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- **Spills**

### **Coastal pollution due to the sinking of the cargo ship *Rak* (India)**

On 4th August 2011, 35 km off Mumbai Port (India), the Panama-registered cargo ship *Rak* sank in unspecified circumstances after its 30 crew members had been evacuated by the Indian Navy and Coast Guard.

The ship was transporting 60,000 tonnes of coal from Indonesia to the State of Gujarat, and its bunkers contained 290 tonnes of bunker fuel and 50 tonnes of diesel. This fuel began to leak out on 6th August due to the influx of water into the vessel.

The initial leak rate was estimated at 1.5 to 2 tonnes/hour according to the Indian Coast Guard (ICG), which sent its equipment for survey and response at sea on site, including the spill response vessel *Samudra Prahari*. The main strategy considered was chemical dispersion, but lightering and refloating operations were deemed a priority despite difficult sea and weather conditions (monsoon season).



*Aerial view of fuel leaks from the sinking Rak  
(Source: Indian Navy)*

Four days after the vessel sank, the action plan had been defined by the Indian authorities<sup>1</sup>, the local representatives of the P&I Club and those of the salvage companies it had contracted:

- The insurer had to mobilise the resources required to plug the leaking tanks (using divers, as soon as weather conditions allowed) or remove the fuel from the wreck's bunker tanks and, in the meanwhile, mark the wreck as soon as possible (buoys, in collaboration with the Directorate General of Lighthouses and Lightships). Attempts by divers to plug the leaking tanks were hindered by strong currents and poor visibility for several days on end, from 11th to 20th August – when these operations had to be postponed for a fortnight.
- The fuel continued to leak out of the wreck at a slower rate, 1 tonne/hour, resulting in a continuous trail at the surface, 12 nautical miles long, with slicks stretching over 1 to 2 nautical miles and sheen beyond. The ICG then began to monitor and disperse the oil, while continuing to conduct overflights on a daily basis.

After the first week following the incident, the appearance of upwellings (discontinuous sheen) above the wreck showed, according to the ICG, a clear decrease in the leak. At this stage, the small scale of the spill, estimated at 150 tonnes in total, together with the sea conditions, did not appear to lead to significant risks of oiling of the coastline. Nevertheless, oil was reported on the shore from 8th August, and the possible link with this incident was examined by the ICG and the Maharashtra State Maritime Pollution Board via a comparative analysis of samples taken at sea and on the shore<sup>2</sup>. The local authorities (Brihanmumbai Municipal Corporation) organised clean-up operations on the shore, with assistance from the ICG.

Following this incident, the level of preparedness of the Indian authorities in charge of spill response was questioned, in particular concerning the lack of a specific State agency. Furthermore, according to representatives of the ICG, the Indian ports' current contingency plans were generally unsuitable for managing ship-source pollution incidents of over 100 tonnes, a situation that remained unaided by the small number of Indian specialised contractors. Lessons were later drawn in terms of preparedness, with the drafting of a Local Contingency Plan (LCP) by the MPCB in October 2011 based on the National Oil Spill Disaster Contingency Plan (NOS-DCP), outlining the respective roles of State and central governments in the various aspects of the response (operations, logistics, scientific/technical support for operations, estimation of impacts, etc.).

In September 2011, the Indian Directorate General of Shipping banned ships insured by the *Rak*'s

<sup>1</sup> State Environment Department, Indian Coast Guard, Mercantile Marine Department, Mumbai Port Authority, Maharashtra Maritime Board and Maharashtra State Pollution Control Board.

<sup>2</sup> This incident occurred only 5 days after the grounding of an oil tanker (*Pavit*) on the coast near Juhu beach, where oil was washed up. Although this other incident did not result in any major pollution, it was considered as a potential source of oil on the coast.

Romanian P&I Club from accessing Mumbai Port, following "repeated refusal to compensate for the environmental damage caused by the pollution"<sup>3</sup>. This ban, applied in early February 2012, was contested by the P&I Club before the Supreme Court of Mumbai.

This spill was not the only one in India this term, as on 23rd November the barge *World Bridge* hit a shallow close to the port of Nagapattinam (southern State of Tamil Nadu) during operations to transfer the cargo of palm oil from a tanker. The barge sank 100 m from the coast and lost its 210 tonnes of cargo. The 10 crew members abandoned ship and swam to the port. This spill is reported to have resulted in surface sheen in the coastal waters within a 5 km radius and in the oiling of 5 to 12 km of shoreline, without a toxic risk having been identified by the authorities.

#### **Crude oil leak in the North Sea from an offshore installation (*Gannet Alpha*, Scotland)**

On 10th August 2011, over 180 km off Aberdeen (Scotland), around 220 m<sup>3</sup> of crude oil was spilt into the North Sea due to a leak from a 95 m deep flowline running between wells E and F operated by the *Gannet Alpha* platform (on the Gannet offshore field operated by Shell).

Following notification of the competent British authorities (Maritime and Coastguard Agency -MCA, Department of Energy and Climate Change -DECC, and Health and Safety Executive -HSE), the well activity was immediately suspended and the line depressurised, thus reducing the leak rate the same day. At the surface, sheen spread out over an area 31 km long by 4.3 km wide. Despite a westward drift, the cold winds and rough seas promoted rapid natural dispersion of the crude oil (light - API 36 - and low in wax), without a significant risk of it reaching the coast.



15th August: Surface sheen near the *Gannet Alpha* platform (Source: Marine Scotland)

On the seafloor, the operator conducted an inspection of the flowline during the first days following the incident, using a ROV. At the surface, a vessel (the British anchor handling vessel *Grampian Prince*), fitted with containment/recovery and dispersion equipment, was mobilised on standby. The high degree of spreading of the oil at the surface – as sheen within an area varying from 1 km<sup>2</sup> to several km<sup>2</sup> – meant that the implementation of response operations would be inappropriate.

One week after the incident, the leak rate of the oil remaining in the line was estimated at less than 150 l/day. Solid blocks (in total over 70 cement blocks) were placed on several sections of the depressurised (therefore floating) line, to hold it in position and to allow access to the valve (action conducted by ROVs and divers). This line was closed 9 days after the beginning of the leak, before the final stage of pumping the oil remaining in the line. After this date, no more oil was reported at the surface during aerial surveys by the MCA, with the exception of small amounts of sheen – which quickly disappeared – due to the disturbance of sediment on the bottom caused by operations to locate the leak point. An internal investigation was conducted to determine the technical causes of the leak.

From 18th August and until the end of the incident, the potential impacts, in particular on seabirds, were monitored by visual observation (counts) from ships or aircraft. This monitoring indicated that there had been no significant impact on seabirds.

Over and above the management of operations themselves, we note that Shell was heavily criticised by public opinion, via the media, for not having communicated on this incident until 2 or 3 days after the spill. While this period was considered necessary by Shell to assess the scale of the event, the spill occurred in a "post-Deepwater Horizon" context in which expectations of the oil industry in terms of information provision in the event of an incident are higher than ever before – in particular for offshore activities.

<sup>3</sup> The insurer considered that the provisions of both the Indian Merchant Shipping Act and the insurance contract indicated that the environmental cost should be covered by the shipowner.

### Coastal pollution following the grounding of the container ship *Rena* (New Zealand)

In the early hours of 5th October 2011, in New Zealand, the Liberian-flagged container ship *Rena* (236 m; 37,209 DWT) grounded on Astrolabe Reef<sup>4</sup> (Bay of Plenty, North Island), 12 nautical miles off the coast and 3 nautical miles from Motiti Island. The ship was travelling from Napier to Tauranga, taking a short cut as it was running 13 hours late.

Despite a relatively calm sea, initial attempts to refloat the ship were unsuccessful.



*The Rena with its bow section on Astrolabe Reef (Source: MNZ)*



*6th October: leak of IFO 380 at sea from a cracked bunker tank (Source: MNZ)*

The structure, whose bow section was resting on the reef, was listing 10° to port and, due wave action, soon sprung leaks. A bunker tank cracked the day after the incident, causing a leak at sea of a volume later estimated at 350 m<sup>3</sup> of heavy fuel oil.

The bunkers of the *Rena* contained, at this stage, 1,750 tonnes of IFO 380 and 150 tonnes of diesel, and its cargo comprised 1,368 containers. Initially, 11 of these containers were declared to contain hazardous chemicals.

