FRENCH SEA TRIALS ON CHEMICAL DISPERSION: DEPOL 04 & 05

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Abstract[*]. In 2004 and 2005, Cedre organized sea trials off the coast of Brittany with the French Navy and in collaboration with the French Customs. While the 2004 trials were large experiments looking for global assessment of the technique of dispersion, the 2005 sea trials were small scale sea trials focused on the efficiency of the dispersant product itself. The 2004 sea trials, DEPOL 04, involved three controlled oil discharges which were treated with two chemical dispersants using aerial spraying equipment, (Cessna equipped with a spraying POD) and shipborne spraying equipment. The slicks' evolution was monitored with remote sensing techniques, sampled for analysis and measured *in-situ* with spectrofluorometry. The objectives of these sea trials were:

- To study the natural weathering of the slicks
- To assess the chemical dispersion of the slicks
- To assess the operational possibilities of the spraying systems
- To run the annual *Bonnex* intercalibration exercise of the remote sensing means of the Bonn Agreement members
- To test new remote sensing devices under development
- To test roughly an oil recovery device purchased recently by the French Navy, (Sweeping Arm), to equip its spill control vessels.

The 2005 sea trials, DEPOL 05, aimed to establish an at sea testing procedure on small oil slicks to assess the real efficiency of dispersants versus different oil types. This paper presents these sea trials and their results considering mainly the chemical dispersion. For DEPOL 04, the dispersant treatment gave positive results despite the very calm meteorological conditions:

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- Although the first slick was not totally treated with dispersant, most of the oil was dispersed.
- The comparison of the last two slicks' evolution tends to show either a significant advantage of the aerial treatment over the ship-borne one, or a higher efficiency of one dispersant over the other one.

For DEPOL 05, an operational incident forced the planned testing program to stop prematurely, but the proposed procedure proved to be promising: such a testing method will allow the running of an important number of comparative tests while working with controlled application conditions especially the dispersant-oil-ratio.

Keywords: dispersants, oil spill response, spraying, remote sensing

1. Introduction

In 2004 and 2005, CEDRE organized sea trials off the coast of Brittany with the French Navy and in collaboration with the French Customs.

While the 2004 trials were large experiments looking for global assessment of the technique of dispersion, the 2005 sea trials were small scale sea trials focused on the efficiency of the dispersant products.

The 2004 sea trials, DEPOL 04, involved three controlled oil discharges which were treated with two chemical dispersants using aerial spraying equipment, (Cessna equipped with a spaying POD) and ship borne spraying equipment. The slicks' evolution was monitored with remote sensing techniques, sampled for analysis and measured *in situ* with spectrofluorometry.

DEPOL 04 sea trials covered the following main objectives:

- Assessment of the chemical dispersion of the slicks, when treated with an aerial application system, the Cessna-POD, and with a ship-borne application system.
- Study of the weathering of paraffinic and asphaltenic oils.

These sea trials gave the opportunity to carry out additional tasks:

- The BONNEX exercise, intercalibration of the aerial remote sensing equipment of the Bonn Agreement members, (Sweden, Belgium, United Kingdom and France participated in this exercise).

- The testing of new oil detection devices under development, DETECSUIV (ACTIMAR French company), LIDAR (NMRI, Japan).
- Finally, the French Navy tested at sea its new recovery device, the sweeping arm which equips its supply vessels.

DEPOL 05 sea trials, aimed at setting a procedure to conduct comparative and well controlled tests in open sea, on small oil slicks, on different oils and dispersants, in order to assess the real efficiency of dispersants versus different oil types. The testing procedure was designed to obtain a good control of the oil and dispersant application conditions, especially the dispersant-oil-ratio.

These experiments have been carried out with the additional co-operation of TOTAL S.A. which supplied the oil and the dispersant, OSRL which owns the Cessna POD dispersant application system, and SINTEF (Norway) and MUMM (Belgium) for scientific support.

2. DEPOL 04 General Organization

2.1. GENERAL PROGRAMME

DEPOL 04 sea trials lasted over three days:

- First day: release of 10 m^3 of a paraffinic oil, slick A, which was left to weather for ~6 h and was treated with aerial application of dispersant.
- Second day: release of two 10 m^3 slicks of asphaltenic oil, slicks B and C, which were left to weather for 7 h; the slicks were then treated with dispersant either by aerial application or by shipborne application.
- The third day was devoted to the recovery of the residual oil.

2.2. ANALYSES, MEASUREMENTS AND DATA COLLECTION

Different data collections were performed during these sea trials:

1. Oil sampling of the slicks was carried out with rubber boats, in order to measure, in the onboard laboratory, the physical properties

of the oil (viscosity, density, emulsification) (Guyomarch *et al.*, 2001, 2002).

2. Spectrofluorometry measurements were conducted with rubber boats in order to assess the dispersed oil content in the water column.
3. Aerial imagery was carried out by the six remote sensing aircrafts, and two additional ones, flying over the slicks: visible, IR and UV, and laser fluorometry sensors were used and sometimes combined together.

As a general comment, it was quite difficult to carry out oil sampling on the slicks; the long distance between the slicks and the support vessel, as well as the operational restrictions due to the take off and landing of the helicopter on the support vessel, led to limitations for bringing back on board as many samples as expected.

