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SCIENTIFIC AND CLEANUP RESPONSE TO THE IDOHO-QIT OIL SPILL, NIGERIA.

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ABSTRACT

On 12 January, 1998, a 24 inch pipeline from the IDOHO platform to the Mobil Qua Iboe terminal ruptured. This resulted in the release of approximately 40 000 bbl of Qua Iboe light crude oil into the marine environment. In response to the spill, cleanup and containment equipment were immediately deployed. Dispersant application played an important role in the cleanup response because the bulk of the oil remained offshore and was transported westward by prevailing currents, thus providing an extended opportunity for treatment at sea. As a result of dispersant application, natural dispersal and evaporation, over 90% of the oil was dispersed and evaporated offshore. Heavy shoreline oiling was limited and localized, with oiling of sensitive estuarine mangrove habitats limited to a few locations. Remnants of the spill that tracked 5-10 km offshore from the spill source were observed at Lagos harbor, about 900 km west of the spill site. Most of the exposed sand beaches in the spill zone self-cleaned within 2-3 weeks and cleanup of the limited number of heavily impacted shoreline areas recovered approximately 1000 bbl of oily waste. A national and international team of scientists was convened within 24 hours and initiated scientific studies to measure the short-term impact of the spill on environmental resources important to local human activities. Elements of the short-term scientific program were (1) an offshore component, including fisheries, benthos, chemistry, microbiology; (2) a riverine/estuary component, including extensive water analyses to detect any spill input to waters used by local settlements and chemical analysis of local fish market samples. The results of the short-term scientific study indicated that any initial environmental effects were limited and localized. Based on the initial scientific program, a larger follow-up scientific program was initiated on September 15, 1998. This involved a multi-disciplinary program with the following components: offshore fisheries and benthic studies; a shoreline fate and effects program; a study of impacts to estuarine mangrove habitats; and a study of any socioeconomic and human health effects. The study plan was based on comparisons of data from spill zone and non-spill zone locations. The key elements of the study design of this comprehensive longer term study are described.

Keywords: Dispersant, Nigeria, injury assessment, cleanup, oil spill.

INTRODUCTION

On 12 January, 1998, a rupture in a 24 inch pipeline three miles offshore between the Idoho platform and the Mobil Producing Nigeria Ultd. (MPNU) Qua Iboe Terminal (QIT) facility resulted in the release of around 40 000 bbl of Nigerian crude oil. In response to the spill, cleanup and containment equipment were immediately deployed. Clean Nigeria Associates (oil spill cooperative in region), other oil companies, as well as Nigerian and foreign experts were invited to assist in the cleanup and the assessment of the impact of the spill on offshore and coastal areas. This paper will describe the elements of the cleanup response and the elements and key findings of the short term scientific response. The study design of the longer term scientific fate and effects program initiated in late 1998 will also be described as an example to provide guidance for future studies of a similar nature.

The Niger Delta region of Nigeria is a major oil producing region. Within this area, there are 13 oil companies operating onshore and offshore oil production facilities. The QIT facility and its associated offshore production platforms is one of the region's major oil producers, supporting production of approximately 600 000 bbl per day. This region has a number of coastal environments at risk to oil spillage. Figure 1 shows the location of QIT and the oil spill as well as the major coastal regions in the spill zone.

