recovery operations at sea were implemented.

24 June 2013: viscous, cohesive texture of 60/70 grade bitumen (fragmented pollution) (Source: MECA)

Given the proximity of the spill to the coast, most of the oil rapidly reached the shoreline, where clean-up operations were very rapidly organised. The Committee defined 4 operational sectors, 2 of which were affected by bitumen groundings; each of these 2 sectors were attributed to one of the 2 companies contracted. The NCC decided to treat 70% of the affected shoreline, and to leave the remaining areas to be cleaned naturally, given that these were rocky areas exposed to strong wave action. The operations mainly involved manually recovering accumulations (patches, patties, tarballs) stranded on beaches or floating at the surface or subsurface at the water's edge.

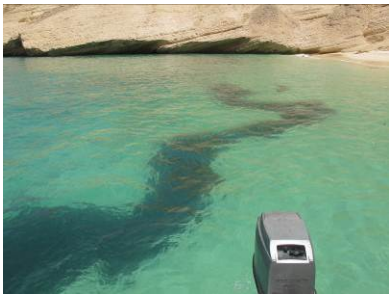
Among the operational difficulties met, we note:

- the remoteness and inaccessibility of most of the sites, requiring personnel and clean-up equipment to be brought by boat,

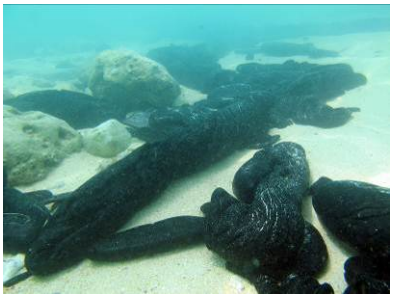
[1] Source: "Incidents involving the IOPC Funds 2013". According to the results of subsequent wreck inspections (see below), this quantity may well be in excess of 300 tonnes.

[2] Intended for the manufacture of asphalt/road surfacing material. This grade of viscosity is attributed following the implementation of the standardised test ASTM D5 / D5M – 13 (Standard Test Method for Penetration of Bituminous Materials), which consists in assessing the depth (to the nearest 0.1 mm) to which a needle penetrates the bitumen, at 25°C in 5 seconds. The higher the grade, the lower the viscosity of the bitumen. Grade 60/70 represents a penetration depth of 6 to 7 mm.

- locally, the need to renew recovery operations and to continue to monitor areas already treated, due to the remobilisation of sunken accumulations in areas of shallow water (bitumen fluidified due to sunshine and high daytime temperatures).



D_{+5}: Submerged bitumen in front of a beach (left); Free slicks (centre); Partially buried patch (right) (photos: MECA)

D_{+11}: Fragmented free pollution (left); Sunken and persistent bands of bitumen (right) (photos: MECA)

These clean-up operations lasted until the end of July. Thereafter, fears of impact on the environment, fishing and tourism caused MECA to call upon Cedre to provide assistance and advice to NCC, in charge of preparing a compensation claim to be addressed to the IOPC Funds.

Within this context, an agent from Cedre was sent on site in September 2013 to survey the polluted areas, study the documents relating to spill response and environmental sensitivity and to meet various people involved in operations. Cedre then provided strategic and technical recommendations based on the outcomes:

- of site surveys, indicating:
    - the presence of bitumen on certain very remote and uncleaned sites, mainly in the form of thick patches either submerged in front of the beaches (generally around one metre long, sometimes a few metres), or stranded and sometimes buried,
    - residual pollution on certain treated sites, with deposits of bitumen, at the surface or buried, or submerged clusters and slicks.
- of interviews with those in charge of the ministries responsible for establishing compensation records, relating to clean-up costs, any economic damages suffered (fishing and tourism) and expected ecological impacts (in particular on coral).



09/09/2013: Remote uncleaned beaches, with accumulations of buried and submerged bitumen (left); buried bitumen partially unearthed/eroded by waves (centre). Submerged slick on a cleaned shore (right) (Source: Cedre)

In terms of shoreline response, Cedre's recommendations focused mainly on the need to recover major accumulations of submerged bitumen and bitumen stranded/buried on the beaches, while highlighting the importance – for a reliable and detailed compensation claim established by the NCC – of rigorously recording the data relating to clean-up site management and the waste produced.

In October (i.e. approximately $t_{+4months}$), the total quantity of bitumen recovered reached 250 tonnes. According to the IOPC Funds, further recovery operations on submerged accumulations in front of beaches and additional shoreline monitoring operations were continued after October 2013.

From the first days following the incident, the Marine Science Center (MSC) launched a monitoring programme to control the quality of the water, sediments and seafood (fish and bivalves), at 6

sampling points, including the spill location, with a sample of bitumen being sent to Petroleum Development of Oman (PDO, the national oil company). On the whole, the type and extent of the pollution did not cause the authorities to fear a significant impact on exploited marine resources. The Fisheries Development Department (FDD) did not issue any fishing bans, however fishermen from a dozen villages had to suspend their activity for 2 weeks due to oiling of their fishing gear (nets). The FDD decided to compile the complaints of all these fishermen in a single compensation claim.

No impact on local tourism was reported and no complaints were filed, at least within the 3 month period following the incident. This appears to be mainly due to the fact that the incident occurred outside of the peak tourist season.