In addition to that, the spectrofluorometry measurements did not give all expected information on the dispersed oil concentration in the water column; the operators faced different problems such as pollution of the measuring cell of the equipment which led to false measurements, bogging down of the internal memory of the equipment which did not allow downloading the recorded data.

The collection of oil samples as well as the measurements at sea met with difficulties due to logistical and technical problems. Thankfully, the 8 aircraft which flew over the slicks collected a large amount of images which contributed to interpreting the behaviour of the slicks and the dispersion process.

3. Description of the Tests

3.1. METEOROLOGICAL SEA CONDITIONS

During the three days, the meteorological conditions were quite calm especially on the second day (see Table 1).

3.2. "SLICK A"

3.2.1. *The Oil*

The oil was a mixture of fresh crude oils, especially North sea crude oils, chosen in order to get a significant proportion of paraffinic compounds. It was pre-weathered in CEDRE by evaporating 11% of its volume.

TABLE 1. Meteorological conditions during sea trials DEPOL 04.

	Wind (m/s)	Average (m/s)	Sea temperature
05–25th- morning	0 to 1	0.5	
05–25th- afternoon	1 to 3	1.7	15°C
05–25th to 26th- night	3 to 2	2.6	
05–26th- morning	2 to 1	1.3	
05–26th- afternoon	1 to 0	0.3	
05–26th to 27th- night	0 to 2	0.5	
05–27th- morning	0	0	

The properties and composition of this pre-weathered oil are given in Table 2; the saturate fraction of the oil is the majority. A representation of the GC pattern of the initial oil is given in Figure 1 and shows the evaporation process which affected the linear alkanes up to C16.

TABLE 2. Properties of the oil in slick A.

Density		0.843 @ 14°C
Viscosity		7 mPa.s @14°C
Composition	Saturates	68.7%
	Aromatics	25.8%
	Resins	4.6%
	Asphaltenes	0.9%

3.2.2. *Description of the Operation*

In the morning, the 10 m^3 of oil were released crosswind for around 500 m. The dispersant application was performed around 6 h after the oil release, by the airplane Cessna of OSRL, equipped with a POD dispersant application device and guided by the UK spotting aircraft.

According to the airplane crew, five spraying runs were performed, and 1 m^3 of Finasol OSR62 dispersant was applied on the slick. By the end of the day, (8 h after the oil release) a complementary treatment was undertaken by the French Navy vessel Lynx with Gamlen OD 4000 to get rid of the residual surface oil. As some remaining oil was observed on sea surface two days after the oil was released, the residual patches were recovered by the oil spill recovery vessel Alcyon equipped with a sweeping arm and 1 m^3 of emulsion was collected.

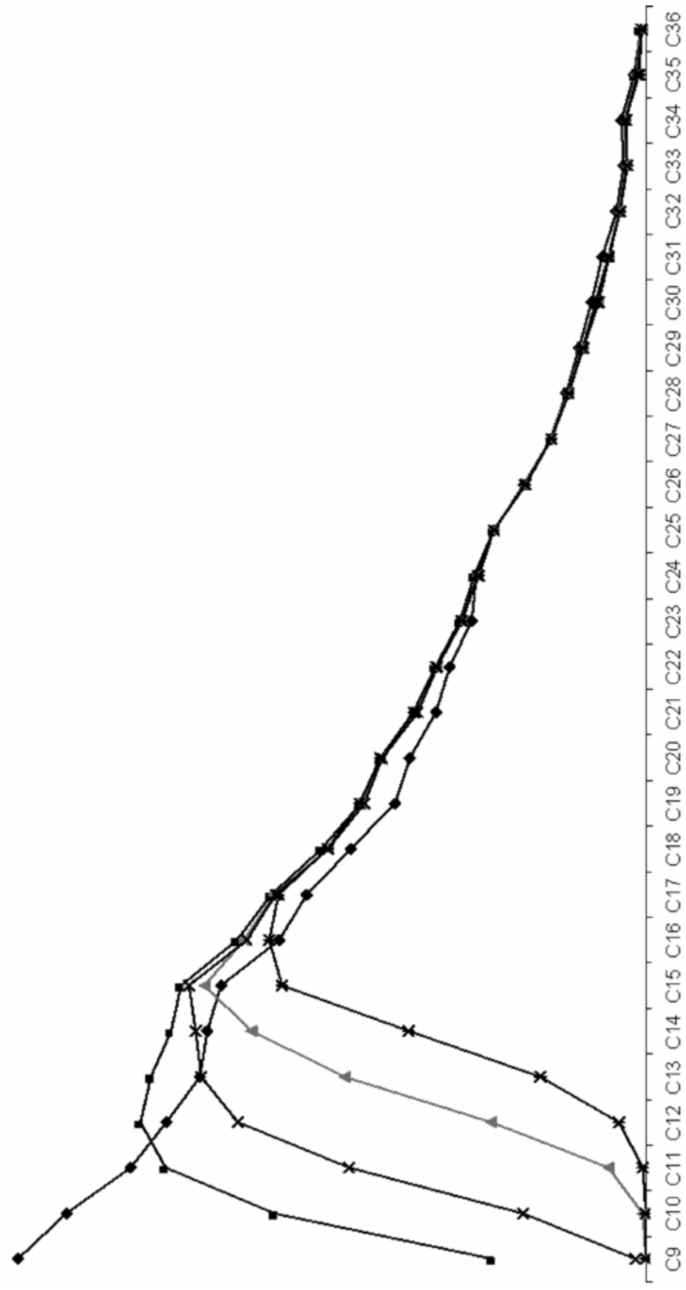


Figure 1. n-Alkanes distribution of slick A oil, at the time of the release and 1, 4, 7 and 45 hours after (all the GC are normalised on C25).