These products included combustive substances (hydrogen peroxide, trichloroisocyanuric acid, potassium nitrate) and potentially toxic substances (ferrosilicon, liable to produce toxic gases – arsine and phosphine – upon contact with water; alkyl sulphonic acid – corrosive). Later (22nd November), the insurer alerted Maritime New Zealand (MNZ) as to the presence of additional dangerous goods not declared as such on the ship's manifest: 21 containers of cryolite, i.e. 490 tonnes of aluminium trisodium hexafluoride (powdered product, noxious in the case of prolonged exposure, irritant for the skin and mucous membranes) in one-tonne bulk bags.

The rest of the cargo included 2,900 tonnes of perishable foodstuffs (milk powder, meat in refrigerated containers), as well as various materials – timber, plastic beads, etc.

The 25 crew members were evacuated on 11th October, as the gradual decline of sea and weather conditions threatened the structure's stability and integrity. Given the pollution risk, the National Contingency Plan (NCP) was activated in the first hours following the grounding, at Tier 3 (national spill, involving national and international resource mobilisation). In this context, responsibility for the response at sea and on the shore was placed under the authority of MNZ, through the Marine Pollution Response Service (MPRS).

The implementation of the NCP involved the establishment of an Incident Command Centre (ICC) which included 200 to 300 people at the height of the response (October-November 2011)<sup>5</sup>. Its command, by MNZ, was placed under the authority of an On Scene Commander (OSC) in charge of supervising around 15 units specifically dedicated to the various aspects of the response: surveying the pollution at sea and on the shore, survey/monitoring of the wreck, containers, shoreline clean-up, waste treatment, logistics (equipment and staff), risk assessment and impact on wildlife, etc. Furthermore, many experts were made available to the ICC by the Australian authorities, given the close cooperative links between the 2 countries in terms of managing such emergencies.

Experts from the companies contracted by the *Rena's* insurer also joined the ICC, in particular representatives of Svitzer and Smit for wreck salvage (fuel and container removal), London Offshore Consultants for structural strain calculations, OSRL for evaluating the possibility of chemical dispersion and Braemar Howells for the recovery of containers fallen overboard and washed up on the shore.

The day after the incident, the ship's insurer contracted Svitzer to assess the feasibility of pumping

<sup>4</sup> Well charted rock but unmarked by any beacons.

<sup>5</sup> Including, among others, representatives of MNZ, the National Response Team, various regional and local authorities, the Department of Conservation, the New Zealand Fire Service, as well as academics (Massey and Waikato Universities) and representatives of NGOs (e.g. WWF).

the estimated 1,700 tonnes of fuel remaining in the bunker tanks and removing the containers as priority actions. Throughout the response, surveys<sup>6</sup> and operations were dependent on the variable weather conditions and the deterioration of the *Rena* (on which sensors were placed from 9th October, to assess the strain on the structure and anticipate its evolution). On 12th October, the hull cracked vertically up the port side, arousing fears of the hull breaking completely. On the night of 12th to 13th October, severe weather conditions caused the vessel to shift to a severe starboard list (20°), causing a new release of oil as well as the loss of 90 containers. On 8th January 2012, the vessel eventually broke in two, causing more containers to be lost and the stern section to sink off the edge of the reef in waters 60 m deep.



From 12th October: crack in the port side of the *Rena*



Severe list and loss of containers on 12th October



The *Rena* broken in two on 8th January 2012 (Photo source: MNZ)

Three days after the incident, a first tank-to-tank fuel transfer was performed, with a view to pumping the fuel and lubricants to a small double-hulled tanker (*Awanuia*) moored (and held in position by a tug) a few dozen metres to the rear of the *Rena*. Yet, very early on, the implementation of these operations proved difficult, due to the list and slippery decks of the container ship (requiring work platforms to be built), the need to fly in all the equipment (pumps, hoses, power packs, etc.) and the handling of large (5" to 6") hoses. Furthermore, adverse weather conditions temporarily prevented access to the *Rena*, thus postponing the fuel transfer to the *Awanuia* until 16th October. The pump rate of the initial screw pump proved to be low (<5 m<sup>3</sup>/h), and was therefore rapidly replaced with a Marflex submersible pump with a 6" discharge pipe with water injection to reduce friction loss and a Y (two separate 3" hoses) fitted with two booster pumps, thus doubling the pump rate, to reach around 8 m<sup>3</sup>/hour.

Operations by divers to set up a cofferdam were initiated with a view to accessing the manhole of an underwater bunker tank and pumping out the 350 m<sup>3</sup> of fuel oil. The cofferdam under construction was destroyed during another spell of bad weather in early November, and the fuel was finally pumped out by hot tapping.

In the end, the majority of the accessible oil in the wreck, i.e. around 1,350 tonnes, had been pumped out by around 20th November 2011 (MNZ estimated that 2 m<sup>3</sup> of heavy fuel oil and 5 m<sup>3</sup> of diesel could not be pumped out).

The *Rena* was carrying 547 containers on deck: between October 2011 and April 2012, following the grounding then successive spells of bad weather and dislocation of the vessel, 267 of them fell overboard and sank or drifted towards the coast.

Only 1 container of HNS (24 tonnes of alkyl sulfonic acid) fell overboard at the beginning of the incident, without affecting the environment due to its probable rapid dilution. The loss of containers generated all sorts of debris – cargo and burst (or dismantled) containers.



Grounding of bags of powdered milk (Source: MNZ)



Timber on Matakana Island (Source: MNZ)

<sup>6</sup> Requiring airlifting of experts by helicopter onto the ship in dangerous conditions.



Recovery of containers by a barge  
(Source: Cedre)

When these containers washed up on the shore, they were visually inspected by experts contracted by the insurer to determine (i) the possible risks associated with their content and (ii) their treatment method (suitable option – decontamination, *ad hoc* waste treatment centres, recycling, etc.) in collaboration with local companies. After their recovery using variable equipment according to the accessibility of the coastal sites (road vehicles, helicopters, or even – on Motiti Island – barges), the containers were emptied and cleaned at an industrial site in Tauranga, for subsequent scrapping or reuse.

On board the wreck, the recovery of containers began on 16th November 2011 with the arrival of the crane barge *Smit Borneo* from Singapore. Often interrupted by sea conditions, these operations could not be completed below deck before the vessel broke in two, after which operations continued underwater for the submerged stern section.

The area between the vessel and the coast was grid-searched for sunken containers using side-scan sonar. A few dozen containers were located and tracked until they could be recovered by the *Go Canopus*, a vessel from Singapore with major lifting capacities specialised in laying anchors in deep waters. We note that, during container removal operations, certain containers on deck were fitted with acoustic 'pingers' so that they could be easily detected if lost at sea.

In early 2013, MNZ announced the recovery of 1007 containers (from the vessel and the shore) while around 18 empty damaged containers remained in the bow section, and around 40 had been located on the seabed. The remainder (303) was divided in undetermined proportions between the stern section and the debris surrounding the wreck.

Cutting operations to remove the bow section of the *Rena* began in August 2012. They continued into early 2013, at a slower pace as they were carried out underwater, and aimed to cut it down to 1 metre below the low tide mark. These operations were contracted to Resolve Salvage & Fire and resulted in the recovery, by autumn 2012, of 670 tonnes of steel from the wreck, lifted by a crane barge and taken to shore by helicopter. Over 500 tonnes of debris (containers, structural parts, etc.) were recovered in waters 30 m deep, within an area of 1 ha in which the sediment, in October 2012, showed locally significant concentrations of copper and aluminium fluoride (due to the cargo of cryolite).

In terms of response at sea, the day after the grounding MNZ began to examine the possibility of chemical dispersion.

After checking the environmental<sup>7</sup> and logistical prerequisites, initial assessments of the efficiency of spraying (by boat then by helicopter) Corexit 9527 and 9500 were performed in situ, on slicks 'chosen' on the basis of aerial surveys. This option was abandoned after 5 days of unsuccessful results due to the operational conditions (poor visibility and sea state), the form of the pollution (a lot of sheen or small fragmented slicks) and the fuel oil's characteristics (low dispersibility). In total, 3 m<sup>3</sup> of Corexit 9500 were sprayed, in a controversial context<sup>8</sup>.



Visual observation of the persistence of the IFO 380 after spraying dispersant by helicopter (Source: MNZ)

Following these attempts, mechanical recovery was the only option retained, which proved to be limited by the sea and weather conditions and the relatively small amount of pollution – not to mention the rapidity with which it was being washed up on the shore. Recovery was therefore mainly attempted following the release of 350 m<sup>3</sup> of fuel oil during the first week of the incident, mobilising 3 large mussel barges (around 20 m long) fitted out with booms, skimmers and many intermediate bulk containers (around 1 m<sup>3</sup>). These operations met with little success and were not

<sup>7</sup> Via a Net Environmental Benefit Analysis (NEBA).