One of the major fears of the authorities was over the potential long term impact of the pollution on coral. The drifting oil reached certain reefs, but appeared not to have caused oiling due to its non-adhesive nature. By September, no evidence of visible impact or of the presence of deposits in a sufficiently high quantity to cause damage to the coral reefs had been reported.

More widely, the hypothesis of significant impact on the coastal environment appears to have been eliminated due to the physical and chemical characteristics of the pollutant (high viscosity, low adhesiveness, low toxicity, low bioavailability) and to its final distribution mainly on foreshores and in front of sandy beaches with high mobility and low ecological sensitivity. Nevertheless, in September it became evident that 2 large beaches, remote from the spill location and uncleaned despite being heavily polluted, played an important functional role, as breeding sites for 2 endangered species of turtles (the green sea turtle *Chelonia mydas* and the hawksbill sea turtle *Eretmochelys imbricata*). This led Cedre to recommend priority cleaning of these nesting sites, together with medium term monitoring of the presence of these turtles during the breeding seasons (different for the 2 species), especially given that Sultan Qaboos University has multiannual data[3].

In terms of compensation for damages caused by the pollution, as the owner of the vessel had not fulfilled his obligations with regard to the 1992 International Convention on Civil Liability for Oil Pollution Damage, the IOPC Funds are likely to have to provide compensation for admissible losses due to the incident (and seek reimbursement from the owner). By October 2013, MECA had filed 2 claims relating to the cost of clean-up operations, pending further claims relating to wreck surveying costs. In September 2013, inspections by divers sent by the NCC indicated the presence of around 500 tonnes of solidified bitumen in the tanks of the wreck (no longer representing a significant risk of release into the environment), as well as 5 m^3 of diesel and 1.5 m^3 of lubricants. According to the IOPC Funds, Oman informed the 1992 Fund that it did not intend to remove the cargo from the wreck.

• Response preparedness

Towards a European dispersant aerial application service?

In January 2014, the European Maritime Safety Agency (EMSA) launched a procedure to identify and contract public or private entities capable of contributing to the development of a chemical dispersant aerial application service. EMSA thus aims to be able to respond to assistance requests in this field from coastal States, by rapidly acquiring one or two planes, with qualified crews and the necessary spraying equipment.

The original deadline of 10th February 2014 was extended to 20th March 2014.

For further information:
http://emsa.europa.eu/tender-archives/current/112-archived-calls-for-tenders/1950-emsa-cdi-01-2014.html

Korea: designation of a national organisation in charge of impact assessment

As part of efforts to improve its oil spill response preparedness organisation, the Korean Ministry of Land, Transport and Maritime Affairs has tasked the Korea Marine Environment Management Corp.

[3] In the inventory of incidents involving the IOPC Funds in 2013, a study is mentioned, in progress in autumn 2013, concerning the possible impact of the pollution on turtle breeding (as well as on fishing and tourism), although its results are not yet available.

(KOEM) with implementing marine pollution impact assessment on a national level.

This official appointment as the Marine Pollution Impact Assessment Organization is part of a government initiative launched in 2007 (following the *Hebei Spirit* spill)[4], which notably led to the creation of an institute (MERTI)[5] in charge of training response personnel and placed under the auspices of KOEM. To accomplish its tasks, KOEM acquired the necessary equipment for the chemical analysis of oil and for the measurement of the ecotoxicity of pollutants. According to the Korean Marine Environment Management Act, KOEM is also authorised to conduct marine pollution impact studies.

• Recovery

Viscous pollutants: evaluation of the use of self-propelled skimmers

In January 2013, as part of a tender by the Norwegian cooperative NOFO (*Norsk Oljevernforening For Operatørselskap*) aimed at improving 6 of its offshore recovery systems, several self-propelled skimmers were evaluated in the Ohmsett test tanks[6]. Among the selection criteria was the need for equipment with a high efficiency on highly viscous substances together with a discharge/transfer capacity over a distance of around 100 m.

Given these criteria, 3 models of offshore skimmers available on the market were tested, each fitted with thrusters and remote controlled via an umbilical containing the necessary hydraulic hoses and circuits: 2 models of oleophilic brush skimmers (Lamor LFF 100[7] and Desmi Giant Octopus[8]), and 1 mechanical paddle drum skimmer (Framo TransRec HiVisc 150).

We note that, in addition to the measurement of the skimmers' performances using the relevant ASTM standard (F2709)[9], evaluation procedures for the manoeuvrability and sea keeping ability of the skimmers, in various agitation conditions, were specially designed. For instance, by timing the movement of the skimmers across a 60 m distance, data was obtained on the deployment/positioning speed; the maximum force exerted by the thrusters (bollard pull) was also measured; finally, the behaviour of the skimming heads with various wave patterns (height and direction in relation to the umbilical) was qualitatively evaluated.

Given that it is not currently possible to apply standardised tests – or even necessarily draw upon quantitative results – these tests on this offshore equipment in reproducible conditions apparently highlighted, according to NOFO, significant variations in performance, beyond what could be expected based on their technical specifications: this observation emphasises the benefit of such an approach in the evaluation (or re-evaluation) of the response capacity in terms of mechanical recovery at sea.