Figure 2 gives IR thermographies from the French Customs describing the evolution of slick A, after release, after dispersant application and one day later, respectively.

3.2.3. *Oil Behaviour*

One hour after the release, the oil viscosity reached 3,400 mPa.s and the water content of the oil was found to be around 80%; the emulsion stability increased progressively: at the beginning, 75% of the water settled after 2 h, just before treatment 20% settled after 2 h. Small lumps of emulsion (see Figure 3) gathered to form the thick part of the slick were reported by observers, which can be interpreted as the crystallisation of the paraffinic compounds.

At the time of the treatment the area of the slick was about 100–120 ha (3 × 0.4 Km). After treatment the viscosity dropped to 1,000 mPa.s, but the emulsion water content remained relatively high, around 66%; however, its stability decreased significantly: 40% water settled after 2 h. Observers who sampled the slick reported a clear reduction in the number of emulsified lumps; the residual patches tended to break up when subjected to some agitation (e.g., a ship bow wave). Two days post oil release, (T = 47 h), the remaining emulsion pre-sented water content of 59% (Figures 4 and 5).

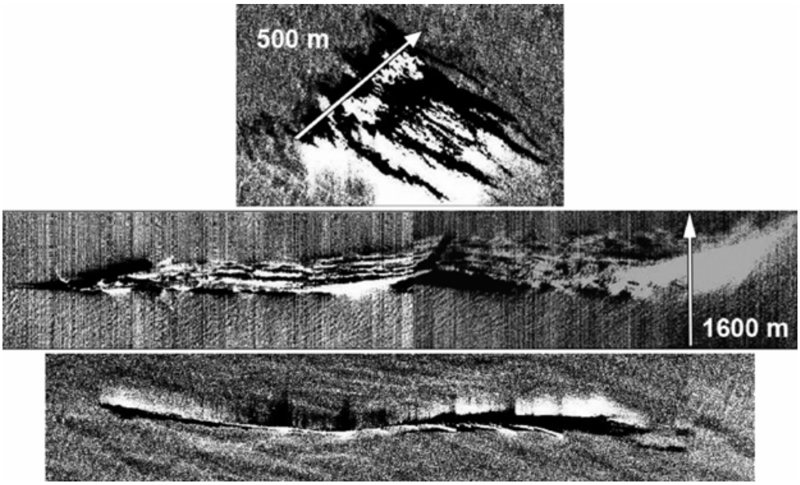


Figure 2. IR thermographies of slick A after release, after dispersant treatment and one day later.

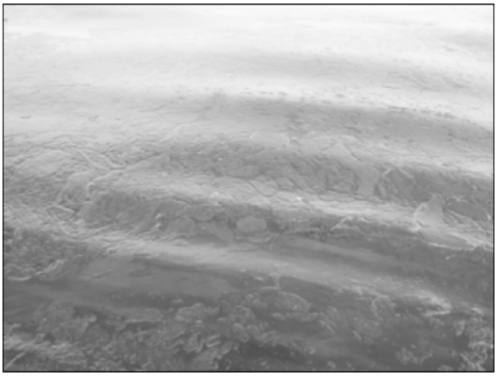


Figure 3. Appearance of the emulsion before treatment.

Figures 4 and 5. (4) Recovery of the remaining emulsion from slick A with the sweeping arm in very calm seas two days after release. *(5)* Aspect of the emulsion.

3.2.4. *Dispersant Application*

On aerial images the tracks of only four runs are clearly visible (1,900–3,040 m long and ~40 m width); the treated surface can be assessed to 38 ha, which represents between 30% and 40% of the total surface of the slick (see Figure 7).

The treatment led to the clear reduction of the area of the thickest part of the slick (which dropped from 6% to 3% of the total surface of the slick). Figure 6 shows a stripe of remaining emulsion after the treatment. In the area of the slick, the relative oil concentrations in the water column measured with Spectrofluorometry doubled after the dispersant application.

