RECOVERY OF SUNKEN AND BURIED OIL IN COASTAL WATER DURING THE ERIKA SPILL

Pascale Le Guerroué, Gérard Cariou, Emmanuelle Poupon, and François Xavier Merlin
CEDRE
Rue Alain Colas BP 20413
29604 Brest France
Pascale.Le.Guerroue@le-cedre.fr, Gerard.Cariou@ le-cedre.fr,
Emmanuelle.Poupon@ le-cedre.fr, and Francois.Merlin@ le-cedre.fr

ABSTRACT: *The Erika spilled a very high density, high PAH content persistent heavy fuel oil that impacted over 400 kms of France's West Brittany coastline resulting in a protracted period of shoreline cleanup. One of the sites oiled by the HFO was Pen Bron, located seaward of the Croisic salt marshes. This laarge and very environmentally sensitive area with extensive salt pans and bivalve production was polluted by a significant spill of sunken oil buried in the sediment. In view of the risk to local resources and amenities, operations were undertaken to remedy the sunken oil spill: the pollution was mapped and cleanup techniques studied to define the optimum technique for removing the oil that sank and was buried in an area subject to strong tidal currents. Site restoration was conducted in two stages:*

1. *Sediment in the most polluted area (700 m²) was mobilized by a mechanical shovel dredge mounted on a barge and the sediment was sent to a refinery to be disposed of along with waste from other locations.*
2. *Sediment from the surrounding area (10 000 m²) was removed by a pump dredger; pumping the sediment- oil - water mixture ashore to a lagoon where the oil was removed from the sediment by floatation and skimmed while the water was filtered before being released. The residual oil concentration in the sand was monitored by chemical analysis to decide on how to dispose of it best: replacing it on site or treating it as a specific waste.*

This operation involved over 5,500 tonnes of sediment. Environmental impact was minimised as 85% of the sediment was reinstated safely on site, thus avoiding the risk of shoreline erosion which could have happened in the event of excessive sediment removal.

Introduction

On 12 December 1999, the tanker Erika with a cargo of 30,000 tonnes of HFO broke in two and sank 70 nautical miles off the French west coast releasing 15,000 tonnes of very dense, high HAP content HFO. Four hundred kilometers of coastline were oiled to one degree or another resulting in a long, difficult and costly shoreline clean-up.

The Pen Bron salt marshes located seaward and to the north of Le Croisic were seriously oiled by the HFO from the Erika. Very extensive full scale clean-up operations were conducted in the area in the spring of 2000 and resulted in a serious set back for the local economy based on salt production, shell-fish farming and tourism.

In June 2000, a submerged slick of HFO was found buried in the seabed in the entrance channel at Pen Bron constituting a potential and permanent pollution threat likely to deteriorate the quality of the water in the bay in addition to hampering the recovery of the local economy.

Background and site description

Le Croisic bay is a 700 hectares area of sand and fine sediment with salt pans covering more than 2000 hectares. One of the main features of Le Croisic bay is it semi-diurnal tidal activity with a mean tidal range of 3.3 metres (reaching 4.5 metres during spring tides).

The local dune system to the north west of the bay comprises a sandy spit that is 1,300 metres long protected by rip-rap, at the southernmost tip of which is an old breakwater (called the Pen Bron jetty) that separates the bay from the Atlantic ocean. A channel links the bay to the ocean. The bay itself is divided into two smaller water areas, the Lesser and the Greater Traict to the north and the south of Le Croisic bay respectively (figure 1).

A major feature of the channel is that during spring tides the currents can reach 3 to 4 knots. The narrowest part of the channel features coarse grain sand (grain size ranging from 0.5 to 1 mm, mode 0.75 mm) in addition to fine grain sand towards the east where grain sizes are bigger than 0.3 mm.

Le Croisic bay typically demonstrates a high degree of sediment mobilisation, is a feeding ground for fish and shellfish and a haven for birds. Quite apart from the salt pans located to the north and the east, the area is used extensively by shell-fish breeders.

The issues at hand

Despite the large scale clean-up operations conducted in spring 2000 in the northern and southern sections of the channel and the sandy-silty part of the bay, the amount of oil in the seawater (500 ng/l) and the shellfish (2,5 mg/l) was very high in the northern as opposed to the southern part of the bay. Consequently, the PAH content was systematically higher than the levels authorised (15 ng/l for the seawater and 0,5 mg/kg for shellfish) by the health authorities that finally led to keep the saltpans and the oyster breeding grounds closed. The problem with the ban was that it soon became crucial to open the saltpan sluice gates to avoid excessive drying and therefore to maintaining the pans in operating condition.

The fact that recurrent pollution was constantly being reported in the Pen Bron area lead officials to realise that there was surely a submerged slick at the entrance to the bay in the Pen Bron channel causing chronic pollution whenever the tide came in.