Recovery barges and automatic separation/transfer system

Again at Ohmsett, in early 2013 the Chinese firm Qingdao Sunic Ocean Marine T&S Co., Ltd. had one of its current developments tested: a modular dynamic recovery system which could be used onboard both specialised response vessels and vessels of opportunity. This system combines a DIP 200 (Dynamic Inclined Plan) belt skimmer (which is submerged in the water as the vessel advances and is equipped with 2 containment arms)[10], a pump generating a water flow so as to channel the pollutant towards the recovery system and most importantly an automatic separation and transfer system fitted with a sensor. The originality of this system lies in this last point, which is designed to greatly reduce the quantity of water in the fluid recovered and therefore the primary storage capacities required.

This prototype, under development by Sunic Ocean Marine since around 2010, underwent various improvements in 2013, in particular in terms of its deployment. These trials were the opportunity to

[4] See LTML 27-28
[5] Marine Environment Research and Technology Institute ; Cf. LTML 33.
[6] Oil and Hazardous Materials Simulated Environmental Test Tank, USA.
[7] Fitted with 2 conveyors each with 4 V-chains of oleophilic brushes, with a GTA 115 pump.
[8] Comprising 3 modules each with 5 chains of brushes and fitted with 2 DOP-250 pumps.
[9] http://enterprise.astm.org/filtrexx40.cgi?+REDLINE_PAGES/F2709.htm
[10] Concept developed in the 1970s by JBF, and marketed by US firm Slickbar, which became Lamor Slickbar after being bought over by the Finnish firm in 2008, then Lamor USA in 2011.

optimise certain operational aspects, in particular relating to the speed of the turbine (and the ingoing flow) and the rotational speed of the conveyor belt according to the speed at which the vessel is travelling.

Recovery vessel with integrated Elastec X30 oleophilic discs

Building on the success of their oleophilic grooved disc skimmer (winner of the Wendy Schmidt Oil Spill Cleanup X Challenge[11]), marketed since 2012 as an individual skimmer (the X150), Elastec/American Marine are now marketing a spill response boat, christened *Rozema 47* (after Rozema Boat Works, a project partner) and whose structure comprises an integrated version of the skimmer.

An outrigger and 10-m sweep boom are fitted to each side of the 14 m vessel in order to concentrate the oil and channel it towards an X30 skimmer embedded in the hull.

The X30 has 2 grooved discs and is a smaller version of the X150 (which has 10 discs) with a recovery rate of 30 m^3/h according to the manufacturer (giving the OSRV a total recovery rate of 60 m^3/h).

Outrigger and sweep boom of the Rozema 47 (Source: Elastec)

X30 skimmer with 2 grooved discs (Source: Elastec)

The working speed of the vessel (whose propulsion system is composed of two 447 kW engines) is 4 knots (approx. 7 km/h) and its top speed is 26 knots (48 km/h).

While this boat is designed for use in coastal/marine waters and fitted with appropriate interior accommodation, its onboard storage capacity (just under 8 m^3) can require additional storage capacities to be available in the spill area, if large quantities of oil are to be recovered.

Among the recovery boats marketed by Elastec/American Marine, we also note that in early 2013 the firm partnered with Kvichak Marine Industries to become the exclusive International Sales Agent for Kvichak/MARCO Harbor Class recovery vessels (9 m aluminium boats fitted with a MARCO Filterbelt) outside of the United States. These lightweight vessels, designed primarily for use in semi-sheltered or inland waters, have been in existence for over 20 years and are well established on the North American market in particular[12], with a few also present in Europe.

For further information:
http://www.elastec.com/workboats/

Pumping viscous pollutants: evaluation of offloading pumps

With a view to replacing the EGMO W200 submersible twin-screw pumps fitted onboard the *Egmopol* barges[13] in the French POLMAR-Land equipment stockpiles, after almost 30 years of service, whose manufacturer (SEP EGMO) has ceased production, CETMEF (*Centre d'Etudes Techniques Maritimes et Fluviales*)[14] recently called upon Cedre to identify a few suitable pumps and assess their performances.

Within this context, 3 submersible pumps (DESMI DOP 200, FOILEX TDS 200 and LAMOR GTA 50) were selected as contenders based on their technical characteristics and hence their capacity, in principle, to:

- be embedded in the *Egmopol* barge itself, in terms of configuration of use (e.g.

[11] See LTML N°35

[12] The Kvichak/MARCO vessels are commonplace in the US and are found in the spill response stockpiles of many private and public operators (including for instance the US Navy which, with the purchase of an additional 15 vessels in spring 2013, now has over 80 for response to small Tier 1 spills).

[13] Reminder: the self-propelled *Egmopol DAH 1041* barge is designed for response to floating pollution in ports, coastal areas and other sheltered water bodies. It is fitted with a paddle belt mechanical recovery system (*Egmolap*) and its storage tank is emptied by an *Egmo W200* twin-screw pump powered by a hydraulic diesel power unit (also powering the *Egmolap* and propulsion systems onboard the *Egmopol*).

[14] Now part of CEREMA (*Centre d'études et d'expertise sur les risques, l'environnement, la mobilité et l'aménagement).*

discharge capacity over a height of 10 m and a distance of 20 m), power compatibility (hydraulic power pack existing onboard the vessel) and dimensions (maximum weight of 90 kg for attachment to the lifting arm...).