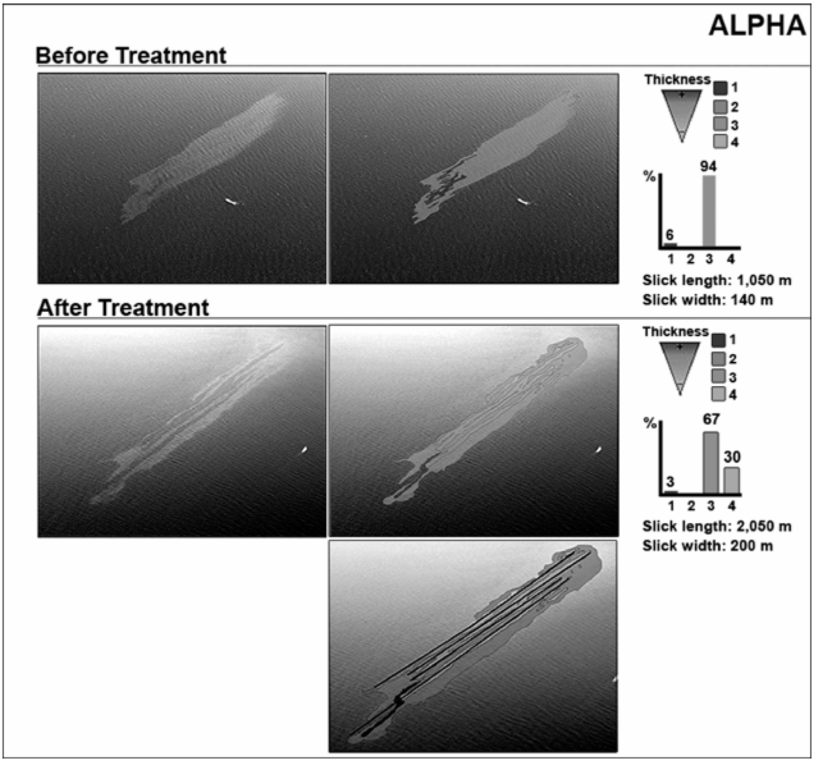


Figure 6. Visible picture of slick A before and after dispersant treatment: on the left – aerial photography; on the right – the original pictures have been processed to assess the relative areas covered by the different oil thickness (black emulsion to sheen) – see the histogram; the four treatment runs are indicated in the bottom picture.

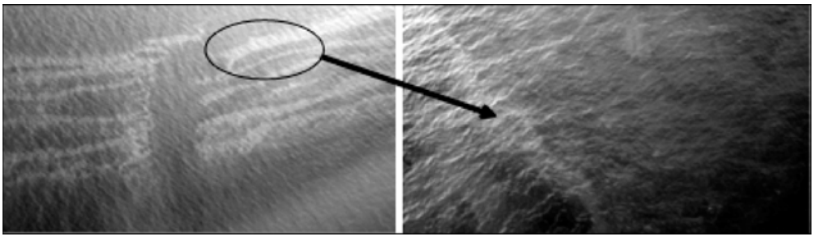


Figure 7. Appearance of the slick after treatment with some untreated stripes of emulsified oil.

3.2.5. *Discussion*

Despite the fact that the dispersant treatment of this slick was carried out under optimal conditions (good visibility, slick well targeted, assistance of the UK spotting aircraft for guiding, well trained crews), the slick was not totally treated (roughly half of the slick remained untreated as well as half of the thickest part – see Figure 7). The remaining emulsion recovered two days later could probably be attri-buted to the emulsion left untreated. These observations confirm that there are still possibilities for improving the operational procedures for dispersant application in order to apply the dispersant more evenly over the whole slick; thus, avoiding untreated areas. Surprisingly, the width of the treated tracks (30–40 m) is much larger than what could be expected from the spraying equipment Cessna-POD (8 m according to the crew, possibly up to 10–15 m), which proves that the dispersant had some herding effect on the oil slick.

Despite the lack of natural agitation, the chemical dispersion with the Finasol OSR62 gave a positive result: it succeeded in reducing the amount of surface oil; the cubic metre of residual emulsion recovered after two days (1 m^3 which represented around 0.6 m^3 of pure oil) should be compared to the 10 m^3 of oil initially released which would have become about 30 m^3 of emulsion.

3.3. SLICKS B AND C

3.3.1. *The Oil*

The oil used for slicks B and C was asphaltenic; it was a mixture of Heavy Fuel Oil (60%) and Light Cycle Oil (40%). These two products were mixed in CEDRE facilities to get a homogeneous mixture with the following properties: density of 0.948 and 4.9% of asphaltenes. Preparatory work carried out in laboratory showed that this oil could give, at sea, an emulsion up to 80% water with 5,900 cSt viscosity; such characteristics would have been suitable to test the operational efficiency of dispersion.

3.3.2. *Description of the Operations*

For each slick, 9 m^3 of oil were released early in the morning, crosswind, over approximately 600 m in length. Slick B was marked out with a dye spot of rhodamine (red) and slick C released half an hour later was marked out with fluoresceine (green). The surface oil was sampled between 1 and 3 h after the release, then again from 5 to 7 h after release. The dispersant was then applied by the Cessna-POD on slick B and by the ship Lynx on slick C. After the dispersant application, ships were sent cruising at high speed on each slick to bring some mixing energy in order to enhance the dispersion process (Alcyon on slick B and Lynx on slick C). After an additional sampling session (T = 8.5 h), and an aerial evaluation (T = 10 h), a complementary dispersant application was undertaken to treat the residual oil. As previously, this complementary treatment was carried out by the Cessna POD on slick B and the ship Lynx on slick C; the dispersion application was followed with mixing provided by ships cruising in the slick.

3.3.3. *Oil Behaviour*

The weather was very calm and the sea quite flat (wind speed ~1 m/s dropping to 0 during the afternoon); therefore, and unexpectedly, no real emulsification (formation of water in oil emulsion) was observed; sample water content was between 1% and 5% for slick B and in the range of 0–3% for slick C (Figure 8). On both slicks the surface oil sampling became almost impossible due to the rapid spreading of the oil on a large area combined with the lack of emulsification which resulted in very low thicknesses; therefore, for the following sampling sessions it was too difficult for the dinghies to collect enough oil to get a significant sample.