<sup>8</sup> Questioning by the public, broadcast by the media into the political sphere, and fuelled by the recent (yet incomparable) pollution in the Gulf of Mexico (April 2010, Cf. LTML 29-30).

continued much beyond the fortnight following the incident.



13th October 2011, Papamoa Beach: **Left:** trails of fuel oil on the beach (Source: MNZ); **Right:** manually collecting tarballs (Source: New Zealand Defence Force)

The fuel oil spilt at sea, in particular during the 6 days immediately following the incident, rapidly washed up on the shore (mainly at Tauranga), in the form of thin trails or tarballs (1 to 10 cm in diameter) weathered to varying degrees.

The affected shores were characterised by sandy beaches with dunes and a few rocky foreshores. On these heavily exposed shores, the fauna typically present was relatively low in abundance and diversity. The local hydrology promoted a high accumulation of varied plant debris – potentially large in size – and possibly waste along the tide mark. These sectors, with relatively low ecological sensitivity, were nevertheless of importance in terms of their uses, both recreational and related to Maori culture.

More ecologically sensitive, large intertidal marshes and lagoons located behind sand spits<sup>9</sup> were ultimately under little threat from the oil.

Selective manual collection of tarballs on the shore was performed by soldiers with support from a horde of volunteers, totalling up to 800 people at the height of the response. The volunteers were not paid, except for the Maoris who were the only people authorised to work in areas considered by their traditions as sacred sites and whose traditions require some form of reward.



Protecting sites behind the dunes with containment booms (Source: Cedre)

Initially, MNZ recommended not involving volunteers in operations, and the public was clearly told to keep off the oiled beaches. Then, given the influx of requests and a certain degree of public pressure<sup>10</sup>, their involvement was organised, under their auspices of MNZ and the local authorities (e.g. Bay of Plenty Regional Council, Tauranga City Council, etc.). Almost 8,000 applications were made via the MNZ institutional website and in the end 21,000 hours of work were carried out during the 150 clean-up operations.

On the beaches, the recovery of the remaining micro-tarballs, sometimes buried under the sand, locally required fine sand screening (sifters, possibly sand screening machines) or surfwashing operations (not requiring recovery by sorbent nets). On the rocks, scrubbing was completed where necessary by rinsing with moderate pressure hoses.



Final clean-up: volunteers fine-sifting the sand (**left**); moving sediment down to the surf zone for surfwashing (**middle**); manually scrubbing oil on rocks (**right**) (Source: MNZ).

The bulk of recovery had been completed a fortnight after the incident, although clean-up operations were continued in some locations, due to sporadic leaks of small volumes of fuel oil over the months following the incident. In total, 1,041 tonnes of oil and polluted waste were collected on the shore and transported to a specialised treatment plant near Tauranga. Despite selective recovery, these

<sup>9</sup> At which protection measures were implemented by the preventive laying of various types of booms – shore-sealing, sorbent, etc.

<sup>10</sup> With some people taking it upon themselves to collect the pollutant – interfering and potentially technically inappropriate initiatives (secondary contamination, burial/scattering of the pollution by trampling, etc.).

figures suggested that the volume of oil on the shore was far lower than the 350 m<sup>3</sup> spilt at sea.

Major wildlife issues were rapidly identified, due in particular to the presence of an endangered species<sup>11</sup> of endemic shorebird, the New Zealand Dotterel (*Charadrius obscurus*), in the coastal marshes, represented on the North Island by a single subspecies, *aquilonius*. Furthermore, the pollution coincided with the breeding period of the Little Blue Penguin (*Eudyptula minor*), a more emblematic than endangered species, present in large numbers on the shore at the time of the incident.



Installation of a temporary oiled wildlife response centre at Tauranga wastewater treatment plant (Source: MNZ)

In compliance with the National Contingency Plan (NCP), from the first days following the incident, the risk for these species resulted in the involvement of around a hundred staff specialised in the capture of and care for oiled wildlife: members of the National Oiled Wildlife Response Team referenced in the NCP, vets, ornithologists, etc. A temporary response centre, set up near Tauranga wastewater treatment plant, received just over 400 birds, including 345 Little Blue Penguins and 60 New Zealand Dotterels (i.e. 50 % of the population of the Bay of Plenty) captured preventively<sup>12</sup> then released for the most part between November and December (in 2012 the temporary on-site centre was demobilised and Massey University took over wildlife monitoring<sup>13</sup>).

In total, just over 2,400 dead birds were collected on the shoreline in the weeks following the incident, of which 60 % were oiled. This figure included over twenty species and was largely dominated by Procellariiformes, an order of seabirds, in particular Diving Petrels (over 450), Shearwaters (around 200 *Puffinus gavia* and around 100 *P. bulleri*) and around 40 Storm Petrels (*Pelagodroma marina*). Only twenty Little Blue Penguins were killed, while some particularly rare specimens of Procellariidae (in particular the Mottled Petrel, the Blue Petrel *Halobaena caerulea*, and the Antarctic Prion *Pachyptila desolata*) even in small numbers, also fell victim to the spill.

Over and above birdlife, the environmental impacts were very low, and mainly came down to 5 oiled juvenile seals treated at the oiled wildlife response centre.

In conclusion, this spill led to many potential risks and required a long term response: although it involved a moderately sized container ship (in comparison to recently built ships), it nevertheless raised many issues, ranging from HNS to oil, not forgetting the dangers generated by the loss of containers at sea. Furthermore, it occurred near to an economically and ecologically sensitive shoreline, within a delicate political context (national elections, in November 2011, of the New Zealand Parliament). Despite the pressure related to this context, incident management proved to be efficient, in particular thanks to a single response organisation (at sea and on shore) which facilitated the consistency and transparency of actions, together with the input of public and private international expertise, the use of personnel duty rotas (two weeks on site including overlap) and controlled communication with the media.

We note a few lessons drawn by MNZ, which should lead to revisions to the NCP, in particular in terms of:

- chemical dispersion, with the updating of recommendations on dispersant use and dispersant stockpile controls
- the management of the influx of volunteers, with a specific section designating a coordinator and detailing the training given to volunteers (and supervisors) in the event of an incident
- wildlife management, recommending the planned installation of bird care centres near wastewater treatment plants (effluent management).

For further information:

<http://www.maritimenz.govt.nz/rena/>

<http://www.renarecovery.org.nz/>

<sup>11</sup> Listed on the IUCN (International Union for Conservation of Nature) Red List of Threatened Species.

<sup>12</sup> A first for this species – this practice is generally applied to Spheniscidae (penguins).

<sup>13</sup> In spring 2013, the results of the monitoring of local populations of New Zealand Dotterels revealed normal rates of survival and reproductive success in preventively captured individuals.

### **Pollution caused by offshore development drilling (*Chevron Brasil Upstream Frade Ltda, Campos Basin, Brazil*)**

On 8th November 2011, sheen and thin oil slicks were detected at sea 370 km north-east of Rio de Janeiro (Brazil), near a production well operated since 2009 by *Chevron Brasil Upstream Frade Ltda*, in waters around 1,200 deep in the Frade Field (Campos Basin).

According to the operator, the pollution was not linked to the production well, but resulted from a leak from nearby development drilling (appraisal well 9FR-50DP-RJS), due to a sudden, uncontrolled pressure spike. Its activity was suspended as soon as crude oil upwellings were detected at the surface. Meanwhile, thanks to the inspection of the seabed by cameras fitted to ROVs, several oil seeps were detected at fissures on 9th November, apparently caused by a variation in pressure in the rock and located within a 50 m radius around the well.

Development drilling was stopped and the well "killed" by mud injection on the 13th and cemented 3 days later. While upwelling from this well was stopped on the 15th, seepage from the rock continued, although reduced to "infrequent droplets"<sup>14</sup>.

On the 10th, following aerial surveys, Chevron estimated the total volume at the surface at less than 10 m<sup>3</sup>, revised 2 days later to between 60 and 100 m<sup>3</sup>, with an estimated flow rate of between 30 and 50 m<sup>3</sup>/day. These estimations were immediately disputed by the NGO Skytruth, based on their interpretation of satellite images (MODIS/NASA's Aqua satellite), according to which the flow rate was closer to 600 m<sup>3</sup>/day<sup>15</sup> during the first 4 days.