- meet with certain constraints in terms of the type of product recovered, relating to the scope of application of the barge (harbours/sheltered coastal areas): significant recovery rate for highly viscous pollutants (minimum of 20 m^3/h at 100,000 cSt) so as to rapidly offload products which may have become weathered/emulsified after drifting at sea from the storage capacity of the *Egmopol*; good tolerance to debris in the mixture to be pumped (potentially frequent, due to the paddle belt system).

These 3 selected pumps also have the advantage of being equipped with annular water injection systems, so as to significantly optimise the transfer of viscous pollutants[15]. The pumping performance was able to be measured for increasing viscosity gradients (water, then non-emulsified heavy fuel oil, followed by emulsified heavy fuel oil), with and without annular injection (cold water at pump discharge for trials on fuel oil).

A series of trials was performed with hydraulic power similar to that of the power pack onboard the barge, whose maximum rate is lower than that required for the pumps tested. The trials on water suggested that, even when placed in these unfavourable conditions, the 3 pumps tested met the requirement for a minimum pump rate of approximately 20 m^3/h for fluid substances, with a different evolution in rate, according to the model, in response to an increase in discharge pressure (in a pressure range equivalent to that tolerated by the Egmo W200). On viscous oils however, the tests showed that the hydraulic power pack onboard the *Egmopol* was not sufficient to reach the minimum target rate, except by using annular injection, which proved to make a very significant difference (increase in pump rate by a factor of 2 to 8 according to trial conditions), or even proved indispensable in such a context.

In addition, CETMEF requested that Cedre further these tests with an evaluation of the performances of these pumps this time with optimal ad hoc hydraulic power (rate close or equal to the admissible maximum rate). These trials, also conducted according to the full AFNOR NF-T-71-500 procedure, showed that in these conditions, the 3 pumps tested show high rates, all in excess of 40 or even 50 m^3/h on a fluid product and without any back-pressure in the discharge hose. On viscous products (emulsified or non-emulsified heavy fuel oils), the flow rates of each pump were logically found to be more satisfactory – sometimes reaching up to 20m^3/h according to test conditions – but generally only exceeding this value with annular water injection (again leading to an increase in flow rate by a factor of 2 to 8).

• Research

Korean experimental facilities: in situ mesocosms

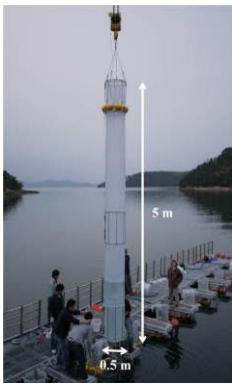
The Korean Institute of Ocean Science & Technology (KIOST), in collaboration with a laboratory of Gyeongsang National University (South Korea), recently published an article presenting the results of a weathering study of crude oil (heavy Iranian crude), treated with chemical dispersant or left untreated, in natural conditions. One of the reasons behind this project was based on recent incidents in Korea, in particular the *Hebei Spirit* spill in 2007[16]. The authors provide various contamination data for deep-water benthic organisms, or demersal fish, thought to have been exposed to oil slicks – whether chemically dispersed or not – from the *Hebei Spirit*, suggesting a different composition of the contaminant to that identified in the tissues of shoreline organisms (oysters in particular). Thus information was sought on the fate and evolution of this crude oil dispersed at sea, whether naturally or chemically, and its potential impact on sublittoral systems.

To do so, this work consisted in monitoring the physical and chemical properties of a product within experimental structures at sea, in this case floating mesocosms with a 1 m^3 capacity, for a period of around 2 months (77 days). These mesocosms, developed by KIOST, are composed of 9

[15] Following tests conducted some ten years ago, Cedre also noted the benefits of this process on the *EGMO W200* pump, not originally equipped with this system.

[16] See LTML n°20

polyethylene cylinders, 0.5 m in diameter and 5 m high, attached to a floating pontoon and in each of which 1 litre of crude oil was released, either alone or pre-mixed with 0.1 litre of chemical dispersant (volume of oil representing a thickness of 5 mm, as observed with the slicks from the *Hebei Spirit* spill according to the authors).



View of the mesocosms developed by KIOST: polyethylene cylinders (left); floating pontoon comprising the 9 experimental cylinders (above). (Source: Joo et al., 2013)

While the limitations of these structures are recognised (which, for example, diminish phenomena such as swell, waves, turbulence and dilution), the use of floating mesocosms is considered here by the authors as an "intermediate" investigation method, between laboratory scale and natural conditions, enabling comparative data to be obtained on the chemical composition of a dispersed and non-dispersed crude oil.

This paper also confirms the benefit of experimental floating in situ structures in terms of obtaining more in-depth knowledge of the fate of products – treated or not – accidentally spilled in the marine environment. We remind readers that Cedre has also worked on similar structures, with the development of its "floating cells" which have regularly been deployed for over 20 years and help to provide original data on the behaviour of chemicals at sea.