3.3.4. *Dispersant Application*

The objective of this trial was to compare the different application methods, (airborne and shipborne application) with mixing energy brought by ships cruising in the slicks to take into account the calm calm sea conditions; however, while the Cessna POD used Finasol OSR 62 on slick B, the ship on slick C had to apply another dispersant, Gamlen OD 4000, due to an unexpected technical glitch which would not allow a proper connection to spraying equipment on the special additional tank rigged on the deck containing the FINALSOL OSR62. Despite these difficulties, observations from aerial images of the slicks gave some interesting information.

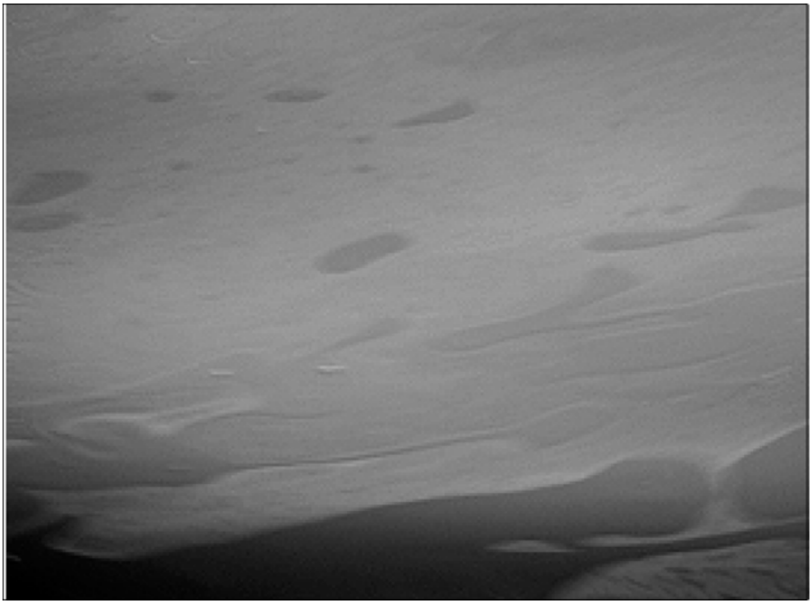


Figure 8. Appearance of the oil of slick C 2 h after release: the sea is very calm and there has been no formation of emulsion.

Figure 9 shows the slick B before and after the dispersant application; the relative areas of different colours (therefore different thicknesses) have been assessed. It can be observed that the dispersion was partial and some thick parts of the slick remained on the sea surface. Nonetheless, looking upwind these thick parts some orange colour can be seen which brings evidence that some dispersion occurred despite the very calm sea conditions. More, the evolution of the relative areas of different thicknesses (see the histograms on the right) shows a relative reduction of the thickest parts for the benefit of the thinnest parts.

Slick C was treated by the ship Lynx for 1 h and 10 min. The dispersant was applied neat with adjustable flow rate spraying equipment from the French Navy; this equipment is composed of 3 spraying assemblies, which can be operated alone or simultaneously to get different flow rates (between 10 and 90 L/min). According to the speed of the ship, the treatment rate can be adapted to the amount of oil to be treated (e.g., at 8 kt, from 20 to 150 L/ha). For the treatment, the Lynx cruised at 10 kt, decreasing to 8 kt at the end to treat the thickest part of the slick. Figure 10 shows slick C before and after the dispersant application. Similarly to slick B, a partial dispersion can be observed, with thick oil patches remaining on the sea surface but also a relative reduction of the thickest parts for the benefit of the thinnest ones. Figure 11, which is an image from Actimar of slick C, confirms that dispersion has been partial: some dispersed oil (yellow to pink plume), the track of remaining thick oil (red) and the ship administering treatment at the bottom of the picture can be seen.

A comparison between the two slicks B and C after treatment can be done on the aerial imagery (IR/UV) taken by the French Customs – see Figure 12; assessment of the IR picture shows a higher reduction of the thickest part of slick B than for slick C: slick B, thick area (white) 11 ha, medium thickness area (black) 8 ha. – slick C; thick area (white) 29 ha, medium thickness area (black) 55 ha. This observation is quite surprising because, with very calm weather, the shipborne treatment which brings extra mixing energy with the ship bow wave should have been more efficient; (such an observation had been made

