Paper ID#76, 1999 International Oil Spill Conference

RAPID OPERATIONAL AND SCIENTIFIC RESPONSE TO THE IDOHO-QIT PIPELINE SPILL, NIGERIA

O. T. Olagbende
Mobil Producing Nigeria Ultd.
Mobil House, Lekki Expressway, Victoria Island PMB 12054, Lagos, Nigeria

G. O. Ede
L. E. D. Inyang
Mobil Producing Nigeria Ultd.
PMB 1001 Eket, Akwa Ibom State, Nigeria

ABSTRACT: *The 12 January 1998 rupture of a 24-inch pipeline from the IDOHO platform to the Mobil Qua Iboe terminal resulted in the release of approximately 40,000 bbl of light Nigerian crude oil. Because of rapid westerly transport, dispersants were the method of primary response, with approximately 250 barrels being applied. Also, because more than 90% of the oil was dispersed offshore, heavy shoreline oiling was limited and localized. However, due to westward transport by nearshore currents, remnants of the spill tracked 5-10 km offshore from the spill source were observed at Lagos harbor, about 900 km away. Oiling of interior sensitive mangrove habitats was limited to a few locations. Exposed sand beaches self-cleaned within 2-3 weeks. Cleanup of heavily impacted shoreline areas recovered approximately 1000 bbl of oily waste. A national and international team of scientists was activated within 24 hours and directed toward measuring impact on environmental resources important to local human activities. Elements of the scientific program were (1) offshore components, including fisheries, benthos, chemistry, microbiology; and (2) riverine/estuary, including extensive water analysis to detect any spill input to water resources used by local settlements and chemical analysis of local fish market samples. Preliminary results indicated that any initial environmental effects were limited and localized. Based on the intial program, a larger followup program is planned involving offshore studies, a shoreline fate and effects program, impact to mangrove habitats, and a study of any socioeconomic and human health effects.*

DISCUSSION

Introduction

On Monday, January 12, a rupture in a 24" pipeline 4.8 km offshore between the Idoho platform and the Mobil Qua Iboe Terminal (QIT) facility resulted in the release of approximately 40,000 bbl of Nigerian crude oil. In response to the spill, cleanup and containment equipment were immediately deployed. Clean Nigeria Associates (CNA), other oil companies, as well as Nigerian and foreign experts were invited to assist in the cleanup and the assessment of the spill's impact on offshore and coastal areas.

The Niger Delta region of Nigeria is one of the major oil producing regions of the world. Within this area, there are 13 oil companies producing oil onshore and offshore. 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/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. The characteristics of these regions are as follows (Dublin-Green et al., 1997):

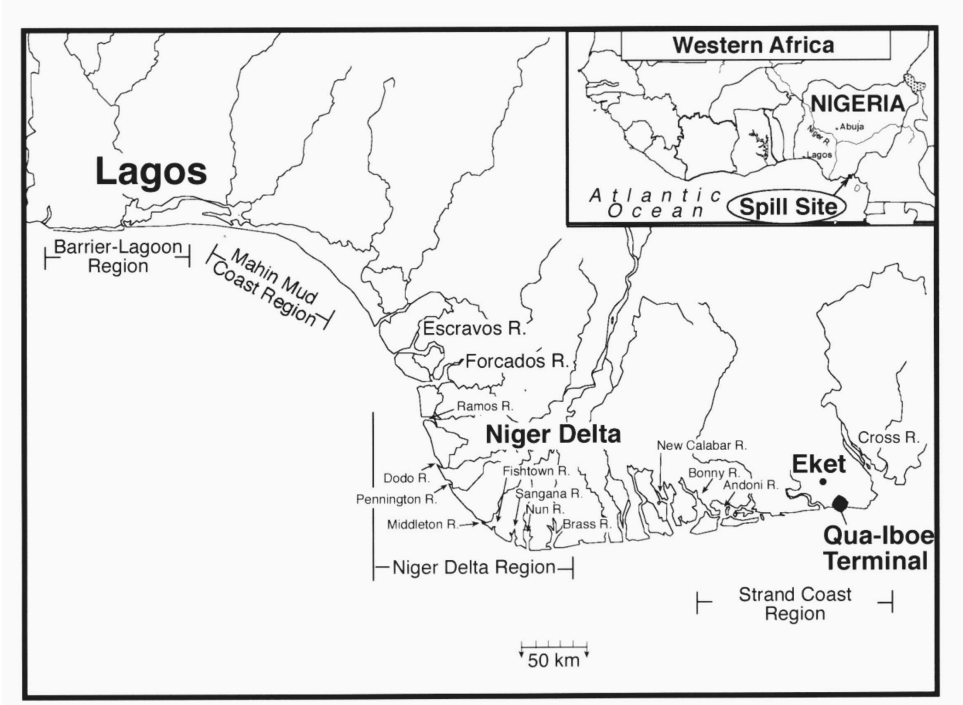

Figure 1. Map of Nigerian Coast, with Inset Map of West Africa Major Physical Features and Coastal Regions.