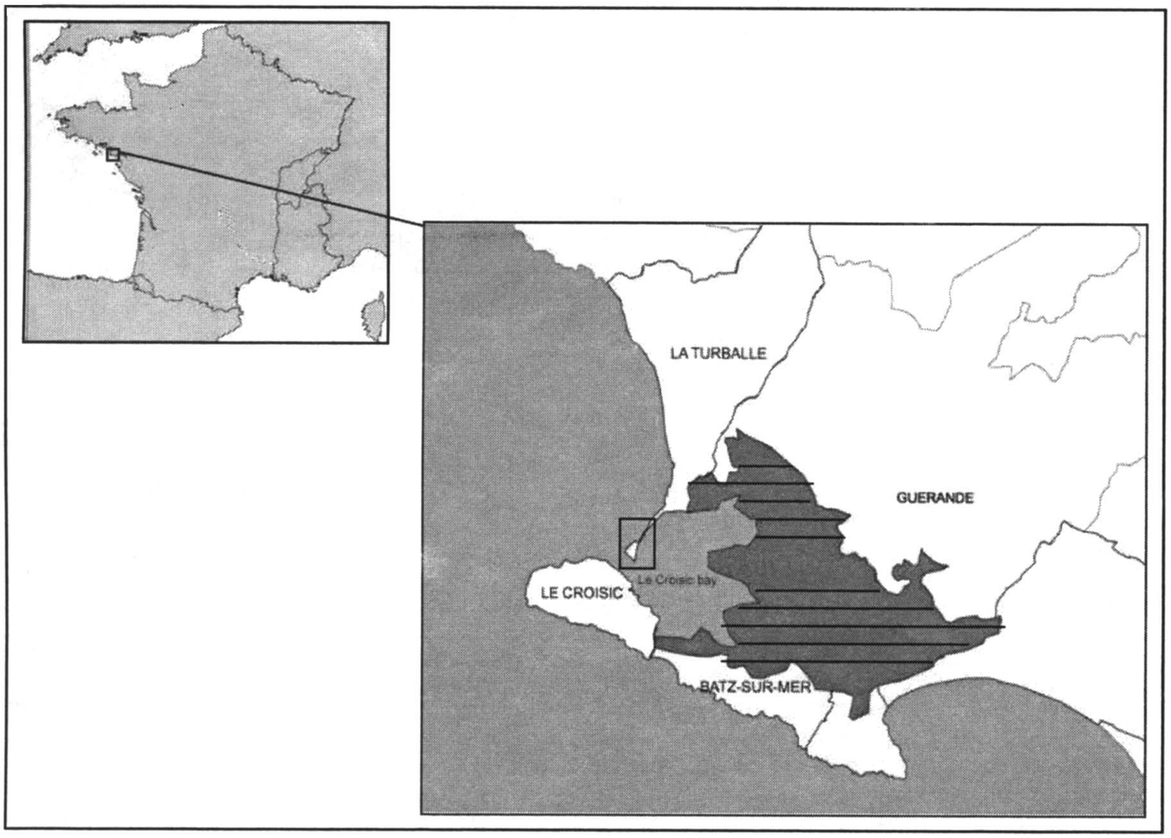

Figure 1. Map of Le Croisic bay.

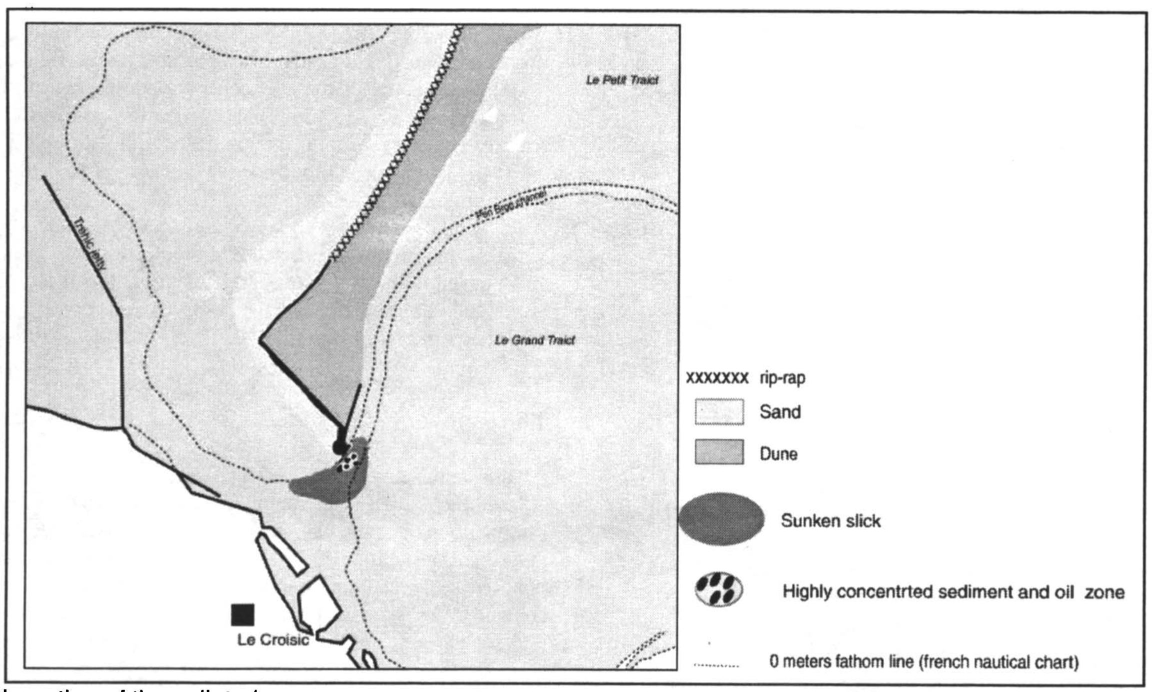

Figure 2. Location of the polluted area.