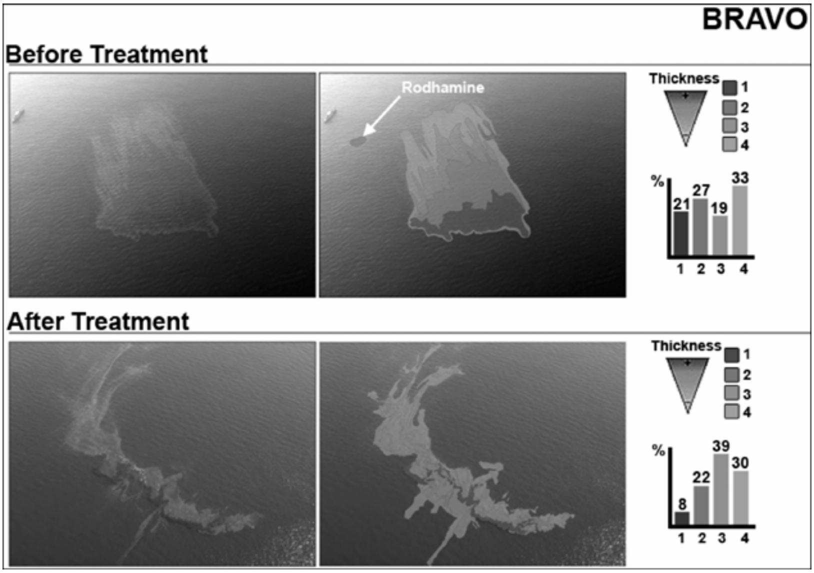
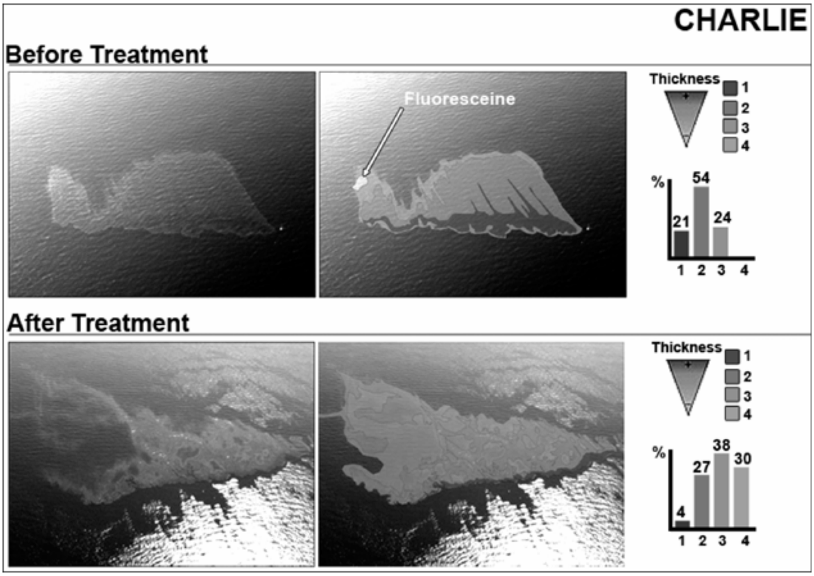


Figure 9. Aerial pictures visible spectrum, of slick B before and after dispersant treatment: left – aerial photography; right – the original pictures have been processed to assess the relative areas covered by the different oil thicknesses (red emulsion to sheen) – see the histogram.



[illegible] Aerial pictures visible spectrum, of slick C before and after dispersant treatment: left – aerial photography; right – the original pictures have been processed in order to assess the relative areas covered by the different oil thickness (red emulsion to sheen) – see the histogram.

during Protecmar 6 sea trials in 1986 (Bocard *et al.*, 1987): comparison of treatment in very calm weather with a ship and an helicopter). Therefore, the difference observed between slick C and B can likely be attributed to the dispersant used, the Finasol OSR 62 used on slick B seems to be more efficient than Gamlen OD 4000 used on slick C. This is reflective of the laboratory efficiency tests carried out prior to the experiment with the IFP dilution test: the FINASOL OSR 62 gave a slightly better efficiency (E = 80) than the Gamlen OD 4000 (E = 74).

Another possible explanation for this difference could be the targeting of the slick: the Cessna POD had been continuously and directly guided by the spotting British aircraft during the treatment while the ship was guided by a few smoke canisters launched by the French Navy helicopter to mark out the thickest parts (see Figure 13). In this respect, slick B may have received better treatment than slick C.

Traces of these slicks were detected the following day: this oil was spread out as a very thin layer which tended to break out and self disperse when subjected to some agitation; these traces were no longer

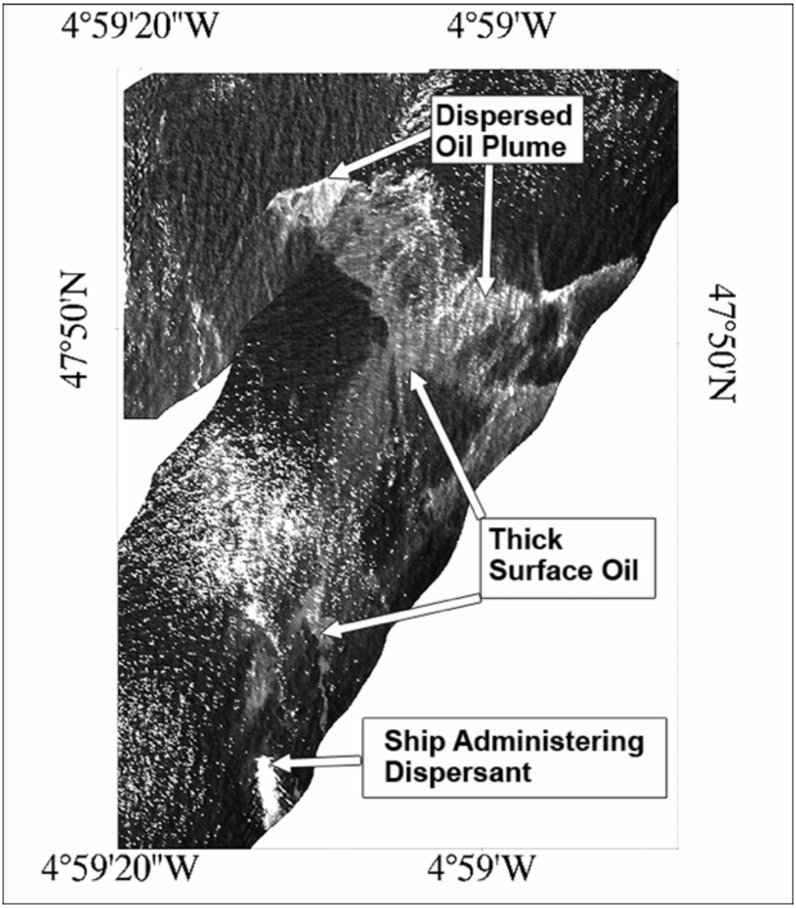


Figure 11. Aerial imagery of slick C during the treatment; we can see surface oil, plume of dispersed oil and the ship administering dispersant (Actimar).

detectable on the third day. Despite the fact that the dispersion process had obviously been limited due to the absence of natural agitation, the dispersion of the slick did occur with time.

