Available online at www.sciencedirect.com

SCIENCE DIRECT®

Marine Pollution Bulletin 53 (2006) 369–374

MARINE POLLUTION BULLETIN

www.elsevier.com/locate/marpolbul

The *Prestige* crisis: Operational oceanography applied to oil recovery, by the Basque fishing fleet

Manuel González [a,*], Adolfo Uriarte [a], Rogelio Pozo [a], Michael Collins [b]

[a] *AZTI Foundation, Herrera Kaia, Portualdea, z/g, 20110 Pasaia (Gipuzkoa), Spain*
[b] *School of Ocean and Earth Science, University of Southampton, Southampton, Oceanography Centre,*
European Way, Southampton SO14 3ZH, UK

Abstract

On 19th November 2002, the oil tanker Prestige (containing 77,000 tonnes of heavy fuel no. 2 (M100)) sank in 3500 m of water, off the coast of northwestern Spain. Intermittent discharge of oil from the stricken tanker, combined with large-scale sea surface dispersion, created a tracking and recovery problem. Initially, conventional oil recovery approaches were adopted, close to the wreck. With time and distance from the source, the oil dispersed dramatically and became less viscous. Consequently, a unique monitoring, prediction and data dissemination system was established, based upon the principles of 'operational oceanography'; this utilised in situ tracked buoys and numerical (spill trajectory) modelling outputs, in combination with remote sensing (satellite sensors and visual observation). Overall, wind effects on the surface waters were found to be the most important mechanism controlling the smaller oil slick movements. The recovery operation involved up to 180 fishing boats, 9–30 m in length. Such labour-intensive recovery of the oil (21,000 tonnes, representing an unprecedented ratio of 6.6 tonnes at sea, per tonne recovered on land) continued over a 10 month period. The overall recovery at sea, by the fishing vessels, represented 63% of the total oil recovered at sea; this compares to only 37% recovered by specialised 'counter- pollution' vessels.

1. Introduction

A synthesis of oil spills, together with other shipping accidents around the Iberian Peninsula, is shown in Fig. 1; of these, 32 have been in Spain and 21 in Portugal, since 1950. Along the southern coast of the Bay of Biscay, progressing from east to west, are the *Castillo de Salas* (100,000 tonnes (of coal), in 1986, Gijón (Spain)), the *Aegean Sea* (74,460 tonnes, in 1992, A Coruña (Spain)) and, more recently, the *Prestige*.

The single-hulled oil tanker *Prestige*, one of a number of vessels which have foundered along the northwestern extremity of Spain (Fig. 1), has become the 'latest exhibit in the tanker hall of infamy' (Whitfield, 2003). Some 63,700 tons of the original cargo of 77,000 tonnes were discharged into the overlying and surface waters; of this, between 55,000 and 59,000 tonnes have been recovered, either at sea or from the adjacent beaches (Bohannou et al., 2003). Of the recovery mechanisms, the more efficient procedure has been the former, rather than extending into shoreline clean-up and restoration. For example, approximately 4–5 tonnes of beach material (oil, together with sand and seaweed) need to be recovered, to be equivalent to the offshore recovery of 1 tonne of (even emulsified) crude oil. Rough seas enhance the dispersion and dissolution of an oil spill (Fingas, 2001). Hence, in the case of the *Prestige*, with oil discharged into a high energy marine setting (in terms of waves, winds and tides), there was a need for an efficient operational (oceanography) system for the prediction of oil and water movement; this, in turn, controlled the recovery operation. This procedure is described in this

---

[*] Corresponding author.
E-mail address: mgonzalez@pas.azti.es (M. González).