Identification of the polluted area

Borings and samples were taken in the area so as to confirm the presence of a sunken slick that was buried to one degree or another under a layer of sand on the seabed. Quantification, however, was not possible. A more detailed evaluation was established visually by divers in June and October 2000 in a bid to locate the polluted area and assess the extent and the volumes to be treated. The polluted area was 10,000 sq m in size, made up of patches of up to 0.15 m in diameter and tar balls. In the centre of the slick there was a 700 sq m area made up of a mixture of highly concentrated sediment and oil (figure 2).

Treatment

To treat this problem, technical solutions had to be found to remove the sunken oil mixed with sediment in a channel with very strong currents whilst keeping the amounts of sediment to be removed to a minimum as this would alleviate the subsequent transport and treatment requirements. It would also enable the response teams to mitigate the risk of sedimentary deficit likely to undermine local constructions (jetties…).

The technical solution was twofold:

1. dredge the centre of the slick where concentrations were highest using a mechanical filter shovel mounted on a pontoon; the pollutant-sediment mixture would be sent to the Donges storage and treatment facility that had been specially set up to handle the Erika oil spill.
2. remove the polluted sediment from the edges of the slick using a suction dredger with a pipe delivery system to the adjacent beach (Pen Bron beach) where the water, sediment and oil would be separated in a settling-filtration pool. The filtered water and sand would be subsequently put back on site and the pollutant sent to Donges for treatment (the sand too if it was still too polluted after the settling-filtration process).

Treatment-phase one: Dredging

Bearing in mind local conditions and in view of the risk of producing large quantities of suspended matters in the water column, this phase had to be conducted after the oyster production season but prior to the opening of the sluice gates at the salt pans, which meant between January and April 2001.

Preparing the work site. This meant conducting a series of borings using differential GPS beacons in a bid to define the most heavily polluted areas requiring dredging in addition to fine tuning the depths to which this would have to be done. Furthermore, 300 metres of sorbent boom were laid and fitted with a very fine mesh net skirt (the kind of net that is normally used for catching glass eels).

Dredging heavily polluted sediment. The excavator was a mechanical shovel of large dimensions mounted on a floating barge (figure 3). The shovel was a 2 cubic metre bucket fitted with a filter to drain the sand (figure 4).

Once drained, the polluted sediment was stored on two barges and shipped to the harbour at Le Croisic where it was unloaded ashore into tippers covered with tarpaulins and taken from there to Donges.

The recovery operation was conducted round the clock for about ten days but only at low tide (when currents and water depths were at their lowest).

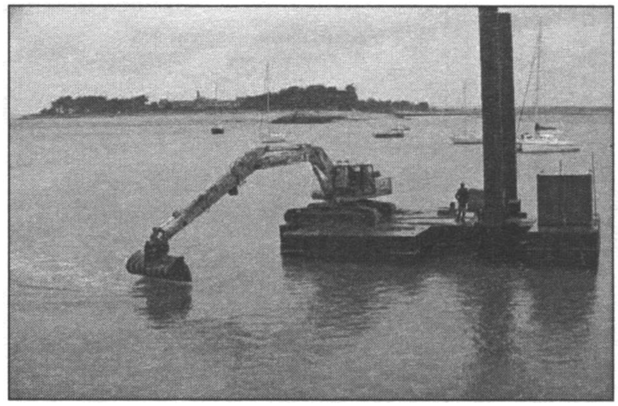

Figure 3. Mechanical shovel on the pontoon.

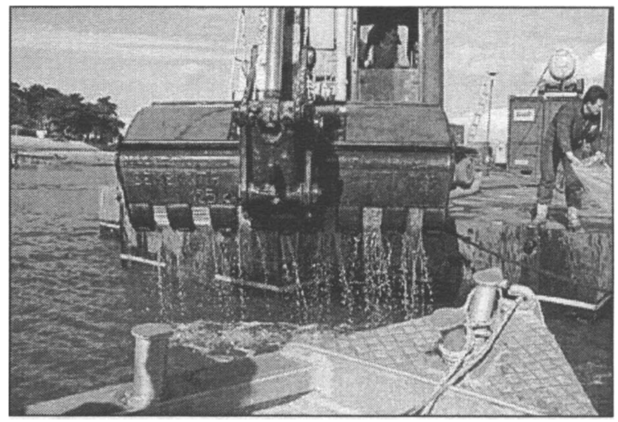

Figure 4. The bucket and the filter.

A surface area of 1,500 sq m (including a 700 sq m area of very heavily polluted sand) was removed down to a depth of about 30 cms involving the subsequent removal of 800 tonnes of heavily polluted sand. This technique proved to be very quick and enabled response teams to cater to first line emergency requirements and in particular the fact of being able to open the saltpan sluice gates.