- The Strand Coast in the eastern area is 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 is 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 consists 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 70 million inhabitants. It is characterized by barrier islands having extensive areas of low-energy sheltered lagoons.

Spill track

The spill incident occurred during the “harmattan” period of the year when easterly winds carry fine dust from the Sahara westward. This caused a reduction in visibility during the initial days of the response and dictated the use of helicopters rather than fixed-wing aircraft for spill tracking. For the first four days after the spill, the spill track was generally offshore and westward, driven by the residual westerly nearshore tidal flow. By January 17, the predominant wind direction shifted to the southwest causing bodies of oil to go ashore at sporadic locations along the coast between the Sangana and Forcados Rivers (Figure 1). Figure 2A shows the position of the offshore body of oil on January 15. By January 28, the final remnants of the same body of oil were in discontinuous bands off the coast of Lagos lagoon, where stranding occurred at specific locations (Figure 2B), approximately 900 km west of the spill site.

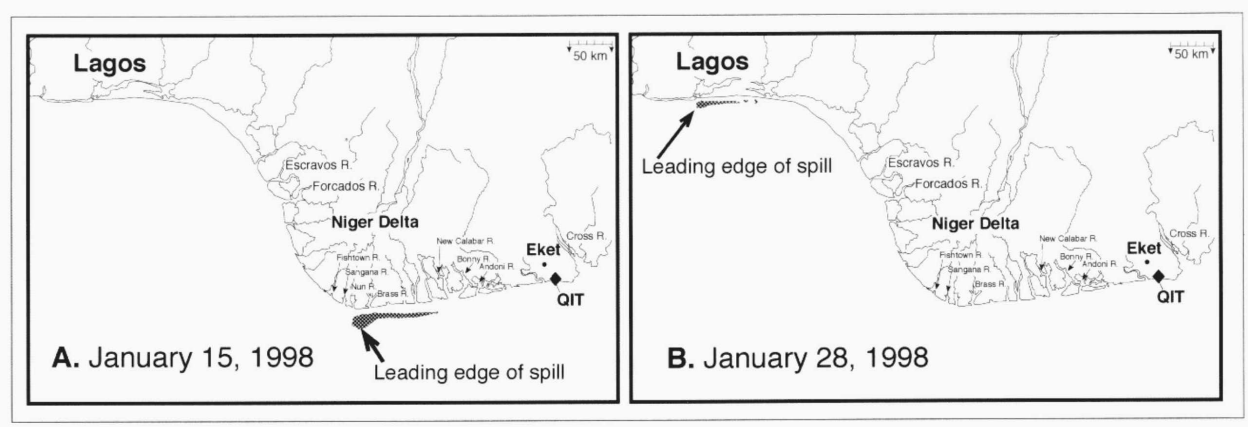

Figure 2. Overview of the spill track. A. The location of the body of spilled oil off the Brass River on January 15 1998. B. The location of the remnants of spilled oil off Lagos Lagoon on January 28 1998

Cleanup response

In response to the spill, the application of dispersants from vessels was mobilized immediately as the principal 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. Aerial observers in helicopters closely tracked the spill and directed the response vessels. With the offshore slick moving to the west and persisting longer than 48 hours, MPNU required information on whether the dispersant operation would be effective after the oil had weathered on the sea surface for longer than 48 hours. Computer modeling of the evaporation of the low molecular weight fraction of the Nigerian crude oil under the 3 knot wind, 28°C water temperature conditions predicted that approximately 40% of the mass of the oil with carbon numbers less than nC15 would evaporate within 72 hours after the spill.

A dispersant use monitoring team (National Environment Technology Centre, NETCEN, UK) was mobilized and began monitoring the dispersant operation 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 hours) during which a significant mass of oil remained on the sea surface. The effect of the high tropical sea temperatures kept the viscosity of the oil lower than it would have been in colder temperate waters, and thereby extended the time period when the spill could be treated by targeted dispersant application. The application of dispersant and the type of products used is summarized in Table 1 and cumulative dispersant use is shown in Figure 3.