0025-326X/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.marpolbul.2005.02.046

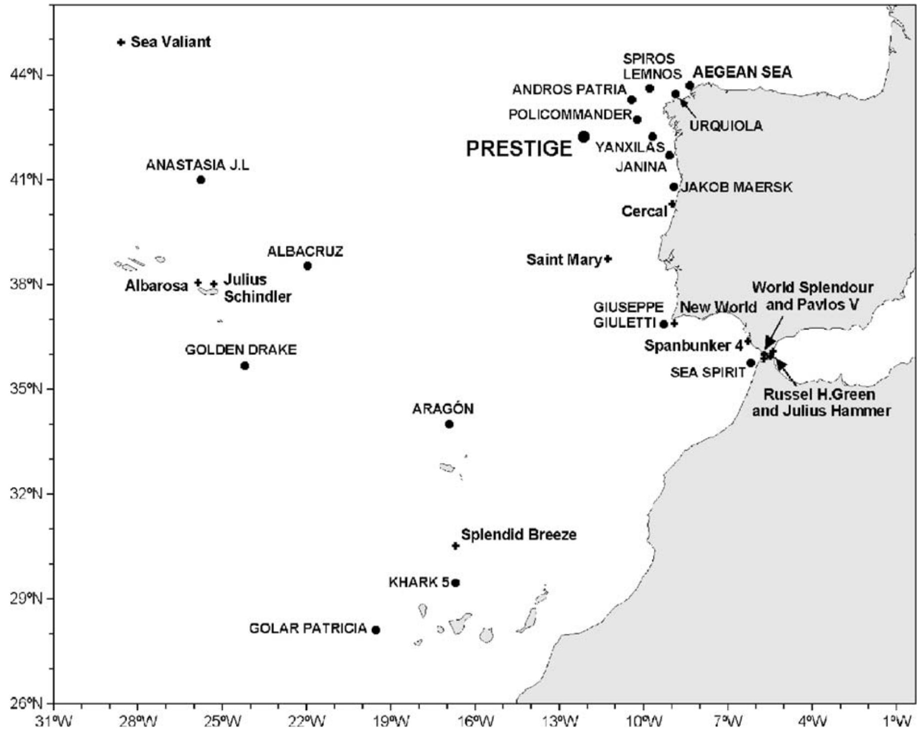

Fig. 1. Summary of accidental spills along the coasts of the Iberian Peninsula (adapted from www.le-cedre.fr). Names in capitals (•) are spillages >10,000 tonnes; in lower case (+) <10,000 tonnes.

contribution, in terms of: data acquisition and transmission (drifting buoys); a processing centre (data analysis/modelling); and information distribution (in particular, to the Basque fishing fleet).

2. Results and discussion

2.1. Source of the spill

On 13th November, 2002, a distress call was sent out by the *Prestige* offshore of Cape Finistere (Galicia, Spain). In heavy seas and strong winds, partial evacuation of the crew was undertaken and attempts were made, to tow the tanker with tug boats; these failed and the *Prestige* was eventually taken in tow by a salvage vessel, on 14th November. It was towed initially towards the north-northwest, then to the south. On 19th November, the vessel broke in two (at 42°15N and 12°08W) and sank in 3500 m of water. The associated oil slick, prior to and during towing and following the sinking of the ship, has been remotely-sensed from satellite imagery (Fig. 2(a)). The loss of oil during towing could have been as much as 40,000 tonnes (El País, 26 August 2003). The movement of the vessel (Fig. 2(a)), which was subsequently a contentious issue in Spain (Bohannou and Bosch, 2003; Serret et al., 2003), led undoubtedly to an exacerbation of the problem. Such movement has been considered to be responsible for temporal and spatial amplification of the spill, causing successive ‘oil waves’ to arrive at the Spanish, Portuguese and/or French coasts; as such, extending the effect on the adjacent shoreline (to over 900 km, in January, 2003). Subsequently, discharge from the *Prestige* has dispersed widely and reached the Channel Islands and parts of the English Channel coastline, i.e. the Isle of Wight and Kent (IOPC, 2003).

2.2. Offshore patterns of water and oil movement

Complex surface water movements in the Bay of Biscay are shown in Fig. 2(a), on the basis of tracked movement of buoys at the time of the spill, within the upper (approx. 20 cm) part of the water column. General patterns of movement of the water/oil are represented in the figure: (A) following initial towage of the vessel, in the surface waters; and (B) originating subsequently from the sunken vessel into the overlying, then surface, waters. In the case of the latter, the mean direction of movement is linked then to the movement of a drifting buoy—deployed on the 29/12/02 and recording until the 24/04/03 (Fig. 2(a)). The trajectories shown indicate the changing direction of movement of the surface oil slicks (as shown by the buoy), in response to changing wind directions; southwesterly, north-northwesterly and, finally, easterly. The recovery patterns of oil (see below) are consistent with the observed movements.