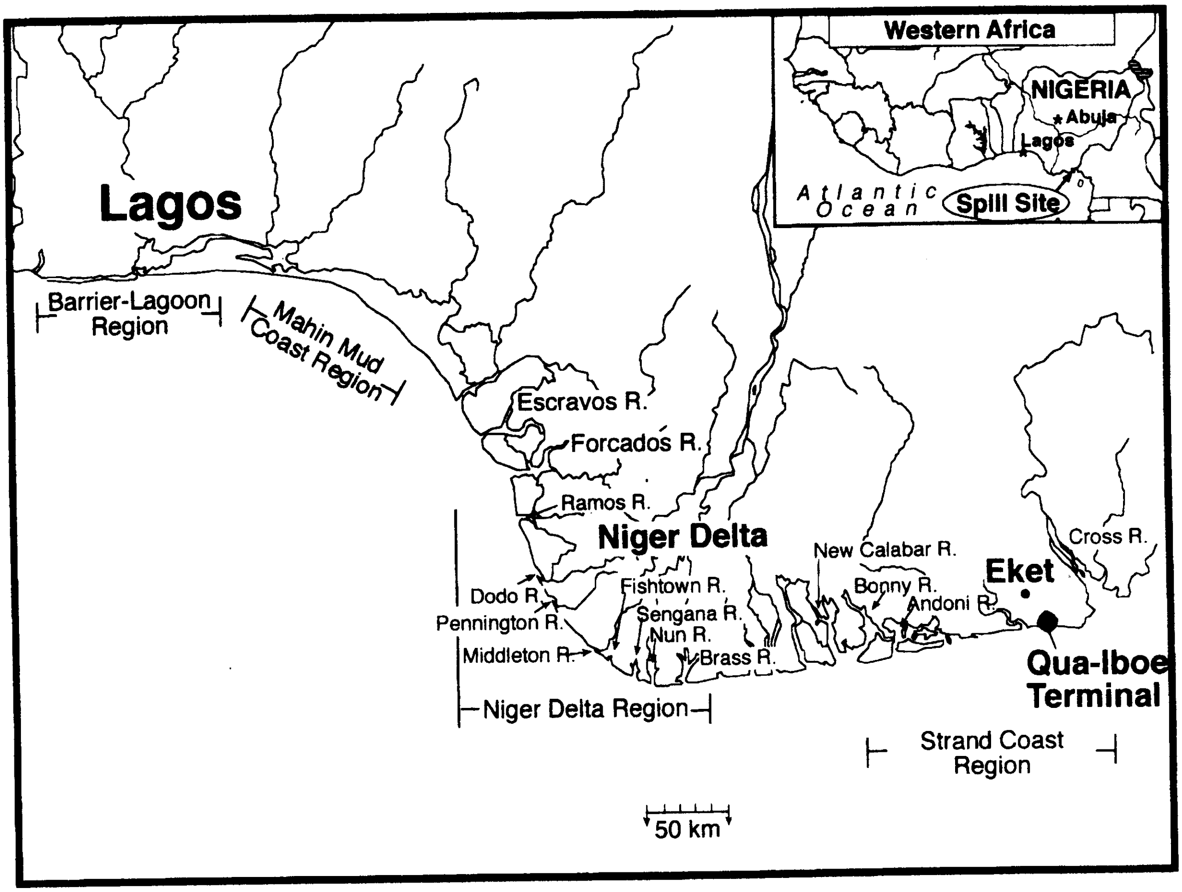

Figure 1. Map of the Nigerian coast with an inset map of west Africa major physical features and coastal regions are noted.

These regions are described as: [1]

- The Strand Coast in the eastern area characterized by terrestrial riverine systems with wide exposed fine sand shorelines. Oil does not persist for long periods of time along these exposed beaches due to wave and tidal action and beach movement.
- The Niger Delta region characterized by extensive mangrove deltaic environments and exposed sand shorelines. The sheltered areas behind the coastal sand beaches consist predominantly of an extensive network of rivers, creeks and streams bordered by tracts of mangrove trees. These are sensitive and biologically productive habitats where oil can persist and cause damage to the trees and associated plant and animal communities.
- The western Mahin mud coast, consisting of low-lying coastal creeks, organic-enriched mud flats and beaches with some mangrove habitat. Due to the sorptive capacity of fine grain sediments for hydrocarbons, these are environments where oil is expected to be persistent.
- The Barrier-lagoon region, including the Lagos area lagoon system in the west, is the most heavily populated region of Nigeria with approximately 10 million inhabitants. It is characterized by barrier islands having extensive areas of low energy sheltered lagoons.

SPILL PATH

The spill occurred during the 'harmattan' period when easterly winds carry fine dust from the Sahara desert westward. The airborne dust resulted in poor visibility and limited the use of fixed-wing aircraft to track the spill during the initial days of the response and dictated the use of helicopters for spill tracking. During the first four days after the spill, the spill track was generally offshore and westward (Figure 2). By January 17, the predominant wind direction shifted to the SW causing bodies of oil to go ashore at sporadic locations along the coast between the Sengana and Forcados Rivers (Figure 1). Direct observation of the spill was supplemented by computer spill-track modeling (OilMap© Applied Science Associates, Narragansett, RI, USA) based on compilations of field observations. By January 28, the final remnants of the spill were in discontinuous bands off the coast of Lagos lagoon approximately 900 km west of the spill site, where stranding occurred at a limited number of locations (Figure 2).