On 20th November, ANP (*Agência Nacional do Petróleo, Gás Natural e Biocombustíveis*) estimated the total volume spilt at between 800 and 1,200 m<sup>3</sup>. Chevron issued a new estimation 2 days later (22nd November), at around 380 m<sup>3</sup>, and ANP revised its estimation to 250-420 m<sup>3</sup>.

The crude oil appeared to rapidly spread at sea and the majority of it dispersed naturally. Seven days after the incident, the authorities (ANP - *Agência Nacional do Petróleo, Gás Natural e Biocombustíveis*) reported sheen drifting out to sea and its natural dispersion, with a polluted area estimated at 163 km<sup>2</sup> (compared to 2,379 km<sup>2</sup> estimated 2 days earlier by Skytruth).

Two days after the incident, Chevron initiated response operations at sea. Little information is provided on these operations in our sources, however they are believed to have mobilised no less than 18 vessels, including the oil company's own resources and those of other industry partners.



12 Nov. 2011: Satellite image (MODIS/Aqua) and visual interpretation of the spread of the surface pollution (Source: <http://blog.skytruth.org>)



19/11: aerial view of residual crude oil seepage (*left*); response at sea (*mixing with jets of water*) (*right*) (Source: Chevron)

Chevron indicated that it applied "methods approved by the Brazilian government", in particular skimming and mechanical dispersion by mixing, with no use of chemical dispersants.

Two weeks after the incident, Chevron announced the "mechanical dispersion of most of the volume spilt" and the recovery of 350 m<sup>3</sup> of an oil/water mixture. The polluted area decreased every day and no surface pollution was detected beyond a fortnight after the leak. No shores were oiled.

<sup>14</sup> As shown in the video images posted on the web page specially set up by Chevron.

<sup>15</sup> Estimation based on the interpretation of a 2,379 km<sup>2</sup> slick on 12th November, with an estimated average thickness of 1 µm, i.e. a quantity of 2,377 m<sup>3</sup> spilt between 8th and 12th November.

On the seabed, measures intended to recover intermittent droplets of crude oil rising from the seep lines were implemented in early December.

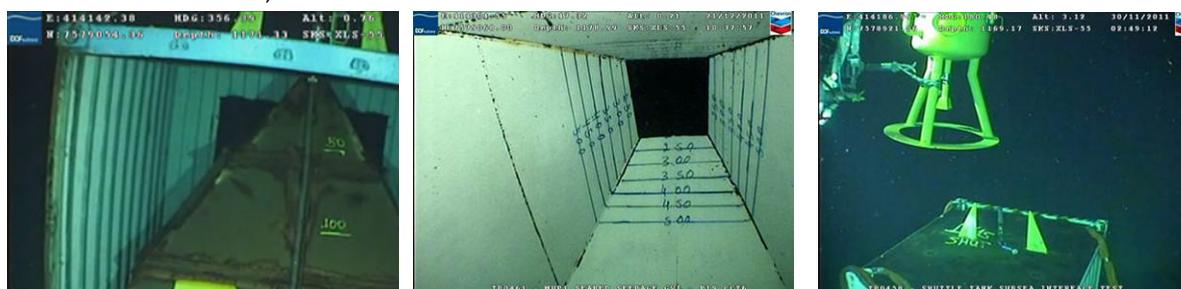
To do so, Chevron had a containment device built, consisting of a steel structure with a "shuttle tank" on top, in which the oil was collected by gravity. The device was tested on 30th November, then deployed at a depth of approximately 1,200 meters at one of the seep points (site P19) first.

Video surveillance of the seeps was set up to appropriately deploy the containment/recovery device.



Video monitoring of intermittent seepage (oil droplets) 1,200 m deep (Source: Chevron)

According to the information released by Chevron, these operations were continued into early January at at least half a dozen sites. The volumes indicated suggest a low seepage rate (for instance it seems that around 7 litres were collected in the first tank placed above seep P19 from 4th to 16th December).



**Left:** Inside of the steel containment device sitting on top of a seepage point, containing a funnel structure; **Middle:** View of droplets rising by gravity inside the funnel system of the containment device; **Right:** Placing the shuttle tank on the steel containment device (Source: Chevron)

These crude droplet recovery operations were repeated in March 2012, around 3 km away at new seeps in another reservoir (confirmed by oil sample analysis), without any drilling activity having been undertaken nearby. Chevron suspended its activities in the Frade field in order to study its "geological complexity".

On 23rd November 2011, ANP formally suspended Chevron's drilling rights. Meanwhile, controversy began to emerge over the operator's transparency concerning seepage estimations, but also concerning the response at sea, in terms of the equipment announced and actually deployed, as well as the adequacy of response strategies. Indeed the authorities at one point suspected Chevron of having spread sand to sink the oil at sea – accusations which were formally rejected by the operator. In terms of the leak itself, Chevron admitted, during a hearing before an environmental commission of the Chamber of Deputies, having made a mistake in its pressure calculations within the development well.

Finally, certain sources propagated by the press claimed that Chevron had surreptitiously been attempting to reach deep presalt layers, an allegation which could partly explain why this, indeed relatively limited, event raised such a political row. The importance of the potential market related to the discovery, in 2007, of substantial presalt reserves (Campos and Santos Basins) gives Brazil high hopes of becoming a major oil player. It was with this as a background, which inevitably gave rise to debates in terms of safety and the environment, that representatives of the Ministry of the Environment of the State of Rio considered this spill as an exemplary case from which lessons should be learnt in terms of regulations and future block concessions for offshore production. Heavy fines were also imposed by IBAMA (*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis*): first a \$27 million fine in late 2011, followed by a second \$5.5 million penalty (for a lack of planning) in early 2012. A third action was initiated by ANP in 2012, for various offences including a lack of compliance with the development plan for the 9FR-50DP-RJS well (although it had previously been agreed with ANP), for which a further \$17 million fine was issued.

In December 2012, an out-of-court settlement between Chevron and the Brazilian government was reached, with Chevron offering to pay \$144 million to settle lawsuits, in order that production could resume in April 2013.

Finally, we note that another, minor, spill occurred on 16th December 2011 in Brazilian waters, with

a leak of around 10 m<sup>3</sup> of crude oil from a MODEC (Mitsui Ocean Development & Engineering Company, Ltd) floating platform near Ilha Grande, off Angra dos Reis (State of Rio de Janeiro). This incident, of unknown cause (under investigation) and for which little information is available, is believed to have caused the oiling of beaches 2 days later, according to the Ministry of the Environment of the State of Rio de Janeiro. The platform operator was fined \$5.4 million in early January 2012.

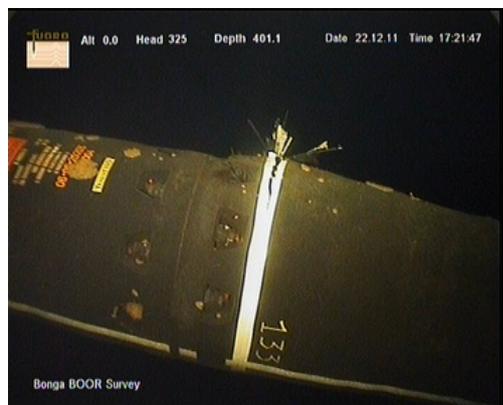
For further information:

<http://www.chevron.com/fraderesponse/>

### Leak of crude oil from an FPSO export line (*Sea Eagle*, Nigeria)

On 19th December 2011, a spill of around 6,300 m<sup>3</sup> of crude oil occurred at sea, at the Bonga offshore oil field, 120 km from the Niger Delta and the coastline of the Nigerian State of Akwa Ibom. The spill occurred while loading an oil tanker at a loading buoy linked to the FPSO<sup>16</sup> *Sea Eagle* operated by Shell Nigeria Exploration and Production Company (SNEPCo).

As soon as the competent Nigerian authorities – Nigerian Department of Petroleum Resources (NDPR) and the National Oil Spill Detection and Response Agency (NOSDRA) – were notified of the spill, they activated the oil spill contingency plan.



*Underwater view of the damaged export line  
(Source: SNEPCo)*

Meanwhile, SNEPCo temporarily suspended its operations in the oil field and began to search for the source of the leak by deploying a ROV. The following day, a breach was identified in a submarine line running between the FPSO and the loading buoy. The leaking line was immediately secured (by de-pressurising the line and shutting down the production well).