This technique was well matched to the recovery of bulk HFO on the seabed but as the recovery operation was not completed, further polishing was deemed necessary.

Treatment- phase two: Dredging the edges of the slick

Response technique principle. A suction dredger removes the polluted sand and the sand-water-pollutant mixture is separated by floatation. The pollutant is shipped to Donges and the sand is recovered and depending on how polluted it is either put back on site or shipped as waste to the Donges facility whilst the water undergoes filtration - settling then secondary filtration prior to reinstatement on site.

Preparing the work site.

Reconnaissance, delineation and preparation of the area to be cleaned. Prior to start up, the site was prepared as follows: potential obstacles were removed such as sinkers and underwater cables which were located and materialised with GPS beacons. Samples were taken to evaluate the extent of the area requiring clean-up (figure 5). These samples were analysed and showed oil concentration beetween 0 and 8700 mg/l.

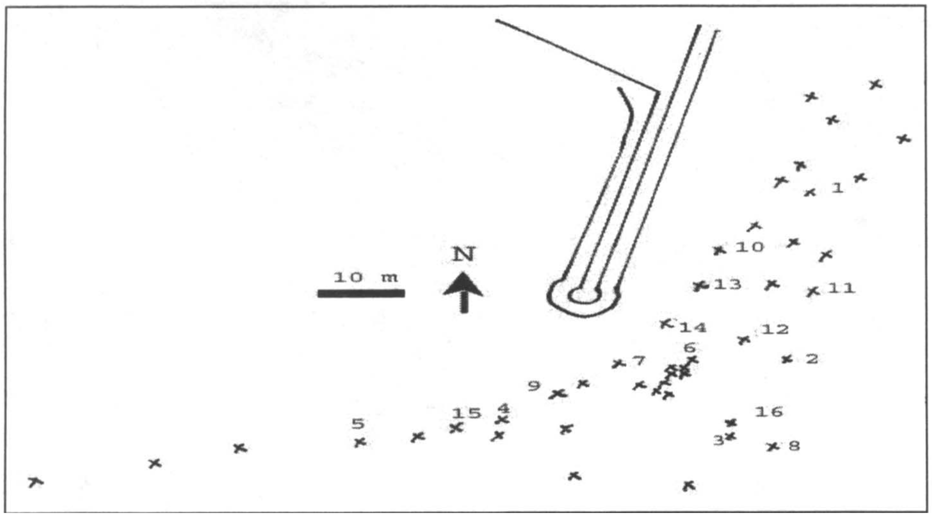

Figure 5. Sampling locations.

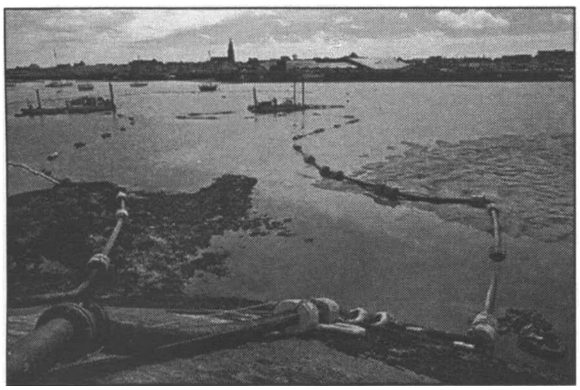

Figure 6. Overall view of the dredging system: two suction dredges anchored on piles and the hosepipes that deliver the polluted sand and water to the settling lagoon.

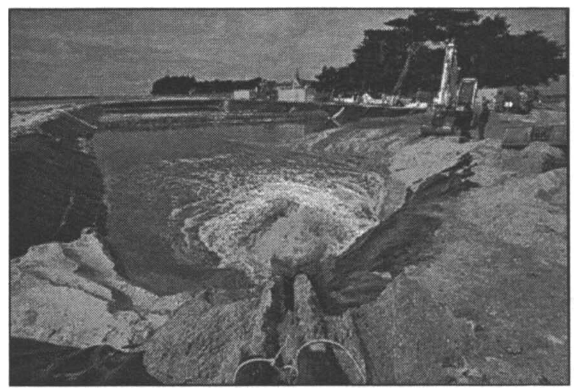

Figure 7. Piping the water-sand-pollutant into the lagoon.

Containment and cordoning off the work site. As stated previously floating sorbent booms (polypropylene) with a fine mesh netting skirt were installed around the dredgers prior to the commencement of operations in a bid to contain sheen and micro tarballs on the surface and prevent them from spreading so as to reduce the risk of disseminating the pollution to the surrounding environment.

Moreover, in order to contain the higher density tarballs (laden with sediment) likely to migrate along the channel bottom, seabed nets with weights were placed up and downstream of the area to be treated.

Operation. There were five stages to the response operation:

1. recover oiled sand by suction and deliver the polluted materials to treatment facilities set up on the shore,
2. floatation settling of sand and pollutant and subsequent recovery of the pollutant
3. primary filtration/settling of the dredged water
4. secondary filtration of dredged water prior to release
5. evacuation of the pollutant, the sand and the dredged water

Collecting polluted sand by suction dredging (figure 6). Collection and recovery of the polluted sand was performed by two identical anchored suction dredgers that could move on. A blade cutter located at the end of the dredging arm cut up the recovered materials whilst a pump recovered and delivered them at a rate of 240 cu m per hour via semi-rigid hosepipes (internal diameter : 250 mm) to a settling lagoon.