For further information:
C. Joo, W.J. Shim, G.B. Kim, S.Y. Ha, M. Kim, J.G. An, E. Kim, B. Kim, S.W. Jung, Y.-O. Kim, U.H. Yim, 2013. *Mesocosm Study on Weathering Characteristics of Iranian Heavy Crude Oil with and without Dispersants.* **Journal of Hazardous Materials 248-249**, 37-46. doi:10.1016/j.jhazmat.2012.12.050.
http://ac.els-cdn.com/S0304389412012186/1-s2.0-S0304389412012186-main.pdf?_tid=86fe5472-e1b5-11e3-b027-00000aacb35f&acdnat=1400765732_9127fda09dcf5deafaf730ab0042761f

• In situ oil detection/monitoring

Oil in Water Monitoring Buoy

The UK-based firm Ocean Scientific International Ltd (OSIL), specialised in oceanographic instrumentation, has made a recent addition to its range of measurement systems with a buoy designed to monitor dissolved hydrocarbon levels in water that can be quickly deployed in the event of a spill.

Powered by solar panels, this buoy measures 60 cm in diameter, is 2 m high and weighs 25 kg. Its central structure accommodates (and protects) a submersible sensor to detect dissolved hydrocarbons in the water column. It can also house various sensors to measure different parameters relating to water quality. The buoy is easily visible (e.g. fitted with lights) and is fitted with the necessary equipment for telemetric transmission of the data collected and its position (in various modes: mobile phone network - GSM, GPRS, UHF/VHF radio, satellite...).

This relatively compact device is designed to be deployed from small vessels, possibly by a single operator (e.g. response in semi-sheltered shallow waters, etc.), while enabling long deployment periods (up to 2 years of monitoring according to OSIL).

For further information:
http://www.osil.co.uk/Products/MarineInstruments/tabid/56/agentType/View/PropertyID/358/Default.aspx.

SHOAL project: robot prototypes for in situ pollutant monitoring

Partially funded by Information and Communication Technologies (ICT), under the Seventh

European Framework Programme for Research and Technological Development (FP7), the SHOAL project, led by BMT (British Maritime Technology Group Ltd)[17], recently resulted in the development of an "intelligent robotic fish", an autonomous underwater vehicle (AUV) capable of detecting and identifying pollution in a given water mass.

Source: http://www.roboshoal.com/

The aim of this technological development was to result in near real-time detection and analysis of pollutants dissolved in seawater, using chemical sensors fitted to systems equipped with software instilling them with "artificial intelligence" (AI). These systems take the form of robotic fish, designed to identify a source of pollution and promote rapid (and allegedly efficient) implementation of response actions.

In short, the AI system aims to enable the robot to autonomously implement a certain number of actions in the environment, including navigating around obstacles, locating the source of a spill, positioning itself in relation to the spill to take in situ measurements, etc. Furthermore, the device developed could communicate and coordinate its actions with a certain number of similar devices, automatically return to a predetermined location to be recharged or for maintenance, etc.

This prototype falls within the category of autonomous underwater vehicles (AUVs), which have recently become popular in major oil spill management, whose use met with great success in the Gulf of Mexico following the *Deepwater Horizon* spill.

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

• Remediation

First year of the European project Kill-Spill

In January 2014, upon invitation by the Technical University of Crete (TUC), an engineer from Cedre's Research team was sent to Hammamet (Tunisia) to join the advisory committee of the European project Kill-Spill. Launched in 2013, this project comes under the Seventh European Framework Programme for Research and Technological Development (FP7). Coordinated by TUC, it involves just under 35 teams (academics, industry and associations from 13 countries, including the US) working on the development of biotechnologies applied to oil spill response in the marine environment.

These research themes aim for instance to develop products to promote oil biodegradation and to develop a "biological" dispersant. The project is divided into 10 work packages, which aim notably to:

- carry out in depth analysis of current knowledge, including an inventory of solutions already on the market
- develop biosensors and in-situ monitoring tools to determine biodegradation efficiency
- develop novel "biological" dispersants and sorbent materials, to increase oil biodegradation by adding nutrients and/or hydrocarbonoclastic microbial consortia
- develop new solutions to promote in situ biodegradation, in particular by burying electrodes (stainless steel wire mesh) on the contaminated site to accelerate biodegradation by promoting electron transfer from the contaminants.

For all of the tools and products developed, toxicity tests are being or will be carried out following international standards. At the end of this phase, in situ trials have been scheduled to validate in as realistic conditions as possible the results obtained from the experiments currently being performed in the laboratory.

A year and a half after its launch, this 4-year European project is starting to be referenced in the

[17] SHOAL is a consortium of 6 European structures including BMT Group, the University of Essex, Tyndall National Institute, the University of Strathclyde, Thales Safare - which recently became Thales Safarepons, and Gijon port authority – the prototype test location).

scientific literature with the appearance of publications based on the preliminary results of tests performed at laboratory scale.

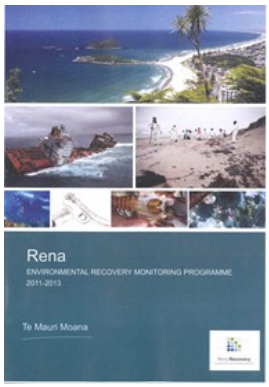
For further information:
http://www.killspill.eu/

• Impact

Rena spill: environmental impact report

In 2013 a report was published presenting the conclusions of the Rena Environmental Recovery Monitoring Programme following the grounding of this ship in 2011 on Astrolabe Reef in the Bay of Plenty (New Zealand) (see LTML n°34).