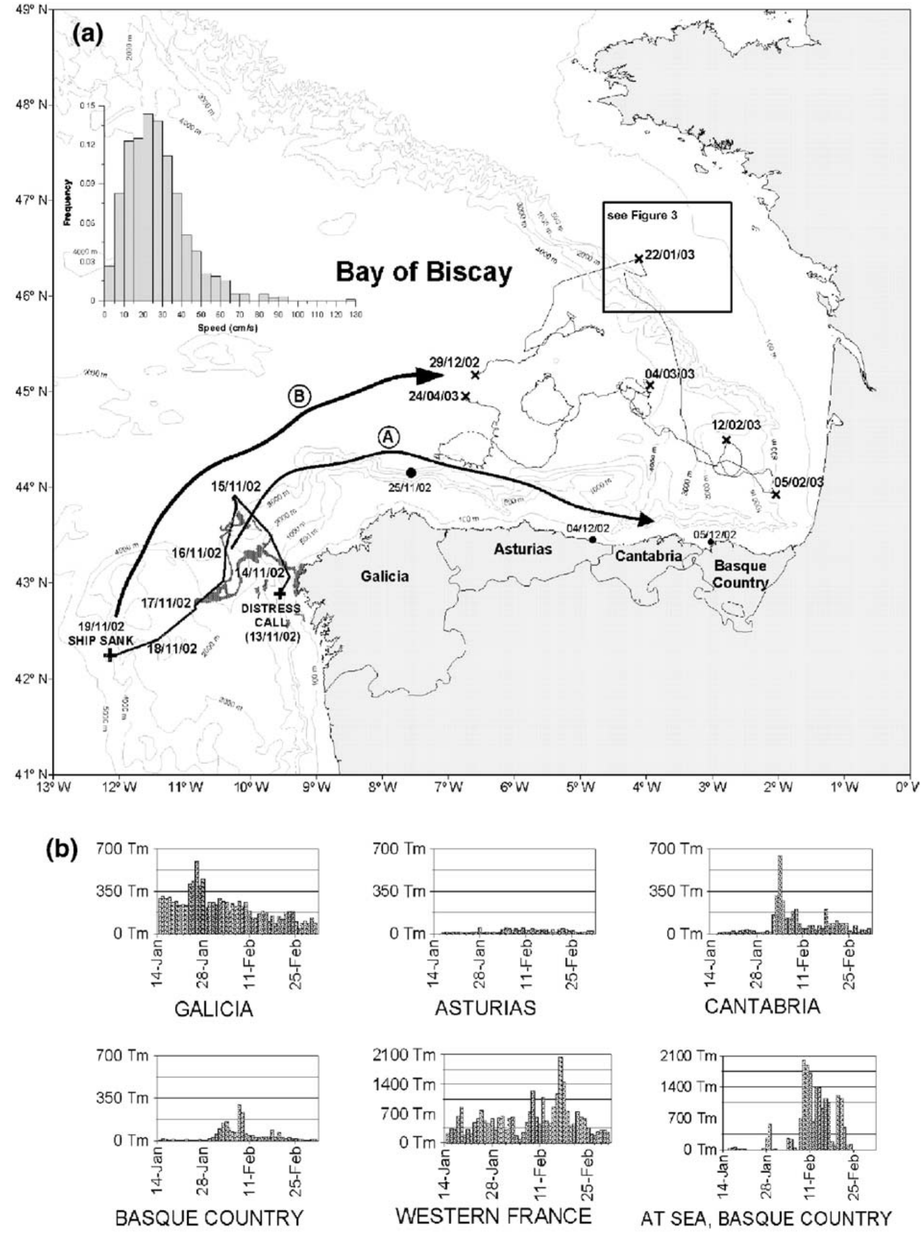

Fig. 2. Water and oil movement and recovery in the Bay of Biscay: (a) Ships track, from distress call to sinking, showing remotely-sensed oil slick; 25/11/02—first sighting of oil offshore of Galicia; 04/12/02 and 05/12/04—first arrival of oil at the coast in Asturias and the Basque Country, respectively; A—generalised trajectory of oil movement in the surface waters; B—generalised movement of oil in then overlying waters, following the *Prestige* sinking, then in the surface waters and shown by drifting buoy movement (see text). Inset shows derived velocities, from buoy data, in terms in frequency and speed. (b) Recovery, over time, of material (oil, sand and driftwood) from the beaches of the northern Iberian Peninsula (in metric tonnes). For comparison, the recovery at sea by the Basque fishing fleet is included.