Floatation settling of sand and pollutant, recovery of the pollutant and primary filtration-settling of the dredged water. The settling operation for the sand and the pollutant plus the floatation settling operation for the water (steps # 2 and 3) were conducted in a 7,000 cu m custom built lagoon. The lagoon was dug on the beach and lined with watertight geotextiles. The bottom of the lagoon was lined with 30 cms of sand and gravel and was divided in 2 by a stone mound:

- first pool for receiving dredged materials by hosepipe, where the pollutant is floatation settled to separate the sand and the pollutant and the latter is subsequently recovered; stage # 2- (figure 7)
- second primary settling pool for water where the stone mound separating both pools acts as a primary filtration mechanism. stage # 3- (figures 8 and 9)

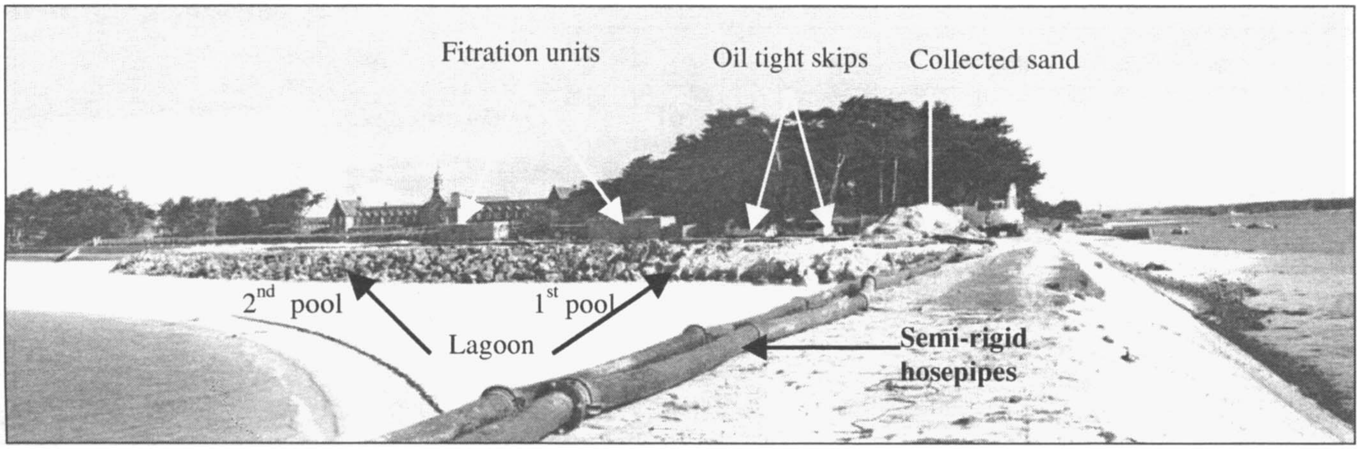

Figure 8. Overall view of the worksite.