In general terms, 2 years after their launch, all the multidisciplinary studies, an integral part of the Rena Long Term Environmental Recovery Plan, indicated a low probability of adverse effects from the spill on coastal habitats and fisheries in the short and medium term.



On soft substrates, the monitoring of populations of a species of bivalve considered to be representative of the affected habitats (wave-beaten sandy beaches) did not show any variations which could be attributed to the pollution. Similarly on rocky foreshores, the high spatial and temporal variability of benthic populations appeared to be less due to the impact of oil than to natural phenomena. In rocky subtidal areas, the natural variability (and the lack of ad hoc reference data) did not result in the identification of significant effects on sensitive benthic invertebrates (urchins) or on the degree of coverage of various algal species.

This wide-reaching programme also included ecotoxicological and histopathological approaches, as well as studies on bacterial populations, on residual contamination of substrates, etc.

For instance, while a laboratory study suggested the potential impact of the fuel oil dispersed with Corexit on local juvenile fish, the concentrations and exposure conditions applied were remote from the in situ context of the incident (short duration of dispersant spraying trials during the response and high degree of dilution in the water mass), eliminating the hypothesis of an effect in the environment.

Residual oil visible on the shoreline (weathered tarballs) was almost non-existent, while local surveys were carried out to detect any areas where the oil may be trapped or re-released. In terms of contamination, the University of Waikato showed local residual contamination of subtidal substrates by PAHs and metals at the end of 2012 (within a 100 m radius around the wreck, and in the north of Motiti Island, although at very low levels).

According to a representative of the University of Waikato, which was involved in the programme, this initiative is to be continued in a few selected areas (most affected by strandings of oil or other debris), to consolidate the results already obtained and to ensure there are no long term impacts.

For further information:
http://www.renarecovery.org.nz/latest-news/little-long-lasting-effect-from-rena-grounding.aspx
http://sci.waikato.ac.nz/research/projects-and-case-studies/rena-research/Rena-report

Impacts of the *Hebei Spirit* spill on macrobenthic communities

In 2007, the incident involving the *Hebei Spirit* oil tanker led to a major spill in coastal waters in the region of Taean (South Korea) of nearly 11,000 tonnes of crude oil[18]. Following this spill, the Ministry of Maritime Affairs and Fisheries (MOMAF) placed the Korea Ocean Research & Development Institute (KORDI) and Chungnam National University in charge of leading an environmental monitoring programme. In 2013 a team from KORDI published the results of a study into the initial impacts inflicted on the macrobenthic communities of the sandy beaches[19] on the Taean Peninsula, which at the time were severely hit by slicks of relatively fresh crude oil.

During the first year following the spill, the authors compared the evolution of hydrocarbon levels in

[18] See LTML n°20
[19] Several km long, low slope with a tidal range of around 5 m.

interstitial waters, the edaphic influence and statistical descriptors of benthic communities (species abundances and biomasses to enable calculation of diversity indices, in this case that of Shannon-Wiener) at two sites heavily oiled in 2007 as well as three control sites.

In short, the authors suggest that the number of species and the macrobenthic diversity are respectively 2 and 4 times lower on the 2 sites affected in 2007 than the control sites. Species abundances are also lower and increased between January 2008 and January 2009 while the biomasses remained low. Although the approach does not suggest any grouping of species into pollution sensitivity categories (opportunistic, tolerant, etc.), these results appear to indicate the ecological succession process observed in the case of organic pollution of soft sediments, both classically and following several oil spills (e.g. *Amoco Cadiz*, *Aegean Sea*). In the case of the beaches of the Taean Peninsula, the data presented suggests a degradation phase among macrobenthic communities following the *Hebei Spirit* spill, from the first month following the incident and lasting at least 12 months. As the authors concluded, the estimation of the re-establishment of macrobenthic communities will probably require the analysis of more long term data.

For further information:
Yu O.H., Lee H.-G., Shim W.J., Kim M. et Park H.S., 2013. Initials impacts of the *Hebei Spirit* oil spill on the sandy beach macrobenthic community west coast of Korea. Marine Pollution Bulletin 70, pp. 189-196.

Development of a system to track rehabilitated oiled birds

In 2013, ITOPF (the International Tanker Owners Pollution Federation) awarded funding to Swansea Laboratory for Animal Movement (SLAM) for a study to develop a reliable attachment system, without potentially affecting the birds or their behaviour, for long term monitoring devices for oiled rehabilitated birds released at sea.

The project arose from the recurring observation of the difficulty in estimating the true benefit of oiled bird rehabilitation operations implemented following a spill.

Current bird tagging methods are relatively unsuitable for long term monitoring, as they have a low range and are quickly lost in the case of VHF tags attached to birds' feathers, or else provide little or no information on behaviour at sea, in the case of rings. The idea here is therefore to come up with an attachment system for transmitters, tracked by satellite, in the form of a silicone harness, apparently successfully tested on a variety of species in captivity and now ready for trials on wild birds.

The project builds on a doctoral thesis and has already had several papers published.

For further information:
http://www.itopf.com/in-action/r-d-award/winner-2013/

• Containment

Containment/protection in strong current: Current Buster 6

The Norwegian firm NOFI recently reviewed its Current Buster range – systems designed to contain and separate floating oil in strong current – in particular with the addition of the Current Buster 6. With a change in terminology, the 3 pre-existing models previously known as Harbour, Current and Ocean Buster (in order of size) have been renamed Current Buster 2, 4 and 8 respectively.