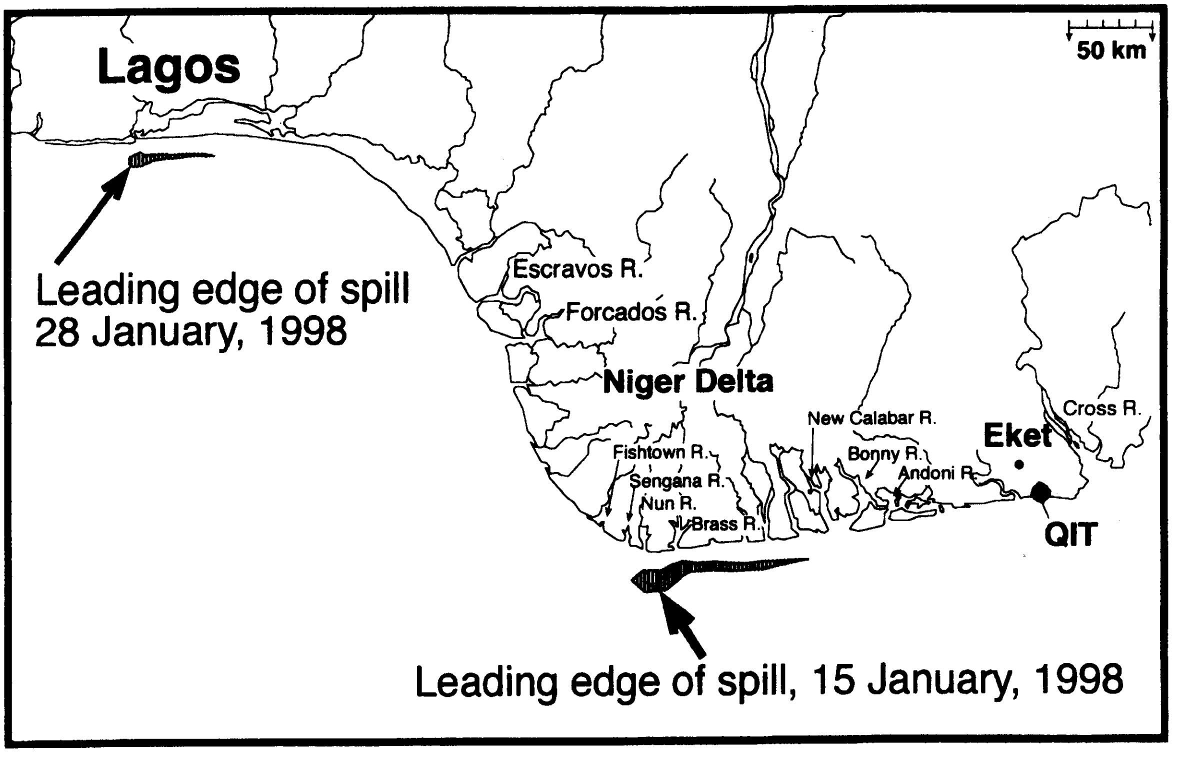

Figure 2. The track of the oil showing the movement of the offshore oil up to 28 January, 1998.

CLEANUP RESPONSE

Dispersant application from vessels was the principal initial response method to remove oil from the sea surface and mitigate any shoreline impacts. Dispersants were applied from vessels equipped with spray booms and fire hoses with close direction from aerial observers in helicopters. With the offshore slick moving to the west and persisting greater than 48 hours, MPNU required information on whether the dispersant operation would be effective after the oil had weathered on the sea surface for greater than 48 hours. To assist in this process, a dispersant use monitoring team (NETCEN, UK) was mobilized and began monitoring of the application of dispersants by aerial observation and by *in situ* fluorometry on a vessel on Sunday, 18 January. The monitoring demonstrated that, at the 28°C ambient water temperatures, the Nigerian crude remained dispersible for the entire period (approximately 150 hr) during which a significant mass of oil remained offshore on the sea surface. Table 1 summarizes the application of dispersant and the products used.

Table 1. Cumulative dispersant usage showing the different products used during the spill response through 18, January, 1998.

Date (Jan., 1998)	Cumulative volume of dispersant applied (bbls)	Dispersant types applied
12	9	Gold Crew™
13	40	Gold Crew™
14	76	Gold Crew™
15	140	Gold Crew™
16	212	Gold Crew™, Corexit 9500™, Corexit 9527™
17	233.5	Corexit 9500™, Corexit 9527™
18	235.5	Corexit 9527™

Over flights of the spill zone monitored areas of shoreline between January 16 and February 5, 1998. Detailed environmental sensitivity index (ESI) maps of the coastal areas west of QIT were available to aid in the identification of sensitive habitats and areas of human activity at risk from the spill. Shoreline video surveys were conducted on January 19, 27, 28 and February 5 and the results entered on a computer Geographic Information System (GIS) database. Figure 3 shows the resulting shoreline oiling mapping for the Niger Delta coast. This shoreline oiling information was the source of the spill history needed to design longer term scientific studies. Moderate to heavy shoreline impacts were limited to a small number of locations, many of which were along exposed sand beaches in the Niger Delta region between the Sengana and Forcados Rivers. Most of these exposed sand beaches self-cleaned as a result of wave action within 2-3 weeks (Figure 3). Observations from over flights of the Niger Delta region done on 18 and 19 January provided an estimate of approximately 100-280 bbl of stranded oil on exposed beaches based on area and density of coverage. There was little oil incursion into estuaries or protected mangrove environments. In only two locations were moderate-heavy