4. Depol 04 General Conclusions

The Depol 04 sea trials organized in May 2004 off the coast of Brittany by CEDRE, the French Navy and French Customs, were designed to study the natural weathering of paraffinic and asphaltenic oils and to

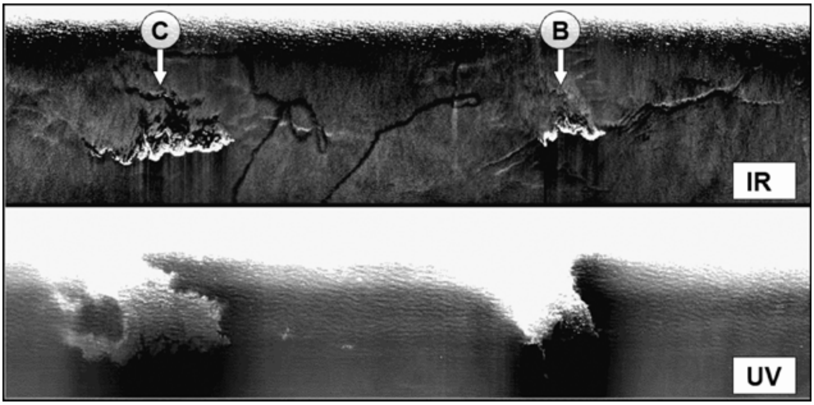


Figure 12. Comparison of slicks B and C on IR and UV imagery.

Figure 13. Treatment by the ship guided with smoke canisters and by the Cessna POD.

assess the efficiency of dispersant treatments. Aircraft Cessna POD spraying equipment from OSRL and shipborne spraying equipment from the French Navy were used to apply Finasol OSR52 and Gamlen OD 4000 dispersants, respectively. In addition, Depol 04 presented an opportunity to run the annual *Bonnex* intercalibration exercise of the remote sensing capabilities of the Bonn Agreement members and to test new remote sensing devices developed by Actimar and NMRI.

The meteorological conditions during these sea trials remained very calm (sea state mainly between 0 and 2) and was not very suitable for the dispersion process due to the lack of natural mixing energy. Nonetheless, on the first slick (paraffinic oil) significant dispersion occurred and led to a large reduction of the residual surface oil: after two days, the weathered oil emulsion recovered at the sea surface represented only 1 m^3 while 10 m^3 of pure oil had originally been released.

Despite the guidance on the slick provided by the UK spotter aircraft, the dispersant treatment carried out by the Cessna POD system did not succeed in covering the entire slick area; particularly, some of the thickest areas were not treated. This observation demonstrates the need to improve the procedures for guiding treatment vessels and subsequently optimizing the effectiveness of dispersant in the areas being treated.

The last two slicks (asphaltenic oils) were treated by the Cessna POD with Finasol OSR 62 and by shipborne adjustable spraying equipment for neat dispersants with Gamlen OD 4000, respectively. A short time after dispersant application, the aerial imagery of the treated slicks showed that some dispersion had occurred in both slicks despite the very calm weather (sea state 0–1); however, although partial, the dispersion of the slick treated by the Cessna POD appeared to be better than that of the slick treated by the ship. This observation indicates that the dispersant Finasol OSR 62 was more efficient than Gamlen OD 4000 and/or that the Cessna POD guided by the UK spotter aircraft targeted the slick better than the ship which was guided by smoke canisters launched by a helicopter on the thickest areas of the slick.

Both observations militate in favour of improving the operational procedures. During the last two decades dispersant formulations and spraying devices have been studied and improved, with the result that dispersion procedures are now the major limiting factor.

5. Depol 05 Presentation

Depol 05 was a sea trial specifically devoted to assess at sea, the intrinsic efficiency of dispersants on viscous oil.

5.1. BACKGROUND

In 2003 OSRL, MCA and ITOPF joined in an effort to run sea trials devoted to assessing the dispersibility of viscous oils according their viscosity, the dispersant and the dispersant to oil ratio (DOR: 1/25, 1/50, 1/10). The trial consisted in spilling very small slicks (a few tens litres) of fuel oils IFO 180 and 380, which were subsequently treated with dispersant and visually assessed for dispersion efficiency by a panel of six experts according to four criteria:

0 = No dispersion
1 = Slow or partial dispersion
2 = Moderately rapid dispersion
3 = Very rapid and total dispersion

The oil was released and treated from a barge cruising at low speed, the experts were in a small boat looking carefully at the slick and noting their observations at 2, 5 and 10 min after the treatment.