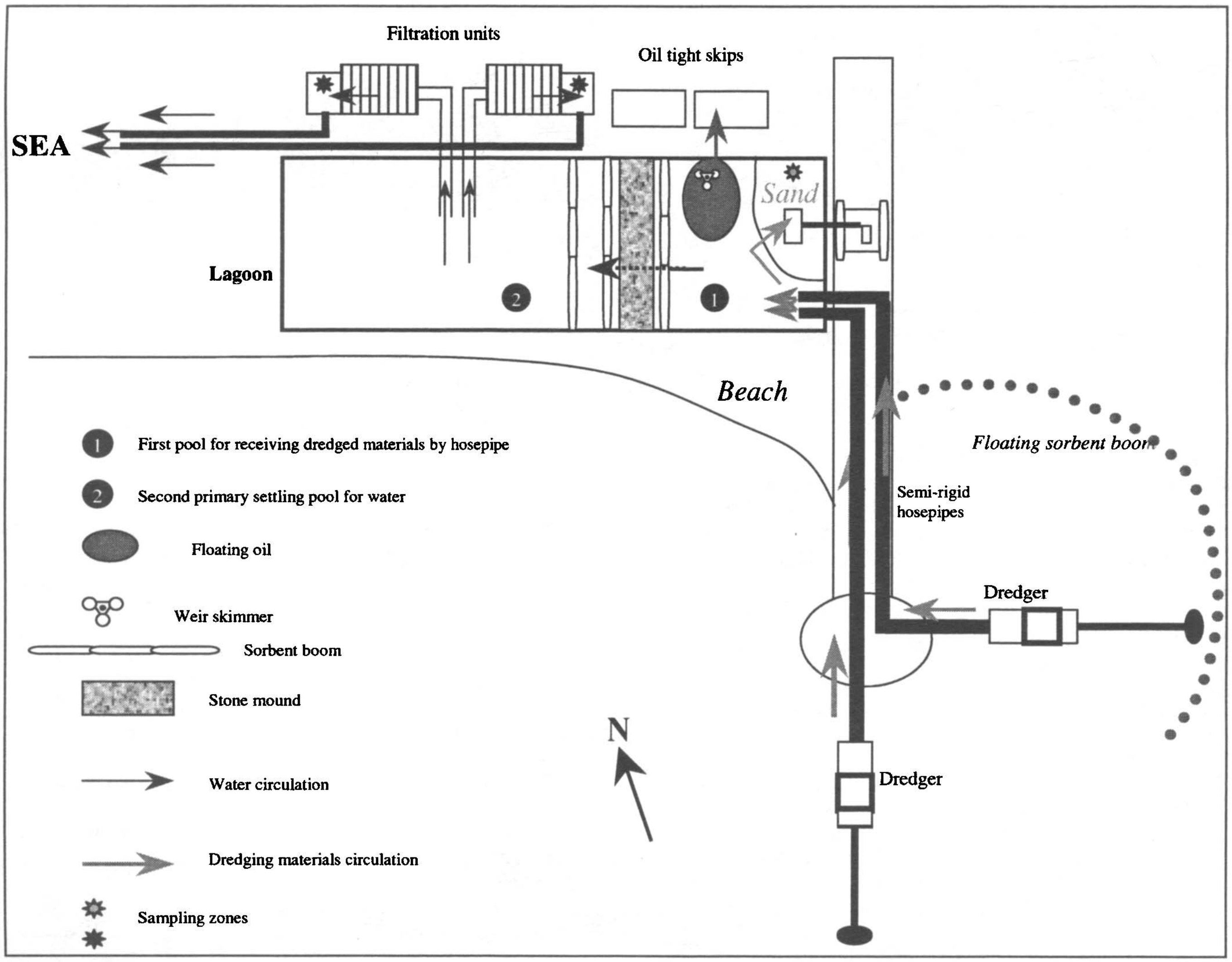

Figure 9. Overall plan of the worksite.

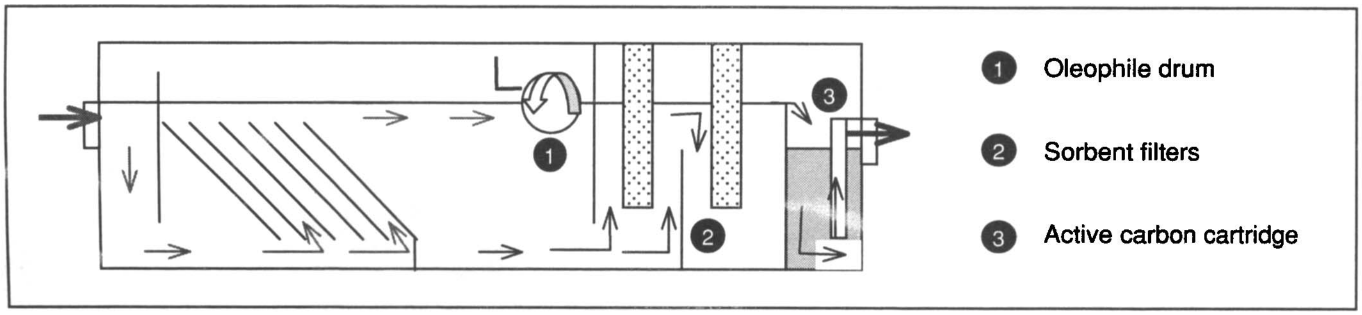

Figure 10. Plan of a water filtration unit (Plan according to Mr Larive (CECA)).

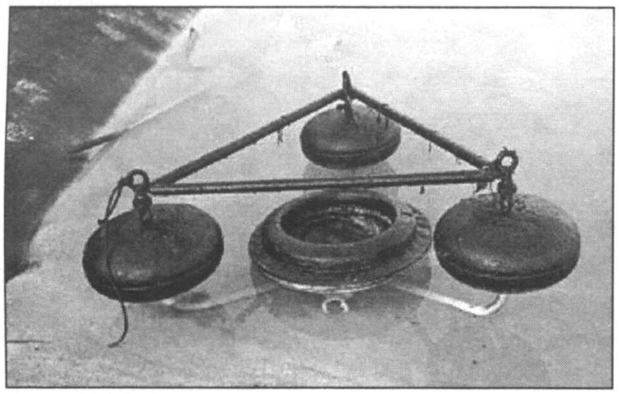

Figure 11. The Foilex adjustable weir skimmer.

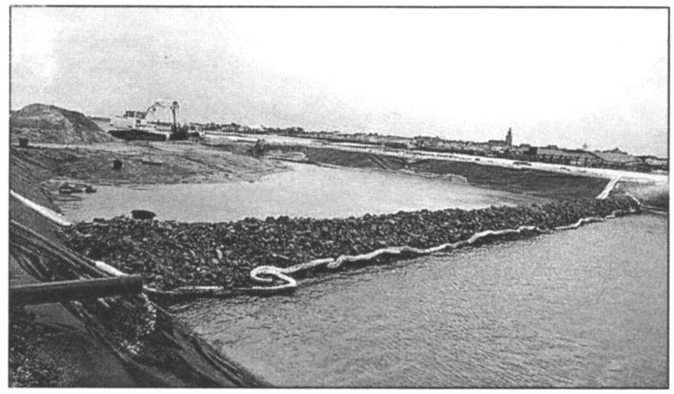

Figure 12. The pools separated by the stone wall/mound. The temporary storage facility for dredged sand.