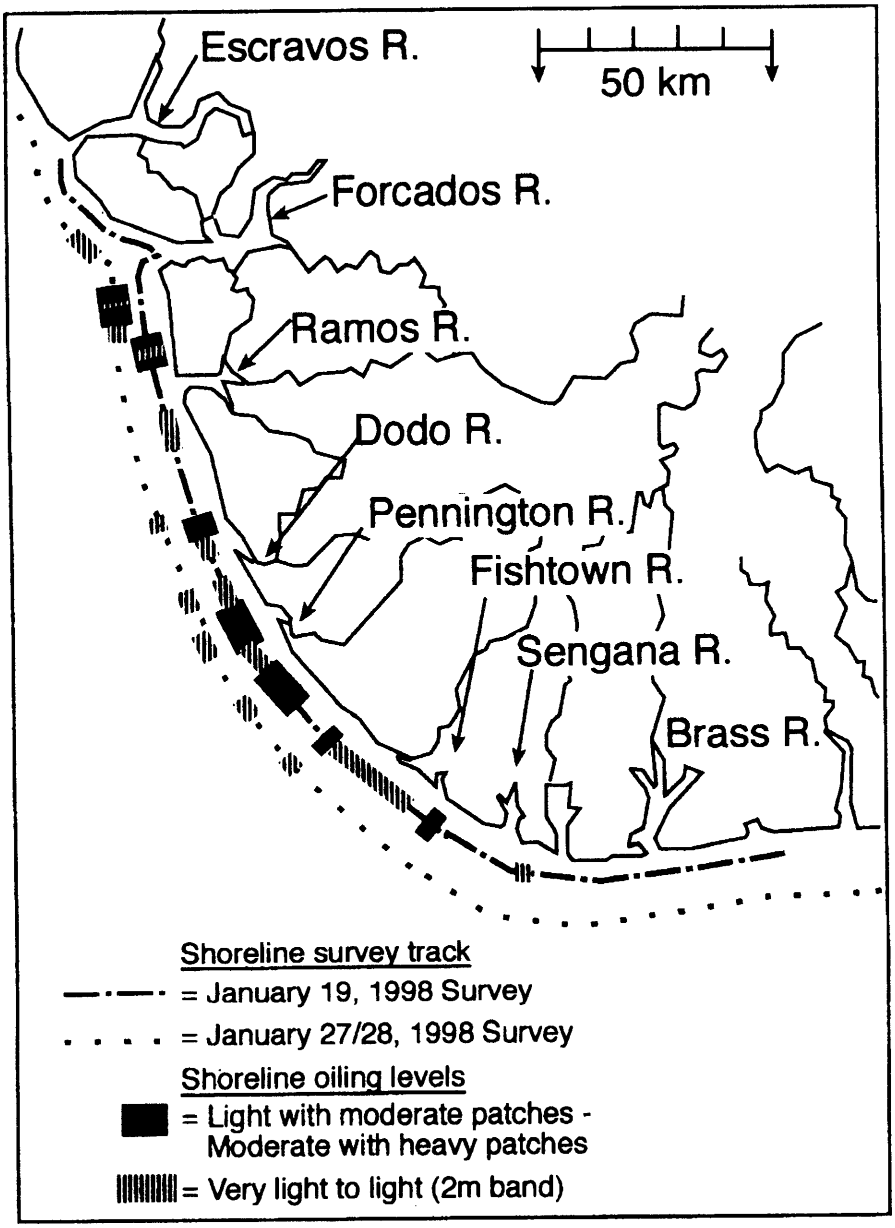

Figure 3. Shoreline oiling map of the Niger Delta region showing the results of aerial video surveys done 19 January, 1998 and again on 27/28 January, 1998.

deposits of oil noted in the mangrove fringe of creeks near river mouths in the Niger Delta. The shoreline between QIT and the Niger Delta region, including the large Bonny River estuary system received little impact from the spill (Figure 4) as was the case for the shoreline west of the Niger Delta region and east of the Lagos Lagoon area (Figure 5). Figure 5 shows that in the Lagos Lagoon area, remnants of the spill reached some shoreline locations 2-3 weeks after the spill, requiring manual shoreline cleanup in the affected areas. Table 2 summarizes an approximate mass balance defining the fate of the spill oil, based on aerial surveys, dispersant use monitoring and estimates of oil behavior in the environment.

A total of 10 shoreline locations had sufficient oil persisting to warrant cleanup activity. Table 3 summarizes the amount of debris collected and manpower used in the shoreline cleanup. It is estimated that the shoreline cleanup recovered a total of about 1000 bbl of oily waste, where the actual oil residue recovered in the shoreline cleanup was <10% of the 1000 bbl of waste recovered.

INITIAL SCIENTIFIC RESPONSE

A major concern during the spill response was the protection of coastal resources used by the local population. The initial response was, therefore, a human resource-based response [2]. A multi-disciplinary group of Nigerian University scientists, local and international consultants, and Mobil personnel was activated immediately after the spill to begin scientific studies. Members of this team were sampling in the field within 24 hr after the spill. Organizations associated with the initial multi-disciplinary scientific response team included:

University of Lagos, Nigeria
Environmental Resources Managers Ltd., Lagos, Nigeria
University of Calabar, Nigeria
E-Tech International Inc., USA
University of Uyo, Nigeria
Fugro-Prodec Ltd, Port Harcourt, Nigeria
Bowdoin College, USA
MPNU QIT, MPNU Lagos, Nigeria