The response at sea was jointly organised by the Nigerian government (NDPR and NOSDRA) and by SNEPCo, which mobilised its own expertise and equipment but also those of its industry partners (gathered within the cooperative Clean Nigeria Associates) and the private companies it contracted.

For the response – which mainly involved chemical dispersion – aerial means were mobilised, equipped with onboard remote sensing systems (IR), to conduct aerial surveys and to guide vessels. We also note the use (with support from partner oil companies) of real time metocean data acquisition and satellite image analysis (1 to 2 per day) to monitor the pollution (surface area, location) and for input into numerical drift models. Meanwhile, the NGO Skytruth analysed Envisat ASAR (European Space Agency) images and announced 70 km long slicks, covering a surface area of 923 km<sup>2</sup>, 2 days after the incident.

The day after the incident, oil weathering modelling led SNEPCo to estimate that 50 % of the crude oil spilt had already dissipated, due to evaporation and natural dispersion of the oil. These results appear to match the surface observations, with the oil tending to spread out in a layer less than 10 µm thick, and rapidly breaking down. Four days after the incident, SNEPCo indicated that an estimated 1,590 m<sup>3</sup> of oil remained at the surface.

According to NOSDRA, 210 tonnes of dispersants (Corexit 9500 and 9527) were used in the response. By 25th December, the pollution at sea had dispersed (naturally and chemically) and, despite the slicks and sheen drifting towards the continent, no significant oiling of the shores had been reported at that time according to SNEPCo.

Oil was reported to have washed up on the shore on 26th December, but was believed to be from another source (ship) and completely independent of the incident according to SNEPCo. The operator agreed to take responsibility for shoreline clean-up operations – which are not detailed in our information sources – and also conducted fingerprinting on samples of this oil to compare it with the crude oil from the FPSO<sup>17</sup>. According to SNEPCo, satellite image analysis clearly showed trails of oil at sea, but at a distance which proved that it was not due to the leak from the *Sea Eagle*.

Production resumed on 1st January 2012, while NOSDRA conducted an impact assessment on the Akwa Ibom coastline, whose results have not, to the best of our knowledge, been widely

<sup>16</sup> Floating production, storage and offloading unit

<sup>17</sup> We are not aware of the results of these analyses.

disseminated. On 17th July 2012, the Nigerian authorities fined SNEPCo an equivalent of €4 billion for this spill. The oil company disputed the legitimacy of this fine, given the rapid response implemented and the low level of impact observed.

For further information: <http://www.shell.com.ng/aboutshell/media-centre/news-and-media-releases.html>

### Port pollution by tall oil from a chemical depot (Söderhamn, Sweden)

On 20th December 2011, a leak of crude tall oil (CTO) was discovered in an Arizona Chemical tank in the Longrör storage depot, in the Swedish port of Söderhamn. Approximately 800 m<sup>3</sup> of the substance was released, polluting the ground and part of it running into the waters off the depot port.

Containment operations were organised in 40 minutes after the leak was discovered, first by building a reinforced sand rampart, then the tank (9,000 m<sup>3</sup> before the spill occurred) was emptied, thus stopping the leak.

The Swedish Coast Guard, the local emergency services and the municipality jointly organised clean-up operations, with Arizona Chemical's own staff. Arizona Chemical announced the recovery of 130 m<sup>3</sup> of CTO, 2 days after the incident, then a total of 370 m<sup>3</sup> on 5th January (a fortnight after the incident) without providing any details of recovery operations.

## • Review of spills having occurred worldwide in 2011

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

#### • Volumes spilt

In 2011, Cedre recorded 39 spills involving volumes of over approximately 10 m<sup>3</sup>, for which sufficient information was available for statistical analysis. These spills occurred at a comparable rate offshore and inshore, and to a lesser extent (around 20%) in ports (Fig. 1). The total quantity of oil and HNS spilt during the year was just under 96,700 tonnes.

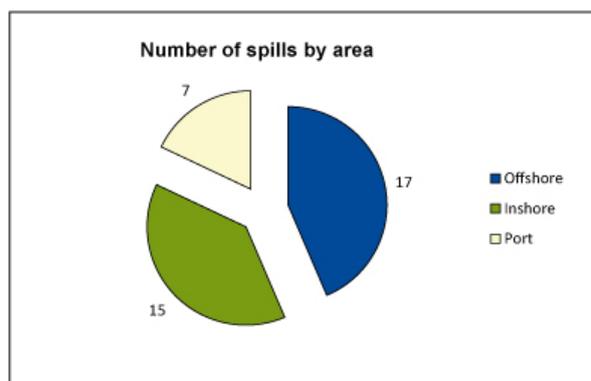


Figure 1

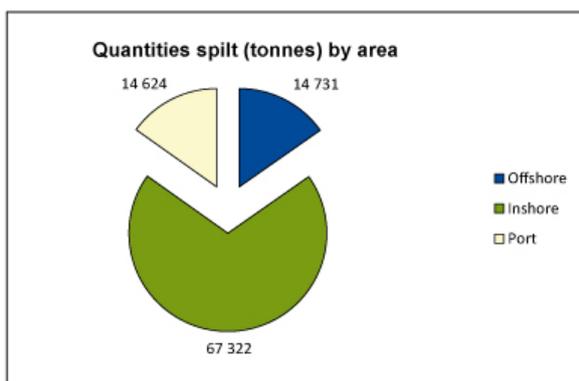


Figure 2

On the whole, this estimation is higher than those obtained using the same approach since 2004 (Fig. 3), with the exception of 2010, which was mainly dominated by the major spill due to the Deepwater Horizon accident (Cf. LTML n°29-30), for a similar number of events recorded (approximately 20 to 30, Cf. Fig. 3).

The spills in 2011 mainly occurred in inshore waters (Fig. 2), with much of the quantities spilt being due to vessels grounding, such as the *Godafoss*, *Oliva* (Cf. LTML n°33), *Rena* (Cf. above) and *Jui Hsing*<sup>18</sup>.

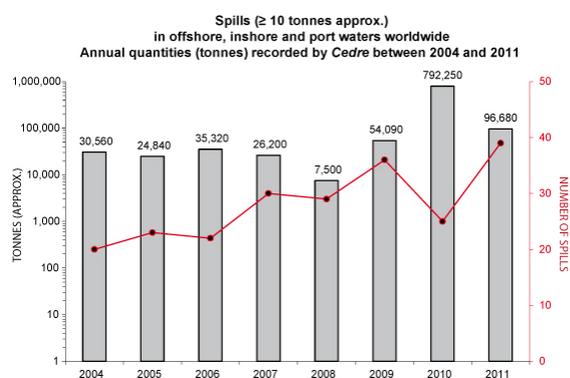


Figure 3

<sup>18</sup> Panama-registered ore carrier grounded on 3rd October, near the Taiwanese ports of Keelung and Taipei during Typhoon Nalgae. The structure broke in two, and the damaged bunker tanks released 300 m<sup>3</sup> of bunker fuel which rapidly polluted the

### • Spill locations



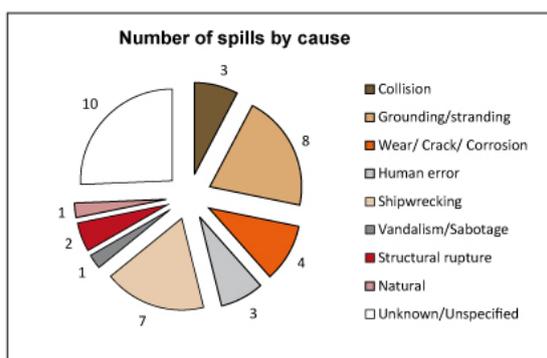
**Figure 4.** Location of oil and HNS spills (≥ approximately 10 tonnes) offshore and inshore in 2011 recorded by Cedre.

### • Spill causes

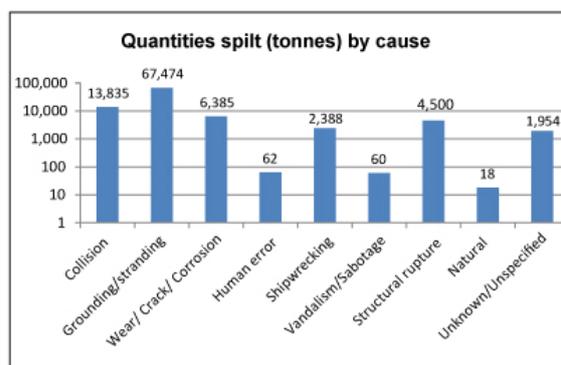
Analysis of the distribution of spills by cause shows a high frequency (26 %) of cases whose cause is **unknown or unspecified** (Fig. 5), half of which were related to offshore oil facilities. Although their contribution to the total volume was low (2%, Fig. 6), this lack of detail, in addition to the patchy nature of certain information on the volumes involved, should be kept in mind in the balance of this analysis.