Secondary filtration of the water. The water was pumped from the second pool to two filtration units (figure 10) that were housed in 75 cu m storage containers.

Once the filtration process was done, the water was then pumped into two tanks fitted with sorbent boom to contain sheen. Each one could handle 200 cu m of water per hour.

Disposal of the pollutant, evacuation of the sand and the dredged water. Real-time analysis was performed on the water and the sand on site so as to produce data that could be used directly for conducting the response in addition to deciding what to do with the collected materials and where the most suitable facilities were to treat them.

The HFO. The dredge stirred up the sediment to such an extent that the oil and sediment began to separate and release the oil that then floated to the surface in pool number 1. There operators jetted the oil towards a self-adjusting weir skimmer (figure 11) which delivered the pollutant to two oil and water tight container whilst awaiting shipment by tank lorry to Donges.

The sand. In pool number one the sand fractions that were nearly fully cleaned were forced against the stone wall and settled quickly as the grain size was relatively coarse. The sand thus settled was then collected by a mechanical shovel and stored temporarily and drained at the edge of the lagoon. Samples were taken to ascertain the residual oil content and the testing was done quickly on the spot using UV - visible photospectrometry in a field lab set up nearby the work site. Depending on the field lab findings, the sand could either be put back into the environment nearby on an exposed section of the coastline for « surf washing » or else shipped to Donges as waste.

Put back in the environment. Reinstatement and surf washing consisted of piling the sand on the foreshore where it could be washed by incoming waves and churned up to promote oil release. The oil was then trapped by very fine mesh eel nets on the beach next to the sand to be cleaned. Field observations showed that the eel nets could contain the pollutant extracted from sand containing up to 1,000 ppm of residual oil. Beyond that, the net tended to clog such that the excess pollutant migrated and repolluted the environment.

This was done near Pen Bron on the exposed section of the dune system in the Le Croisic bay. The objective was to put the sediment back in the environment it had been dredged from so as to avoid massive sand removal that was only likely to undermine the dune system and expose the foundations of the manmade structures located along the edges of the Pen Bron channel.

Disposal as waste. It was agreed that the very polluted sand with an oil content in excess of 1,000 ppm (top limit for this technique) would be shipped to Donges (figure 12).

Results. The dredging operations lasted a month. Sand oil content for nearly the entire length of the operation in pool number one ranged from 10 to 600 ppm. It was only towards the end of the month of March that oil contents in excess of 1,000 ppm were actually detected thus making surf washing unworkable. The sediment was then put back in pool number one for further settling and separation.

All the treated sand was put back in the environment for surf washing and polishing (figure 13). Any released pollutant was contained and recovered with the eel nets.

The water. Once filtered in the filtration units the treated dredged water was checked three times a day in both storage tanks:

- solvent was added to check that the water had no particles in suspension and that the ppm ratings were very low.
- the same check was done again for confirmation using a UV-visible spectrophotometer