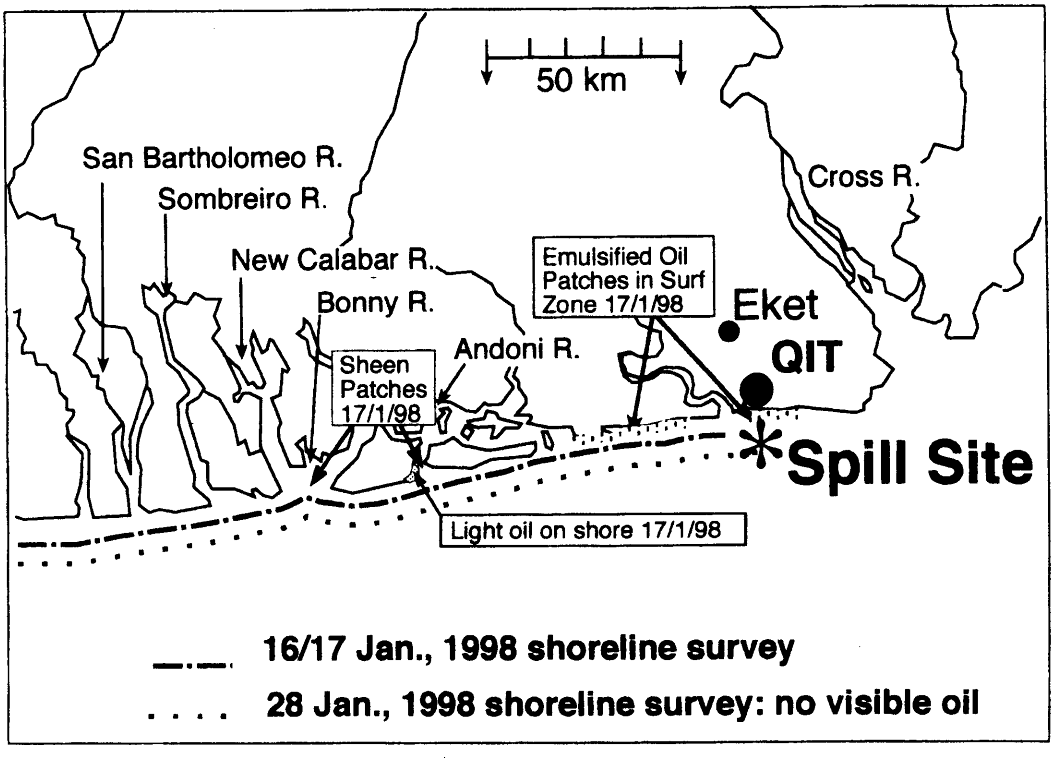

Figure 4. Shoreline oiling map of the shoreline between QIT and the Niger Delta area showing the results of aerial video surveys done 16/17 January, 1998 and 28 January, 1998. Most of the shoreline showed no visible oiling.

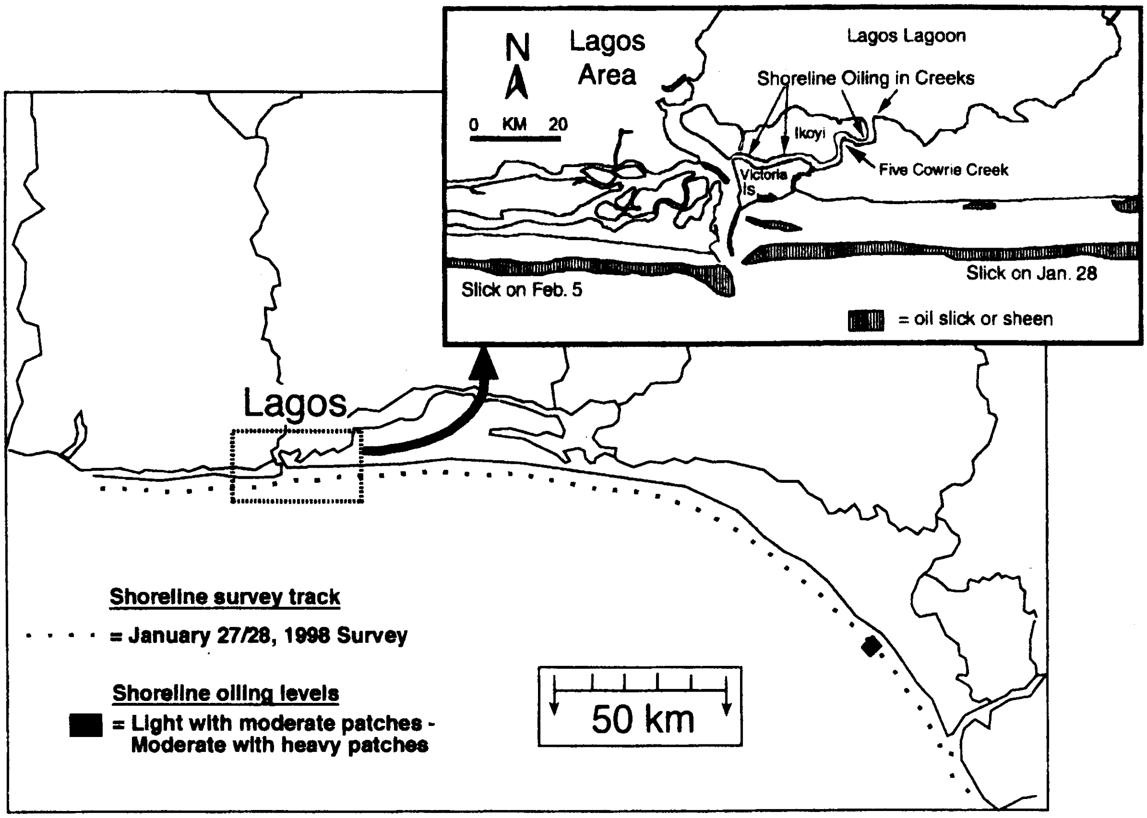

Figure 5. Shoreline oiling map of the area west of the Niger Delta area to the Lagos Lagoon showing the results of aerial video surveys done 28 January and 5, February, 1998. The inset shows the Lagos Lagoon area in detail.