Oil discharged from the *Prestige*, during towing and following its sinking, reached the adjacent Galician coastline rapidly (Fig. 2(b)) in response to rough sea conditions; these, in turn, prevented the use of booms, to control the initial movement of the spill (Whitfield, 2003). Further, the arrival of the 'black tides' on the Galician coast emphasised the absence of any operative systems to track/follow the spill. The progressive arrival of the oil, along the western and northern coastlines of the Iberian Peninsula (Portugal and Spain, respectively), together with western France, are summarised in Fig. 2(b).

Overall, the following patterns of oil recovery can be identified: (i) a peak in the amount of oil reaching Galicia in late January (at around 500 tonnes), resulting from the original discharge of oil; (ii) low levels (50 tonnes) in Asturias, as the initial oil spill trajectory (A) passed this section of the coastline; (iii) a Cantabrian peak (600 tonnes), which occurred in early February in response to trajectory (B) (see Figure); (iv) similarly, but slightly later in the Basque Country (330 tonnes); and finally, (v) in mid-February along the western coast of France (2000 tonnes). These observations reveal progressive movement of the oil, from the western to the eastern part of the southern coastline of the Bay of Biscay.

The measured velocities (based upon buoy trajectories (Fig. 2(a))) extend up to 95 cm s^{-1}, with a majority of the observations being below 75 cm s^{-1} and an average of around 25 cm s^{-1} (see inset, on Fig. 2(a)). For comparison, over this period of time, altimeter-derived geostrophic velocities for the winter slope current, or *Navidad flow*, coming from the west are represented by values ranging from 5 cm s^{-1} (6 November, 2002) to 35 cm s^{-1} (27 November, 2002), with a mean of 17 cm s^{-1} (García-Soto, 2004). This observation provides evidence that wind was the most important mechanism affecting oil dispersion; it accounted for more than 95% of the drift speeds and directions.

2.3. Recovery operations

Although details have been presented for the clean-up operations on the beaches, using a combination of manual labour, artesinal methods and heavy machinery (Whitfield, 2003), only limited information has been published on the recovery of the oil at sea. Initially, a standard approach was adopted, involving the deployment of oil recovery vessels and oil containment booms (Purnell, 2003). Subsequently, the Cantabrian and Basque fishing fleets were utilised in containing the dispersed and fragmented slicks in the southern part of the Bay of Biscay (Fig. 3); their efforts were directed on the basis of operational oceanographic output derived by the AZTI Foundation. In turn, AZTI liaised extensively with similar operations run by other institutions in Cantabria (University of Cantabria) and France (Le Cedre).

An operational oceanography procedure was adopted/established in the Basque Country, in January 2003 and incorporated: (i) the use of aircraft, for visual observation of the oil slicks; (ii) the deployment of transmitting buoys, from helicopters, to monitor the movement of the surface waters and the associated slicks; and (iii) the derivation and utilisation of a numerical model (González et al., 2000), to predict the oil trajectories. Such objectives, within the context of forecasting the pollution of certain areas and the absence of