The most frequently reported events were **vessel strandings and groundings**, representing 20 % of incidents (Fig. 5); they also constitute the main contribution (70 %) to the volume spilt in 2011 (Fig. 6). The most noteworthy of these incidents were those of the bulk carrier *Oliva* (Tristan da Cunha archipelago in March<sup>19</sup>) and the container ship *Rena* (Cf. **Spills** section).

With a comparable frequency, **shipwreckings** at sea caused around half a dozen oil or chemical (cargo) spills. Although apparently exceeding 10 tonnes, the size of the spills generated by these events was often unspecified and their low contribution to the overall volume (2 %, Fig. 6) is probably underestimated.



**Figure 5**



**Figure 6**

Incidents related to structural deficiencies (**wear, crack, corrosion**) represented 10 % of cases, and around 7 % of the annual volume spilt (Fig. 6). The largest of these events was the crack in an

nearby shores. Clean-up operations were implemented, supervised by the Environmental Protection Administration and the Department of Water Quality Protection, with support from the Chinese Coast Guard. Pumping was expected to be completed by 12th October and the removal of the wreck by spring 2012.

<sup>19</sup> Spill of over 60,000 tonnes of soya beans, 1,400 m<sup>3</sup> of IFO 320 and 70 m<sup>3</sup> of diesel, Cf. LTML n°33.

export line linked to the FPSO *Sea Eagle* (Cf. **Spills** section).

The other types of events identified were each responsible for less than 10 % of the significant incidents recorded in 2011. They generally represent minor contributions (< 100 tonnes) to the total annual quantity spilt, with the exception of **collisions** between ships which were responsible for 8 % of spills and, with a total volume of 14,000 tonnes, represented 14 % of the total quantity spilt – mainly due to the incident in April involving the grain carrier *Hyang Ro Bong* near the port of Chittadong (Bangladesh)<sup>20</sup>.

#### • Substances spilt

The most frequently spilt substances in 2011 were oil products, with the most frequent being **crude oil** (28 % of incidents during the year, Fig. 7), mainly from offshore facilities. In terms of volumes, they represented the highest contribution of oil products to the annual total, of which they made up 12 % (Fig. 8). With over 1,000 tonnes, the largest crude oil spills were those of Mumbai Uran Trunk Pipeline (India, Cf. LTML n°33) and the FPSO *Sea Eagle* (Cf. **Spills** section).

With a very slightly lower frequency (around ¼ of events), spills of **white oils** and **different IFOs** (intermediate to heavy) however involved lower combined volumes, with less than 600 and 2,500 tonnes respectively (i.e. around 1 and 2 % of the total volume). Mainly due to ships, these spills did not exceed a few hundred tonnes at most, with the exception of that caused by the sinking of the bulk carrier *Oliva* involving around 1,500 tonnes (Cf. LTML n°33).

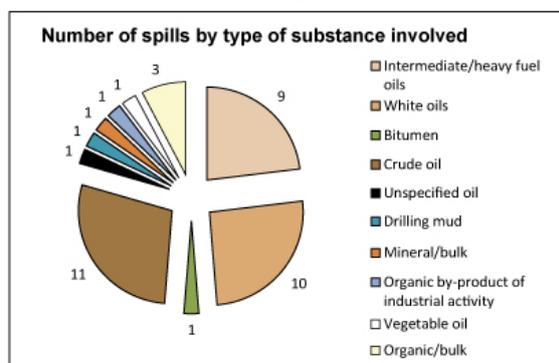


Figure 7

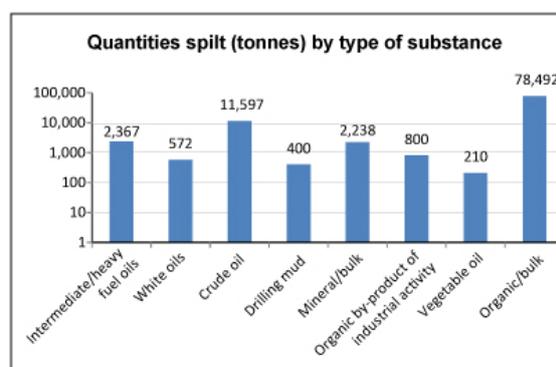


Figure 8

Spills of **bulk organic matter**, although only including 3 spills (i.e. 8 % of events, Fig. 7), represented the highest contribution (around 80 %) to the annual total (with almost 20,000 tonnes spilt, Fig. 8). These spills included the loss of tens of thousands of tonnes of food cargoes, in particular those of the *Hyang Ro Bong* (rice) and the *Oliva* (soya beans) (Cf. LTML n°33).

Spills involving other types of substances were one-off incidents, and the volumes involved were lower than 1,000 tonnes, with the exception of the loss of a mineral cargo at sea – over 2,000 tonnes of iron oxide due to the sinking of the *Union Neptune* in July in the Bay of Biscay, off the coast of Charente-Maritime (France). No significant spills of hazardous and noxious substances (HNS) were reported in 2011.

#### Ship-source oil spills in 2011: ITOPF statistics

The statistics provided by the International Tanker Owners Pollution Federation (ITOPF) on ship-source oil spills confirmed, again in 2011, the downward trend of major spills by ships observed from one decade to the next, in particular since the 1970s. Only one spill of over 700 tonnes and 4 intermediate spills (7-700 tonnes, according to ITOPF terminology) were recorded<sup>21</sup> in 2011, the lowest annual number of incidents observed by ITOPF. Similarly, the total volume of oil spilt by vessels is at an all-time low, totalling approximately 1,000 tonnes for the year – a negligible fraction, as highlighted by ITOPF, of the quantities of oil transported by sea.

For further information:

<http://www.itopf.com>

<sup>20</sup> Cf. LTML n°33

<sup>21</sup> Similar situation to that recorded by *Cedre*, whose incident database includes a single ship-source oil spill of over 700 tonnes for 2011.

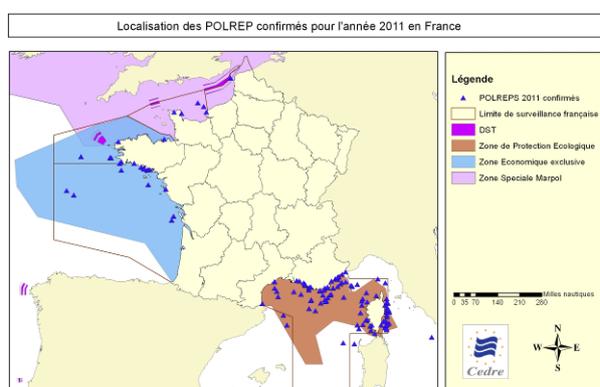
• **Summary of illegal discharges**

**Pollution reports: analysis of 2011 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). Through comparison of the 2011 results with previous data (2000-2010), certain trends can be identified 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 2011 data shows:

- a total of 141 confirmed POLREPs, confirming the downward trend described in previous years (163 in 2010, 397/year on average for the period 2000-2010<sup>22</sup>)
- the distribution of the majority of POLREPs off the Mediterranean coast, where 75 % of reports were made in 2011
- like previous years, oil was the most frequent category of pollutant with a confirmed presence in 58 % of POLREPs
- again in 2011, the origin of the discharge was only determined for 15 % of confirmed POLREPs.



Location of confirmed POLREPs in 2011 in France  
(Source: *Cedre*)

The analysis of the distribution of reports in French waters is consistent with previous years, in particular along the shipping routes in the Channel (Ushant and Casquets traffic separation schemes in particular) and the Mediterranean (Genoa-Barcelona, Genoa-Valencia and Genoa-Strait of Messina routes).

Despite the number of monthly POLREPs being lower than the average for the period 2000-2009, the spring (April) and summer (August) periods continue to show the highest number of POLREPs, with around 20 per month.

Of the 39 POLREPs (i) involving the confirmed presence of oil and (ii) for which information on both the surface area and the colour appearance code was available, the average surface area of slicks was estimated at approximately 3 km<sup>2</sup> (compared to 5.8 km<sup>2</sup> in 2010, and 5.4 km<sup>2</sup> on average during the previous decade) for an average discharge volume of between 1.6 and 11.5 m<sup>3</sup>, quite close to 2010.