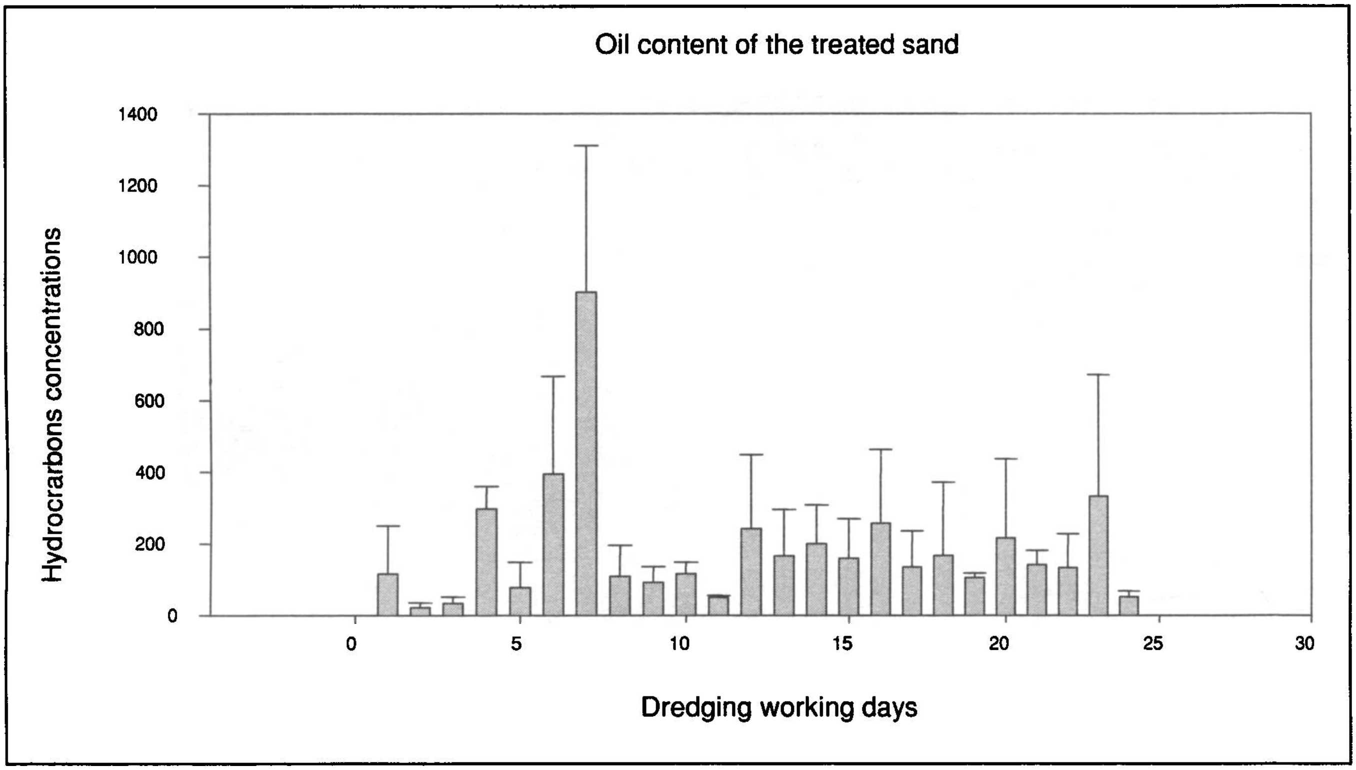

Figure 13. Oil content of the dredged sand.

Oil content would of course dictate how the water would be disposed of: the water could either be released at sea when the oil content was less than 50 ppm otherwise retreated and pumped back into the second pool and filtered again. Initially it had been decided that coagulants could, if necessary, be used at the input end of the filtration unit in a bid to contain any oil particles in suspension.

Results. Apart from one or two peaks where concentrations were of the order of 1 to 3 ppm at the beginning or during the treatment process, readings were below the detection threshold for the UV visible spectrophotometer available in the field (i.e. < 1 ppm)

Ultimately and in order to confirm the readings obtained by UV visible photospectrometry, the odd sample was sent to an official laboratory for analysis using infra red and HPLC fluorimetry. The results confirmed the very low readings obtained previously for the treated water.

Throughout the entire operation the treated water was put back into the environment without further treatment. However, as an additional safety measure the water was released into the environment in Le Croisic bay at ebb tide.

Decommissioning. The component parts of the lagoon such as the stone mound/wall, the geomembrane liner and the sand and gravel in addition to the sediments deposited in the pools were all analysed so as to ascertain which treatment solutions were the best.

The sediment mixed in with the sub layer from pool 1 plus the stone wall were sent as waste to Donges (oil content was 12,000 ppm).

But the fine sediment particles in pool 2 where oil content was close to 300 ppm were mixed with base materials and disposed of. The geomembrane liner was rinsed and stored for future use.

Conclusions regarding phase 2. Suction dredging turned out to be efficient and well suited to recovering oil laden sediment. No clogging was reported even when the suction heads encountered very concentrated patches of oil. The dredging technique was used to polish the response operation in areas where the mechanical shovel had been in use. The technique also enabled the response teams to operate within allotted deadlines. The technique was well suited to receiving and disposing of large quantities of dredged sand and water.

But as the dredges had been designed for use in sheltered waters they soon reached their operational limits in choppy or rough seas. An inshore dredger would have done a much better job and avoided downtime as a consequence of bad weather. This treatment technique was well suited to the Erika oil emulsion which was not too stick to the grain sand and can be separated from the sand.

This treatment technique was well suited to the type of sediment in Pen Bron allowing quick settling of the water-sand-oil mixture. Had the sand and sediment been finer grained, settling times would certainly have been longer and the overall design of the worksite would have had to be changed.

General conclusions

Expenditure for the first and second phase treatments amounted to 12.4 million francs (1.9 million euros). This does not include the reconnaissance work and removal of obstacles such as boats and sinkers. Phase one involved dredging 800 tonnes of polluted sediment using the mechanical shovel and then shipping the waste to Donges. Phase two involved suction dredging, filtration, on site skimming of the water-sediment-pollutant mixture as follows:

- 4 650 tonnes of sand were removed, treated then put back in the environment once it had been checked

- 58 000 cu m of water were pumped, filtered and released back into the environment;
- 15 cu m of water-oil emulsion were shipped to Donges for destruction.

This operation treated 5,500 tonnes of sediment and 85 per cent of the materials were reinstated near the site they had been taken from. The sediment was subsequently mobilised by currents. The technique implemented during this response operation enabled teams to minimise potential erosion likely to affect the dune system and cause it to recede and/or to uncover the foundations of the manmade structures located along the Pen Bron channel. Lastly and more importantly, this response operation obviated further risk of chronic pollution which would otherwise have affected the entire bay at Le Croisic. A few months after the end of the restoration, the oil content in seawater and shellfish were respectively 12 ng/l and 0,2 mg/kg. They clearly made a contribution to facilitating the economic recovery of local businesses that depended on the area for their livelihood, namely shellfish breeding, salt production and tourism.