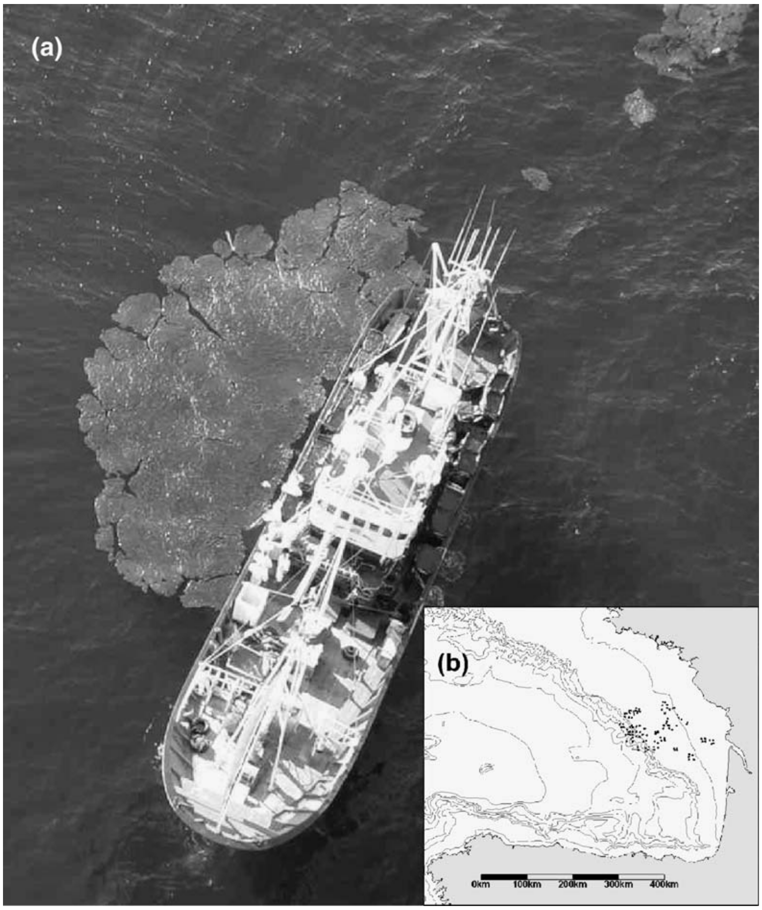

Fig. 3. (a) Patch of oil alongside one of the fishing fleet (25/01/03) showing its extent (approx. 8 m × 15 m); (b) an example of the distributions of oil slicks, based upon airborne visual observations (23/01/03).

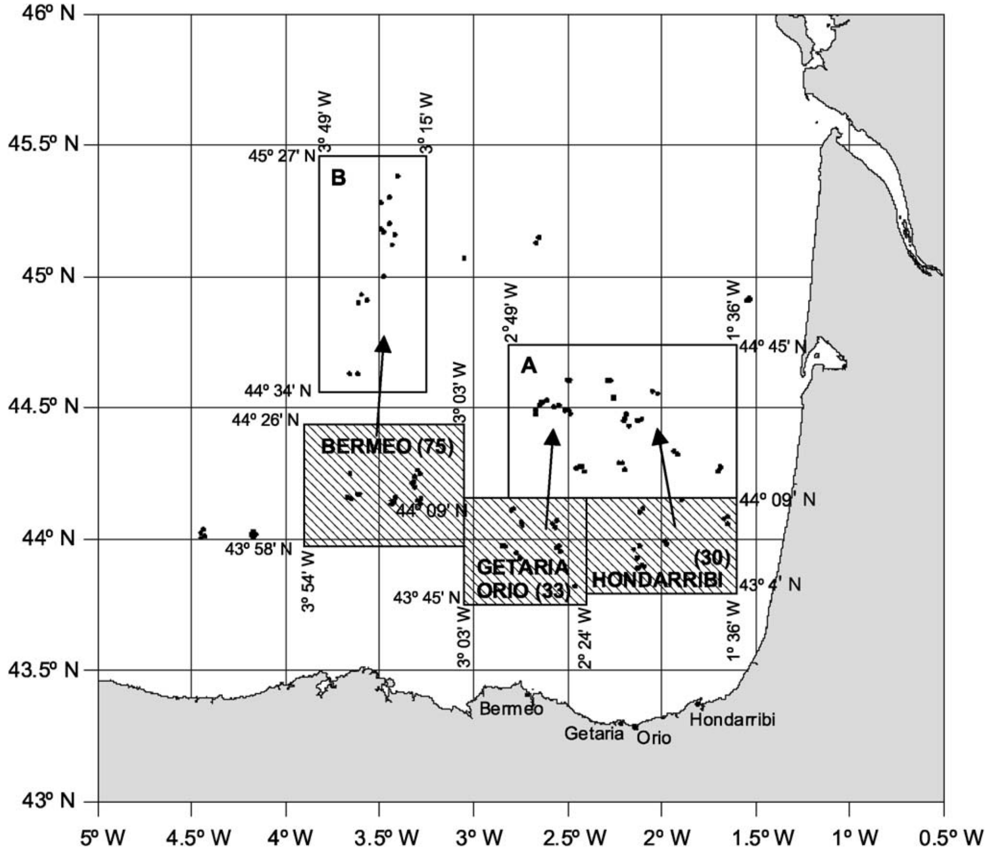

Fig. 4. Distribution of oil slicks/patches on 04/03/2003, together with areas proposed initially for recovery operations (shaded) and 'alternative' offshore areas, based upon field observations and numerical model predictions.