For further information:

*Cedre* report R.12.20.C "Analyse et exploitation des POLREP reçus au *Cedre* pour l'année 2011".

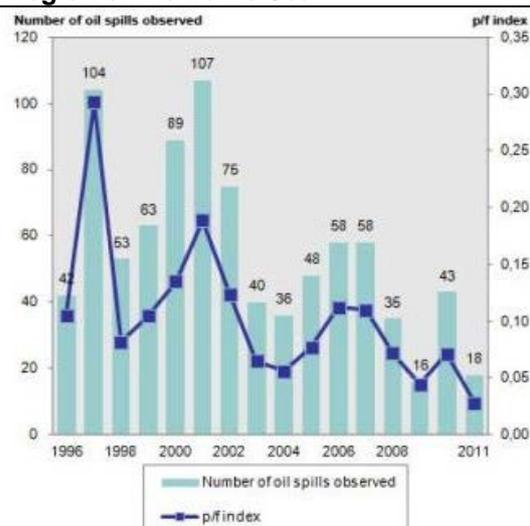
<sup>22</sup> excluding the *Erika*, *Tricolor* and *Prestige* spills.

### Drop in the number of oil discharges in the Finnish region of the Baltic Sea

The number of illegal oil discharges recorded by the Finnish authorities in the area of the Baltic Sea under their jurisdiction continued to drop in 2011, with 57 confirmed detections (out of 83 potential discharges), compared to 70 during the 2 previous years.

Twenty one cases were detected and confirmed by the Finnish Border Guard (FBG): 8 by helicopter and 13 by planes fitted with specialised sensing equipment. According to FBG, 2011 saw an increased number of overflights (645 flight hours) and the lowest value of detections recorded per flight hour (0.03), supporting the hypothesis of a lower annual number of discharges in the Northern Baltic Sea.

Meanwhile, the average volume of discharges significantly dropped in 2011 in the Finnish EEZ (30 litres compared to one to several hundred litres in previous years).



Number of oil discharges detected by Finnish aircraft (bar chart) and detection rate (line chart), between 1996 and 2011 (source: <http://www.helcom.fi>)

According to FBG, these results are satisfactory in that they suggest the efficiently dissuasive character of the national reinforcement of aerial surveillance, in conjunction with the European services such as the CleanSeaNet service by EMSA (European Maritime Safety Agency), and backed by preparedness, put into action – like in 2011 with SuperCEPCO Baltic 2011<sup>23</sup> – through transboundary exercises.

For further information:  
<http://www.helcom.fi/>

## • Response preparedness

### Sensitivity mapping: revision of an international guidance document

Under the auspices of IMO (OPRC-HNS Technical Group and Marine Environment Committee) and the IPIECA Oil Spill Working Group, in collaboration with the International Association of Oil & Gas Producers (OGP), 2011 saw the publication of a revised version of the guidance document on Sensitivity Mapping for Oil Spill Response. This manual focuses on sensitivity mapping and the contribution of sensitivity atlases in terms of optimising the response to a marine oil spill (i.e. by helping to reduce environmental impacts).

The document aims to underline the importance of sensitivity mapping, both in preparedness and in the operational phases of the response (e.g. strategic choices in terms of protection and/or clean-up, coordination, etc.). It provides a standardised, structured approach to developing oil spill sensitivity maps (reminder of criteria and methods of defining sensitivity indices etc.) and integrating them within oil spill contingency plans. It also indicates key elements to be included in each type of map to meet the needs expressed at the different levels of the command chain – from clean-up sites to command posts.

For further information:  
[http://www.iecea.org/sites/default/files/publications/Sensitivity\\_Mapping\\_1.pdf](http://www.iecea.org/sites/default/files/publications/Sensitivity_Mapping_1.pdf)

## • Response techniques and equipment

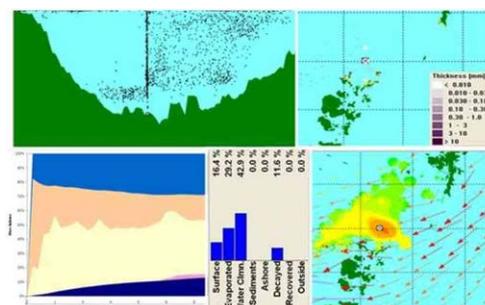
<sup>23</sup> Joint aerial surveillance exercise involving 5 countries bordering the Baltic Sea and 65 flight hours, resulting in the detection of 3 minor discharges (mineral oil and other substances).

### Subsea spill modelling

OSRL recently added subsea oil spill modelling to its range of services through the use of the numerical oil weathering model OSCAR (Oil Spill Contingency and Response Model), developed by the Norwegian institute SINTEF, coupled with 3D modelling of deep water blowouts by the SINTEF DeepBlow model.

For contingency planning or spill response purposes, the service offered aims to assess the different possible strategic options (dispersion, recovery, etc.) as well as providing a basis for analysing the net environment benefits of these options.

This initiative by OSRL is particularly geared towards deepwater offshore oil operators and clearly comes in the wake of the Deepwater Horizon spill in 2010.



For further information:

<http://www.oilspillresponse.com/services-landing/oil-spill-modelling>

[http://www.sintef.no/upload/Materialer\\_kjemi/Marin%20milj%C3%B8teknologi/faktaark/deepblow-web.pdf](http://www.sintef.no/upload/Materialer_kjemi/Marin%20milj%C3%B8teknologi/faktaark/deepblow-web.pdf)

### Containment system by an autonomous vehicle for use in ports

In preparation for emergency response to oil spills at its oil terminal, Copenhagen Malmö Port (Sweden) installed in late 2011 a remote-controlled Autonomous Surface Vessel (ASV), fitted with 2 turbines and designed to allow rapid containment of floating spills in port waters.

The vehicle, self-propelled by an electric engine (200 kg payload) and unmanned, is designed to be automatically launched in the event of a spill alert and to deploy a floating boom (light, permanent boom) by unrolling the boom from its storage reel and mooring itself to a pre-established port structure. The ASV can be radio-controlled live or its trajectories can be pre-programmed. The vehicle is guided by a GPS system.



*View of the ASV towing a permanent fence boom  
(Source: Copenhagen Malmö Port)*

According to Copenhagen Malmö Port (CMP), the oil terminal at Malmö Port can now be sealed off in 6 minutes in the event of a spill. This is the first installation of this ASV technology, developed in close collaboration by CMP with the Swedish firm SP Marine AB, in a major European port. Gothenburg, again in Sweden, could be next in line.

For further information:

<http://www.spmarine.se/>

## ● Conferences and seminars

### Thirty-fourth AMOP technical seminar (Canada)

The 34<sup>th</sup> edition of the Arctic Marine Oilspill Programme (AMOP) technical seminar – held in Banff, Canada, in 2011 – saw the participation of around 150 representatives, the majority of which were from North American federal bodies (Environment Canada, Transport Canada, Fisheries & Oceans/COOGER, Canadian Coast Guard and, for the US, the National Oceanic and Atmospheric Administration -NOAA, the United States Coast Guard -USCG, etc.) or regional bodies (in particular environment ministries of various Canadian provinces), alongside many consultancy firms etc., including for instance Spill Science, ASA, SL Ross Environmental Research and Polaris Applied Science (also speakers at the event). In terms of European representatives, we note the participation of scientific institutes (e.g. SINTEF) and expert organisations (e.g. ITOPF) as well as representatives of various research institutes (chemistry, biotechnology...) from the Black Sea region: Ukraine, Russia, Azerbaijan, Georgia, Moldavia. Cedre gave a presentation on the study of chemical behaviour at sea using in situ experimental resources (floating cells).

Alongside the conferences, a small number of spill response equipment manufacturers were present, in particular the manufacturers of the fireproof booms (Elastec/American Marine and Applied Fabric

Technologies, Inc.<sup>24</sup>, in particular) used the previous year in the Gulf of Mexico.

The conferences were divided into theme-based sessions, including a – now recurrent – session on "Remediation, Restoration and Rehabilitation of Chemical and Hazardous Material Spills", as part of the "CBRNE" (chemical, biological, radiological, nuclear and explosives) risk response. These conferences addressed the decontamination procedures for materials polluted by hazardous substances, in various specific cases and in particular:

- with a view to terrorist attack, for the treatment of sensitive equipment (electronic, optical, etc.) polluted by organophosphorus compounds (pesticides),
- pollution of construction materials (concrete, marble, aluminium, steel...) by various radioelements (Caesium and Cobalt, following a nuclear accident and/or terrorist attack),
- various clean-up techniques for soil or buildings polluted by organophosphorus pesticide.