The Current Buster 6 is a model designed for offshore use, given its dimensions (34 m opening; 63 m long), and which benefits from technical improvements based on the lessons learnt from its recent deployment, in particular as part of the response to the Gulf of Mexico pollution in 2010 (see LTML n°29 & 30)[20].

These improvements include:

- the addition of a second wave dampener and a splash-over cover at the rear to improve behaviour in waves
- the use of a more resistant fabric (PU and PVC blend)
- the incorporation of a debris net, in front of the recovery area to prevent the pumping

[20] In 2011, the Current Buster 6 entered the Oil Cleanup X Challenge held in Ohmsett and obtained encouraging results according to the manufacturer (average of results with and without wave action: recovery rate of around 600 m³/h with 83% selectivity).

system from becoming clogged

- the alteration of the rear section of the device to give it a more hydrodynamic shape to improve its performance in wave conditions, facilitate manoeuvres and reduce drag (and therefore the required strength and size of vessels required for its deployment).

The Current Buster 6 can be deployed by a single vessel with support from a Standard Boom Vane (whereas the Current Buster 8 requires an Ocean Boom Vane). The inclusion of 4 additional water drainage valves in the floor of the separator improves the performance of the water/oil separator, which can store approximately 35 m^3 of pollutant. The maximum current speed at which the device can operate is identical to that of the Current Buster 8, i.e. 5 knots.

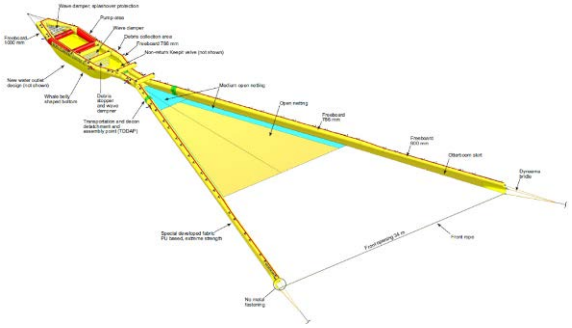


Diagram of the Current Buster 6 (source: NOFI)

Given the generally positive feedback on the Current Buster concept following its use on several recent spills, Cedre evaluated the Current Buster 4 model (22 m opening, 35 m long, designed for use in ports, estuaries and inshore waters), upon request by both public (CEREMA) and industry (Total) partners. These trials were conducted in 2013 in the Loire estuary, with logistical support from the *Grand Port Maritime de Nantes Saint-Nazaire* (GPMNSN). The aim was to test various deployment conditions, in dynamic mode (towed behind 2 vessels, or 1 vessel with a boom vane) and in static mode (moored to a fixed point on the quayside and opening by a boom vane; reversal when the tide turned).

The tests enabled the manoeuvrability of this type of equipment to be evaluated in the different configurations tested, but also its collection and concentration capacity on floating pollutant (simulated with oranges and popcorn) with a current speed of up to 3.5 knots. Additional information was also gathered in terms of the auxiliary resources required to deploy the device (handling, towing, etc.). Furthermore, this site, characterised by strong current and a sudden turn in the tide, required a rapid repositioning procedure to be defined and tested for when the tide turned.

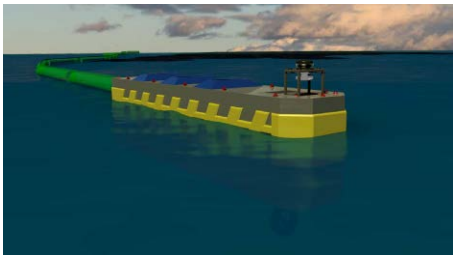
Static mode: the Current Buster 4 moored to a fixed point, deployed using an ORC BoomVane.

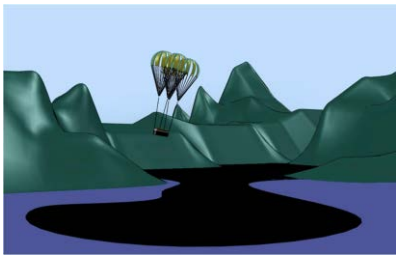
Dynamic mode: Left: pair towing (by a 19 m buoy tender provided by the Saint Nazaire subdivision of Phares et Balises + a small 7.5 m cruiser belonging to FOST); Right: towing by a single vessel, with deployment by an ORC BoomVane (Source: Cedre)

R&D: aerial response containment system

In 2013, the Canadian firm Scout Exploration Inc. (SXCN) acquired the rights for a project developed by IDS Offshore Inc., consisting in a containment system prototype for floating oil in marine or inshore waters. The originality of this concept (currently known as the IDS Containment System), the result of collaboration between industry and Canadian public entities, lies in its method of transport to the spill site: the system is designed for aerial delivery and deployment on site. The prototype is an upshot of a search for technical solutions to significantly reduce response times at sea (and hence to minimise the potential impact on the coast).

At this stage, the possible deployment constraints (metocean conditions required for drop-off and maintenance of the system, requirement in terms of auxiliary vessels if necessary etc.) are not mentioned. According to SXCN, the market for this system could potentially be "enormous" and, given the results of trials released in 2013, this system could be "widely deployed across the globe". To be continued...