detection methods for small slicks, are consistent with the definition of 'operational oceanography' i.e. 'the activity of systematic and long-term measurements of the seas and oceans and atmosphere, and their rapid interpretation and dissemination' (www.le-cedre.fr).

On the basis of the data sets obtained and the derived predictions, daily reports were provided to the Basque Government, for decision-making regarding the deployment of the fishing fleet from Bermeo, Getaria, Orio and Hondarribi (Fig. 4). The fleet consisted of up to 180 vessels, ranging in length from 9 m to 30 m (involving, overall, up to 1100 fishermen). In total 21,095 tonnes of fuel were recovered at sea, representing a ratio of 6.6 tonnes recovered at sea per tonne on land. As such, the scale and complexity of the operation was unique within the context of regional and localised water movements in the Bay of Biscay (Pingree, 2002; González et al., 2004), driven by winds and tidal currents.

3. Conclusions

The establishment of an operational oceanographic system has been described, with rapid response in terms of predictive capabilities and management. In particular, this approach has been adopted for control of the Basque fishing fleet, for oil recovery at sea. Such vessels respond more easily to the different scenarios associated with small slicks, than larger 'counter pollution' vessels. The labour-intensive manual recovery involved the use of forks and hand-held metallic nets.

The fishing fleet has recovered 63% of all the oil at sea; this compares with 37% by the counter pollution vessels. Moreover, the application of operational oceanography and the use of the fishing fleet, has led to an unprecedented ratio of oil recovery of 6.6:1 (between sea and land).

The monitoring and forecasting approach presented, for the southern part of the Bay of Biscay, has broader implications in terms of oil spill recovery. In the case of the *Prestige*; (a) the source point of the pollution was not localised; and (b) the spill was diffused and extensive, with wind shown to be the most important mechanism controlling oil slick dispersion.

References

Bohannou, J., Bosch, X., 2003. Spanish researcher vent anger over handling of oil spill. Science 299, 490.

Bohannou, J., Bosch, X., Withgott, J., 2003. Scientists trace for Bad Tidings after spill. Science 298, 1695–1696.

Fingas, M., 2001. The Basics of Oil Spill Clean Up, second ed. Lewis Publishers, Boca Raton, 233pp.

García-Soto, C., 2004. 'Prestige' oil spill and Navidad flow. J. Mar. Biol. Ass. UK 84, 297–300.

González, M., Espino, M., Comerma, E., Gyssels, P., Hernáez, M., Uriarte, A., García, M.A., 2000. A numerical tool for hydrocarbon pollution forecasting in the autonomous port of Bilbao. In: Brebbia, C.A., Rodriguez, G.R. (Eds.), Oil and Hydrocarbon Spills II. WIT Press, Las Palmas de Gran Canaria, pp. 95–104.

González, M., Uriarte, A.D., Fontán, A., Mader, J., Gyssels, P., 2004. Marine dynamics. In: A., Borja, M., Collins (Eds.), Oceanography and Marine Environment of the Basque Country, Elsevier Oceanography Series, no. 70. Elsevier, Amsterdam, pp. 133–157.

IOPC, 2003. Annual Report of International Oil Pollution Compensation Fund, London, UK. Available from: <www.iopcfund.org>.

Pingree, R., 2002. Ocean structure and climate (Eastern North Atlantic): in situ measurement and remote sensing. J. Mar. Biol. Ass. UK 82, 681–707.

Purnell, K., 2003. Lessons for the World?. Dredging and Port Construction (January), 12–13.

Serret, P., Álvarez-Salgado, X.A., Bode, A., 2003. Spain's Earth Scientists and the oil spill. Science 299, 511.

Whitfield, J., 2003. How to clean a beach. Nature 422, 464–466.