A similar session on oil provided the opportunity for a presentation detailing the biodegradation potential of oil products by a bacterial strain recently isolated from contaminated soil and producing a biosurfactant<sup>25</sup>.

On the subject of **compensation for environmental damages**, a presentation<sup>26</sup> by Applied Science Associates (ASA) focused on the development of a numerical model integrating the calculation, according to the concept of Habitat Equivalent Analysis (HEA, from the NOAA Natural Resource Damage Assessment procedure), of the extent of measures required for compensation for environmental damages deemed to be caused by a spill in the marine environment (e.g. loss of biomass of a given species). The model is currently being adapted for various regions of the US (Atlantic and Gulf of Mexico) via the integration of their own characteristics in terms of populations. In short, this is an extension of an existing ASA model, with the input of locally available environmental data (in particular sensitivity maps) and with support from a calculation module in "\$ equivalents". The level of detail targeted in this model is quite high (e.g. integration of seasonal variability of a certain number of biological descriptors), apparently meeting a need expressed by the US BOEMRE<sup>27</sup> (within the framework of a spill risk and costs evaluation programme).

In terms of the **tracking and modelling of the fate of oil** spilt at sea, many conferences focused on the Deepwater Horizon spill, with in particular:

- the difficulties encountered in quantifying the surface pollution<sup>28</sup>, requiring a certain extrapolation of oil coverage areas, slick weathering and fragmentation, and often the current technical limitations in the assessment of their thickness.
- a presentation (Environmental Research for Decision, Inc.)<sup>29</sup> showing how the study of Lagrangian Coherent Structures (LCS) had been used to define sectors within which the oil slicks had a higher probability of persisting (assessment of the risk of slicks being affected by the loop current and exportation of the pollution to the NE Atlantic). This was a different approach to that of "classic" drift modelling, in that this tool can be used to establish the hydrological fronts in place (blocking structures, transport barriers...) and to produce probability maps of slick spread limits, according to local hydrology (another application possibility was mentioned, that of search and rescue operations).
- in the context of a **deepwater blowout** like that of DWH, a presentation (joint Genwest Systems/NOAA)<sup>30</sup> focusing on the modelling of potential kinetics and distance of oil upwellings according to droplet size. This tool, based on in situ measurements and local hydrological characteristics, integrates a numerical model for droplet formation (size categories) at the blowout. On this issue, a joint presentation by SINTEF and DFO<sup>31</sup> underlined the high sensitivity of oil blowout behaviour models in terms of oil droplet size as input data (unlike "classic" surface drift models). The comparison of the simulation results

<sup>24</sup> Or more exactly Desmi-AFTI, Inc., representative and distributor of DESMI RO-CLEAN products in North America and the Caribbean.

<sup>25</sup> **Bao M., Wang L., et Li Y., 2011.** Biodegradation of Crude Oil with Biosurfactant Production by Strain *Acinetobacter* sp. D3-2 Isolated from Oil-contaminated Soil

<sup>26</sup> **French McCay D., Reich D., Rowe J., Schroeder M., et Graham E., 2011.** Oil Spill Modeling Input to the Offshore Environmental Cost Model (OECM) for US-BOEMRE's Spill Risk and Costs Evaluations.

<sup>27</sup> Bureau of Ocean Energy Management, Regulation and Enforcement

<sup>28</sup> **Lehr B. and Simecek-Beatty D., 2011.** Calculating Surface Oil Volume during the Deepwater Horizon Spill.

<sup>29</sup> **Beegle-Krause C.J., 2011.** Exploiting Lagrangian Coherent Structures (LCS) for the Calculation of Oil Spill and Search-and-Rescue Drift Patterns in the Ocean.

<sup>30</sup> **Beegle-Krause C.J., 2011.** Deepwater Horizon MC 252: Understanding the spill below the surface.

<sup>31</sup> **Niu H., Li Z., and Lee K., 2011.** Sensitivity of a Deepwater Blowout Model to Oil Droplet Size Distribution.

(SINTEF DeepBlow model) obtained with different oil droplet distribution hypotheses (e.g. with/without chemical dispersion – from OHMSETT experimental data) showed a high degree of variability in predictions in terms of (i) surface upwellings (and the formation of floating slicks) and (ii) the adsorption potential of small droplets onto matter in suspension (further slowing the upwelling of the smallest droplets, or even causing them to stay at depths at which the advection potential is lower – increasing currents from the bottom to the surface). From an operational point of view, the potential influence of dispersant application (case of DWH, with subsea injection) on these phenomena was highlighted during discussions.

- a presentation by NOAA<sup>32</sup> outlining the limits and benefits of having used, from the very onset of the DWH spill, a Monte Carlo **statistical approach** to assess the fate of the oil based on the hypothesis of an uncontrollable long term spill. In the absence of sufficiently reliable weather forecasts to produce simulations beyond a few days, NOAA sought to determine the probability of oil being washed up on the coast from the results of some 500 activations of a numerical model, the Trajectory Analysis Planner, using historical climate series provided by BOEMRE as input data. The results of this approach indicated, in relative compliance with observations, the coastal areas with the highest probabilities of oiling, as well as the low probabilities of transfer to the loop current or of oil reaching the Western shores of the Gulf of Mexico. However, the limits of this approach were also discussed, focusing on the difficulty (if not impossibility) of communicating the summarised outputs (oiling probability distribution maps) to the public, let alone journalists, during the crisis. These maps can indeed be incorrectly and alarmingly interpreted, due in particular to the fact that the high probability of an event does not necessarily mean that it will occur, as well as due to the relative uncertainty of predictions in shallow coastal waters.

In terms of **slick tracking using surface drifter buoys**, an overview was presented<sup>33</sup> on the tests conducted between 1977 and 2006 (Canada, Norway, UK, US...), covering in total an in situ evaluation of over 30 types of buoys. In short, the majority of the models identified showed, often major, deviations in relation to the slicks, with the exception of Orion buoys (first tested in 1977) and Novatech buoys (first tested in 1981). Among the other points raised, we note the apparent benefit of oily Cedar chips as oil substitutes, as they are able to simulate the behaviour of oil in a satisfactory manner. From a methodological point of view, the most revealing results on the efficiency of these systems were obtained in combined wind and current vector conditions.

In addition to the themes addressed each year, a full day of "Speaker's Corner"<sup>34</sup> was devoted to **shoreline response following the DWH spill**, mainly involving presentations by Polaris Applied Sciences (sandy beaches) and Research Planning Inc. (marshland). In terms of the organisation and unusual aspects related to the scale of this event, we note:

- that, during the first weeks of the spill, the general organisational model of the Incident Command System, although complete, contained only few elements on the shoreline response structure. Its integration and coordination within the ICS would have required the persistent – and heeded – effort of the experts contracted by BP for shoreline response.
- the relatively low scale of shoreline oiling, spread across 4 States, but mainly sporadic and in small quantities, with a frequent problem of burying. This required the adaptation of oiling classification criteria (Heavy, Moderate, Light), which for DWH represented deposits approximately 3 times lower than usual (it is therefore important to be aware of the use of this terminology when comparing DWH to other historical incidents, such as *Exxon Valdez* for instance).
- the integration, not new but to an unprecedented extent, of expertise in terms of archaeological, historical and cultural heritage (Section 106 of the NHPA) and parts of the environment subject to regulatory provisions (section 7 of the ESA) in the validation of site treatment recommendations (made according to the traditional SCAT<sup>35</sup> procedure).
- the creation, in such a situation (length of coastline potentially at risk, number and range of

<sup>32</sup> **Barker C.H., 2011.** An Early Long Term Outlook for the Deepwater Horizon Oil Spill.

<sup>33</sup> **Fingas M., 2011.** Buoys and Devices for Oil Spill Tracking.

<sup>34</sup> (not available in conference proceedings)

<sup>35</sup> Shoreline Cleanup Assessment Technique.

clean-up sites, of personnel...), of SCAT/ops Liaison Groups to check the compliance of operations at clean-up sites with the recommendations made by ICPs. This provision was appreciated, or even considered indispensable given the scale of the incident.

- that generally, according to North American operational staff, the SCAT procedure was reinforced through its developments to an unprecedented scale in this incident, involving high, ongoing observation pressure.

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