Illustrations of the IDS Containment System prototype as deployed on water (left) and airdropped on site (right) (Source: Scout Exploration, Inc.)

For further information:
http://www.goldmanresearch.com/Popular/the-oil-spill-containment-pioneer.html

• Statistics

Statistical analysis of spills

Using the information contained in the Energy Related Severe Accident Database (ENSAD), the Swiss-based Paul Scherrer Institute published in 2013 a risk analysis of oil spill occurrences (from various structures: vessels, pipelines, storage facilities, refineries, etc.). Their approach was based on a statistical review of 1213 oil spills referenced in the ENSAD database over the 1974-2010 period, including that of the Macondo well in April 2010 in the Gulf of Mexico.

The spill sources were divided into 4 categories, according to whether they were linked to exploration or production (wells, drilling and exploration platforms and rigs...), ships (oil tankers), pipelines (both on- and offshore) and finally storage facilities and refineries.

Analysis of the distribution of both the frequencies and size of the spills gave rise to a number of conclusions, notably:

- within these 4 categories of sources, while exploration/production is the least frequently involved in the spills recorded, the quantities associated with such structures are the highest (we note that no particular precise trend emerges in terms of the frequency of these spills).
- Reciprocally, oil tanker incidents are, for the whole of the period studied, the cause of around 75% of the spills recorded, with however a downward trend both in terms of frequency and size (this finding is consistent with the observations made by various organisations involved in this field, for instance ITOPF but also Cedre through statistical analysis of its own data).
- The frequency of oil spills from storage facilities and refineries, but also pipelines, increased during the study period.
- Finally, the authors found that the expected frequency of a spill on a similar scale to that of the Macondo well was 1 occurrence every 23 years. Over and above this absolute value – to be taken with caution given its uncertainty – we note the similarity of the results obtained with and without the inclusion in calculations of the Macondo spill. In other words, the study shows above all that this spill, although major, does not significantly deviate in statistical terms from the pattern otherwise described by the data set available to the authors for the 1974-2010 period.

For further information:
Eckle P, Burgherr P, Michaux E., 2012. Risk of Large Oil Spills: A statistical analysis in the aftermath of Deepwater Horizon. Environmental Science & Technology 46(23):13002 - 8.
http://dx.doi.org/10.1021/es3029523

• Legislation/convictions

***Deepwater Horizon*: legal proceedings**

In February 2013, the civil proceedings began in New Orleans to establish the causes and liabilities relating to the *Deepwater Horizon* rig disaster, in April 2010, and the subsequent pollution of the Gulf of Mexico.

The case was composed of several aspects:

- one consists in precisely examining the causes of the explosion and establishing the degrees (negligence, faults, etc.) of liability attributable to BP and its partners

(Transocean, Halliburton and others).

- another, initiated in September 2013, aims to draw a definitive conclusion on the quantity spilt and to assess the relevance of the response of various parties, in terms of the implementation of operations to stop the leak.
- the strategies and techniques adopted for spill response operations, including dispersant use, will also be examined.
- finally, the court is expected to give its verdict on the extent of the environmental and economic damages incurred.

This bodes for a lengthy trial, within a legal framework whereby if BP were to be found guilt of gross negligence and wilful misconduct, American civil law provides for the possibility of imposing punitive damages calculated based on the number of barrels of oil spilt at sea, some 3.1 million according to BP, or 4.9 million according to the US Federal Government. With a penalty of up to $4,300 per barrel, this 1.8 million barrel difference could significantly increase the amount of punitive damages. The proceedings are expected to last several more months, unless an amicable financial agreement is found before the case reaches an end.

From a more general perspective, the following point can be noted in terms of the legal proceedings following this accident in April 2010:

- in March 2012, BP was reaching an agreement with the lawyers representing the plaintiffs, i.e. businesses and inhabitants claiming compensation for economic damages. The firm was expecting to pay $8.5 billion in damages to settle tens of thousands of claims (the agreement did not however specify an upper limit).
- In terms of criminal proceedings, in December 2012 BP pleaded guilty to the 11 criminal charges (relating to the death of 11 victims of the explosion) filed by the US Department of Justice, as well as a charge of obstruction of Congress: an amicable agreement was found, with the payment of a $4 billion criminal settlement.
- In January 2013, Transocean, the Swiss-based rig owner, concluded an agreement with the US Federal Government, by pleading guilty to offences with which it was charged (violation of the Clean Water Act) and accepting to pay $1.4 billion in criminal and civil penalties, including a $400 million criminal plea agreement (for misinterpretation of the alarming results of a test performed shortly prior to the blowout) and $1 billion in civil fines for the spill.

In the absence of tests conducted or supervised by Cedre, we cannot guarantee the quality or performance of the response resources mentioned in the Technical Newsletter; the parties (companies, journalists, authors of articles and reports, etc.) providing the information bear sole responsibility.

Any mention by Cedre of a company, product or equipment does not constitute a recommendation and Cedre does not assume any liability with respect thereto.

The articles contained in the "Spills" section are based on information from various sources, in printed or digital form (specialised reviews and publications, specialised or general interest press, technical/scientific conferences, study reports, releases from press or institutional agencies, etc.). When a website or document containing a large amount of relevant information is identified, explicit reference is made thereto at the end of the article, under the heading "For further information".