Table 2. The fate of the Idoho-QIT oil spill: estimated mass balance as of 18 January, 1998.

Oil fate	Estimated value (bbl)
Evaporated at sea	16000
Stranded on shoreline	160
Remaining on sea surface	40
Chemically dispersed at sea	6000
Naturally dispersed at sea	17800

Table 3. Summary of shoreline cleanup by area, with amount of debris recovered and manpower used. Generally local workers were employed in the shoreline cleanup activity.

Areas cleaned	Area map reference (See Figure 1)	Amount of oily debris collected	Number of workers
Twon Brass Beach	Brass R.	25 bags	40 men
Ewoama Beach	Sangana R.	25 bags	40 men
Okpoma Beach	Fishtown R.	25 bags	120 men
Ikei Beach	Ramos R.	1 bag	40 men
Otokolopere Beach	Ramos R.	1 bag	40 men
Akasa I and II Beaches	Forcados R.	(12 villages) 2 bags	150 men
Bar Beach	Lagos	50 bags	20 men
Five Cowrie Creek	Lagos	186 drums/4 containers	250 men
Banana Island	Lagos	4 drums2 containers	250 men

The initial scientific program was directed toward measuring any oil spill effects on those environmental resources important to local human activity [2] There were two major elements to this response: (1) An offshore program designed to detect impacts on fisheries. (2) An element directed toward river estuaries which was designed to detect acute spill impacts on water and food resources used by local people. The major results are summarized below.

Offshore program

There was offshore benthic and water column sampling at 26 stations extending the length of the Nigerian coast from QIT to Lagos (Figure 1). The results of the various elements are summarized below.

Microbiology

Eleven of the 26 offshore stations were sampled for bacteria. The offshore surface waters were very rich in heterotrophic bacteria., with total counts (enumeration on the appropriate solid growth media) ranging from 8×10^6/100ml to 6×10^8/100ml. Coliform bacteria were found at all stations. *Salmonella* and *Shigella* were found at 9 of 11 sites. Hydrocarbon utilizing bacteria were found at all stations, although hydrocarbon degraders never amounted to more than 0.42% (range 0.02 - 0.42) of the total bacteria found. These results indicate that the environment in which these bacteria were living was extremely rich in organic matter with relatively little of it derived from hydrocarbons.

Plankton

A total of 13 sites were sampled for plankton. Phytoplankton abundance and biomass was low at all offshore stations (0-10 cells ml^{-1}) and higher (220 cells ml^{-1}) at the one estuarine station. The zooplankton community was rich and diverse and contained oil sensitive groups such as crab zoea and juvenile copepods.

Water column total extractable lipids

Surface water samples were taken at 30 stations and analyzed for total extractable lipids by infrared spectrophotometry as a rapid survey method. Values ranged from 4.38 to 0.12 ppm. The highest value was found near the IDOHO platform; the lowest value was found 'upstream' of the platform. The general trend was a decrease in concentration with both distance from the platform and time since the spill. No values greater than 1 ppm were found more than 60 km from the platform or after 16 January. Much of this material may reflect naturally occurring levels of background lipids since total extractable lipid determination by infrared spectrophotometry is a non-specific method of lipid analysis.

Offshore benthos

Benthic sediments from a total of 26 offshore stations were sampled using a 0.1 m^2 Van Veen grab. Few benthic macrofauna were found in the benthic sediments with a total of 95 organisms found in all samples. Typically only a few organisms would be found in a sample and one sample off the Sengana River contained no organisms at all. These results reflect the fact that the offshore sediments in this region are very highly enriched with total organic carbon (TOC) and also have very fine grained particles - both factors contributing to low densities of benthic infauna. A 1996 environmental impact assessment study offshore of the Bonny River [3] found median values for TOC (16.6%), sand (20.3%), silt (22.1%) and clay (50.5%) in a total of 15 offshore sediment samples. These Bonny River offshore sediments are so fine grained and have such high TOC values that they are highly reduced and do not support an abundant infauna as was observed for the same general area in the present study. There is no evidence to support a link between the high TOC levels in the offshore sediments and oil production in the area. The Bonny River report cites 86 separate sources of organic contamination in the Bonny River area alone. The coliform bacteria data presented in the present report demonstrate a high level of sewage contamination. Perylene, a polycyclic aromatic hydrocarbon produced by natural processes in organic rich marine sediments was the dominant aromatic hydrocarbon found in the offshore sediments in the present spill study. Thus, the low abundance of infauna in the offshore benthic sediments arises from high TOC inputs and widespread distribution of fine sediments which yield a highly reduced benthic sediment environment and is not an effect of the IDOHO oil spill.

The rivers/estuaries program

The estuaries program had 2 major elements, ambient water quality and fisheries. Both were concerned with measuring directly any spill impact on those aspects of the environment that affect the local population in their daily lives.