Twenty-six tests were run over several days and their results led to interesting conclusions: while IFO 180 was easily dispersed, the dispersion of IFO380 was much more difficult; however, if IFO380 dispersibility was low, it was increasing with the dosage of dispersant. The remaining question was: what would occur with a higher dispersant dosage? Moreover, for each test the observations lasted only 10 min; another remaining question was: would dispersion occur over a longer period of time? In addition, due to the experimental design (i.e., spraying equipment) the dispersant dosage was poorly controlled, as a large portion of the dispersant was applied onto the water surface aside the oil and did not have sufficient time to spread across the slick.

Figure 14. UK sea trials; oil and dispersant applications from the barge, and the observers' boat.

5.2. DEPOL 05 OBJECTIVES AND PRINCIPLES

The Depol 05 experiment was designed to pursue and improve the work initiated in the UK. The objective was to see if viscous oils were amenable dispersal with higher dispersant dosage; the experimental plan considered four oil viscosities (2,000, 5,000, 8,000 and 10,000 cSt), four dispersant dosages (0%, 5%, 10% and 15%) and three dispersants. The principle of the experiment was quite similar to what had been done in the UK with the following improvements.

5.2.1. *Observation Criteria*

To get a better observation of dispersion, observers were requested to specify what they observed according to the following four criteria:

- Observation of a plume of dispersed oil
- Observation of oil resurfacing
- Observation of a spreading effect on the oil
- Observation of a white cloud indicating some dispersant being diluted directly in the sea.

5.2.2. *Oil Release and Dispersant Application Equipment*

A floating open corridor built with two parallel booms held at both ends by frames, was towed aside a ship cruising at slow speed. The oil was spilled from the first frame at the entrance of this corridor and the dispersant was applied on the oil from the second frame at the exit of this corridor. This was done to ensure that the oil had time to spread across and that all the oil would be treated with dispersant. The dispersant equipment was composed of three spraying booms which could be activated independently to get 5%, 10% or 15% dispersant dosage with the oil.

Size of the slicks:
The volume of each oil slick was 150 L in order to have enough time to observe the slick for half an hour. The oil for each slick was prepared from a mixture of heavy fuel and kerosene to obtain the requested viscosity.

Figure 15. The "corridor" system.

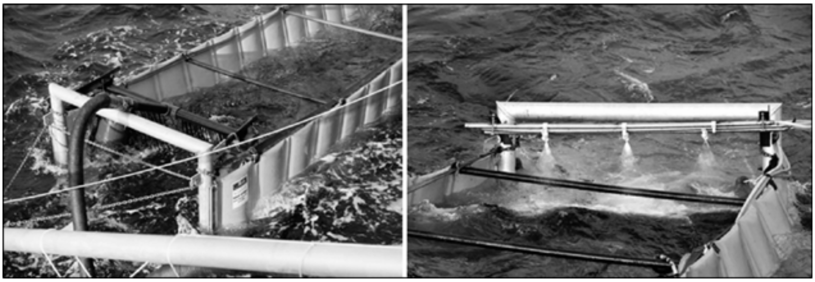


Figure 16. Oil released from the first frame at the entrance of the corridor and dispersant application from the last frame and the exit of the corridor.

5.2.3. *Progress of the Sea Trials*

Unfortunately due to a improper manoeuvre, the corridor system was destroyed by the propeller of the ship during the third test: only 2 tests were carried out of the 22 tests initially planned in the experimental program; therefore, it was not possible to assess the limit of dispersibility for oil in relation to the dispersant type and dispersant dosage. Nonetheless, the two tests that were performed demonstrated the corridor system suitability to apply the oil and dispersant in a well controlled manner. These two tests also demonstrated the importance of the observers' location in regards to the slick: observers should remain close to the slick and without disturbance due to the sun reflection.

5.3. DEPOL 05 CONCLUSIONS

The testing methodology used in DEPOL 05 proved to be promising to conduct repeatable and reliable tests, providing the observers are suitably located close enough to the slick to be observed. Using small volume slicks, it is possible to complete a much larger number of tests considered in an experimental matrix and therefore answer question such as oil dispersibility, dispersant efficacy, etc….

6. General Conclusions

The sea trials program developed in France regarding chemical dispersion involved two types of testing methodology:

- Large sea trials were designed for large scale oil slicks and involved operational means (i.e., planes and ships) to globally test dispersion techniques in realistic conditions. As main conclusions, these trials demonstrated: that dispersion could occur, at least partially, in rather calm sea conditions; and, pointed out operational limitations such as the difficulty to target and treat the entirety of the thickest part of a slick.
- Small scale trials were designed to control for, as much as possible, the testing conditions (oil spillage and dispersant application), the intrinsic efficiency of dispersant products, and to specify the oil viscosity limits for dispersion. Unfortunately, due to a navigation failure these tests were interrupted without giving clear answer to the question of dispersibility. Nonetheless, the testing procedure proved to be well adapted to carrying out such tests, and we hope to resume this experimental program in the near future.

7. Acknowledgements

This experiment would not have been possible without the contribution of Captain Nedelec, head of the antipollution technical team of the French Navy, (CEPPOL), Captain Le Nouy, on scene commander during the experiment, and Mr Castanier, officer in the French Customs. Thanks should be expressed to the other participants, including Ms Dimercantonio from MUMM, Mr Melbye from SINTEF, Mrs Varescon and Lavigne from TOTAL S.A, M Grenon from ITOPF, M Lewis, the OSRL operators, the crews of the Bonn Agreement remote sensing aircrafts involved, and the laboratory team of CEDRE.

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