Ambient water quality

A total of 26 rivers were sampled for water quality. These included every major river from the Cameroon border in the east to Lagos Lagoon in the west. Most were sampled a minimum of four times during the spill event. Some rivers such as the Qua Iboe (at QIT) nearest the spill site were sampled seven times between 17 January and 5 February. Figure 6 shows the mean concentration of total extractable lipids in river water from the Cross River in the east (CRS) to the Lagos area in the west (BDG). It is clear from the data shown in Figure 6 that the concentration of total extractable lipids in the water is not related to proximity to the spill site, but is a property of the baseline inputs of the various rivers. The Middleton River (Figure 1) had the highest total extractable lipid values observed except for those waters offshore of the Mahin mud beach and also supports the highest population of hydrocarbon degrading bacteria. This suggests local anthropogenic and/or natural lipid sources.

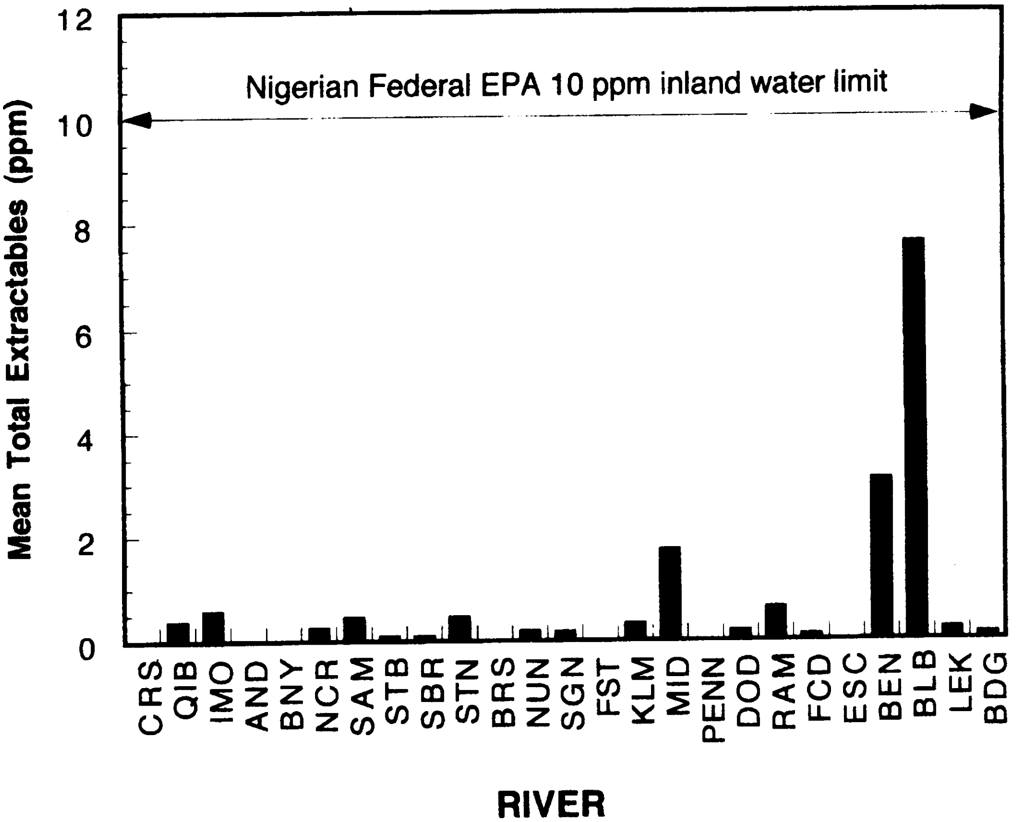

Figure 6. Mean total lipid extractable in river mouth waters sampled in January 1998. The rivers in the figure run from east (Cross River) to west (Lagos Lagoon). Abbreviations for river names are: Cross River (CRS); Qua Iboe River (QIB); Imo River (IMO); Andoni River (AND); Bonny River (BNY); New Calabar River (NCR); Sambreiro River (SAM); St. Bartholomeo (STB); Santa Barbara River (SBR); St. Nicholas River (STN); Brass River (BRS); Nun River (NUN); Sengana River (SGN); Fishtown River (FST);Kulama River (KLM); Middleton River (MID); Pennington River (PEN); Dodo River (DOD); Ramos River (RAM); Forcados River (FCD); Escravos River (ESC); Lagos Lagoon (LEK); Benin River (BEN); Between Lagos and Benin River, off Mahin Beach (BLB); Badagry Lagoon(BDG).

Waters offshore of the Mahin mud beach (Figure 1) had the highest levels of total extractable lipids. This most likely reflects the large suspended sediment load in the coastal waters from this area that adsorb lipid material and hydrocarbons from all sources. However, no single value observed in the entire 100 samples taken in the program exceeded the 10 ppm Nigerian Federal Environmental Protection Agency water quality limit for total extractable lipids in inland waters [4]. On the basis of these data, any hydrocarbons from the IDOHO oil spill posed no public health threat to the river waters used by the local population.

Fisheries

Total extractable lipids in food fish used by local populations were measured in various species obtained from local fishermen in six rivers within the spill zone and two rivers outside the spill zone. This represented the range of fish species consumed by the local population. A total of 96 individual fish representing 41 individual species were collected. Only one of the 96 individuals exceeded the United Nations 25 ppm [5, 6] threshold for hydrocarbons in fish: a *Polydactylus quadrifilis* from Sengana River with a total extractable lipid level of 28.95 ppm. *P. quadrifilis* was found in two other rivers where it was either the fish species with the highest total extractable lipid value or the second highest. The total extractable lipid measurement includes all natural lipid material as well as any hydrocarbons that may be contained in the fish. It appears that *P. quadrafilis* is a very fatty fish and the fish in the Sengana River may have accumulated some hydrocarbons over time where the slightly elevated total extractable lipid level may have no relation to the IDOHO spill and not related to petroleum. Thus it appears the IDOHO oil spill posed no significant public health threat to the food supply of the local population in the spill zone.

LONGER TERM SCIENTIFIC STUDIES

This section describes the study plan for a longer term spill study. The goal of the longer term scientific study is to determine whether injury from the oil spill can be detected in the environmental and human resources of the spill zone. Field sampling began on September 15, 1998 and the results are not yet available. The study plan is designed to enable comparisons between oiled/potentially oiled sites and unoiled control sites. This 8-9 month scientific program is a rigorous multi-disciplinary field program encompassing scientific evaluation of the following components: Offshore Survey, Coastal/Beach Survey, River/Estuary Survey, Socio-Economic Effects Survey and Human Health Effects Survey. Additionally, there are program elements related to Data Management and Mapping, and Mobil Project Management. The major features of each component are summarized below.

Offshore survey

The objective is to determine whether injury occurred to the offshore environment, including benthos and fish through statistical comparisons of results from the oil impact area and from non-oiled control areas. A total of 40 sites were sampled for benthic sediments and water at various depths. The field samples will be analyzed for hydrocarbon and heavy metals chemistry, sediment grain size and total organic carbon (TOC), microbiology and benthic infauna. A fisheries component will assess the health and abundance of offshore fish stocks.

Exposed sand beaches

Because many of these beaches are used by indigenous people, it is important to determine the persistence and effects of spill residues in this part of the environment. The objective is to determine whether there is a detectable oil spill effect on the biological resources of exposed sand beaches in the spill zone. As part of the short-term scientific response, computer-GIS shoreline oiling maps were prepared from aerial surveys (see Figures 3-5). The shoreline oil mapping data were used to select 26 initially-oiled and unoiled beach areas for sampling within the shoreline impact zone in the Niger Delta region (Figure 3). Sediment samples were taken from two intertidal elevations on two transects at each site for hydrocarbon analysis, heavy metals, sediment grain size and TOC and infaunal biology analysis. In addition, 10 beach sites east of QIT (non-spill zone) were sampled as controls.

River/estuary survey

The complex system of rivers and estuaries that dissect the coastal sand and mud beaches of Nigeria is responsible for the high productivity of the adjacent waters and provide habitat and support for the indigenous people of the region. Although not observed as being extensively oiled during the spill, the objective of this component is to determine if injury occurred to this system. A total of 26 major rivers are identified in the spill zone between QIT and Lagos that could have been affected by the spill. All rivers were sampled for water quality (microbiology, total extractables). Benthic and creek bank stations in mangrove creeks near the mouths of oiled and unoiled rivers were sampled for sediment hydrocarbon and heavy metal chemistry, grain size and TOC, benthic infaunal analysis and microbiology. In addition sampling of mangrove epibiota and vegetation in estuarine areas were done. The health and abundance of estuarine fish stocks were also surveyed.

Human health survey

The objective of this program is to determine whether the health of individuals in the spill area was adversely affected by the spill. This will involve an extensive review of pre-spill and post spill health records from clinics and hospitals in the spill zone.

Socio-economic effects survey

The objective of this program is to determine whether the socio-economic well being of individuals in the spill area was adversely affected by the spill. This will be based on data collection through use of standardized questions during personal interviews by trained interviewers in localities within and outside the spill zone.

Data Management and Mapping

The overall objectives are to organize, and record all data collected during these activities; provide mapping support to each program component, and ensure that the history of spill movement and cleanup is fully documented and mapped.

The results of the longer term scientific studies are not yet available and will be reported at a later date.

CONCLUSIONS

- Evaporation at sea reduced the original volume of the spilled oil by approximately 40%. Successful dispersal of approximately 60% of the spilled oil at sea by natural processes and the targeted application of dispersing agents prevented extensive shoreline oiling. Less than 1% of the original spill was estimated to have reached the shoreline.

- Shoreline oiling occurred at a limited number of locations, primarily on exposed sand beaches. The sand beaches underwent self-cleaning by natural processes within 2-4 weeks after the spill.

- Any overall adverse effects of the spill on biological communities were very limited in extent and duration. The lack of heavy and extensive shoreline impact, particularly in sheltered mangrove areas, predicted a rapid recovery from any short term biological effects and minimal, if any, long term biological effects.

The initial impact assessment, which included an extensive shoreline mapping program, provided valuable information on short term impacts and also served as a basis for the longer term fate and effects program.

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