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

Date (January 1998)	Volume dispersant applied (bbls)	Cumulative volume applied (bbls)	Dispersant types Applied
12	9	9	Gold Crew
13	31	40	Gold Crew
14	36	76	Gold Crew
15	64	140	Gold Crew
16	72	212	Gold Crew, Corexit 9500, Corexit 9527
17	21.5	233.5	Corexit 9500, Corexit 9527
18	2	235.5	Corexit 9527

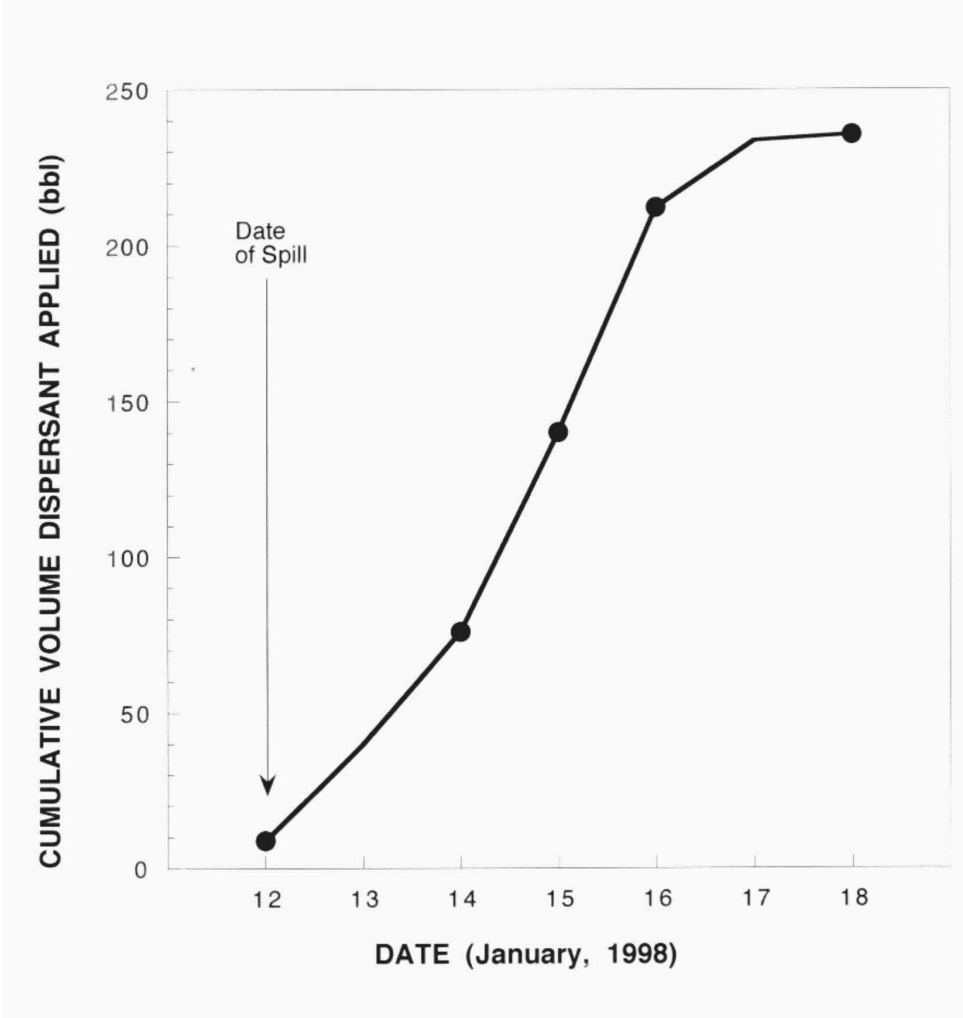

Figure 3. Cumulative dispersant use of all types during the period 12 January 1998 - 18 January 1998.

Over flights of the spill zone monitored areas of shoreline between January 16 and February 5. 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 4 shows the shoreline oiling results for the Niger Delta coast. This shoreline oiling information is 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 Sangana and Forcados Rivers. Most of these exposed sand beaches self-cleaned as a result of wave action within 2-3 weeks. 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-to heavy deposits of oil noted in the mangrove fringe of creeks near river mouths in the Niger Delta. In the Lagos Lagoon area, remnants of the spill reached some shoreline locations 2-3 weeks after the spill, requiring shoreline cleanup in the affected areas. Based on aerial surveys, dispersant use monitoring and estimates of oil behavior in the environment, an approximate mass balance defining the fate of the spill oil can be made. This is summarized in Table 2.

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

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

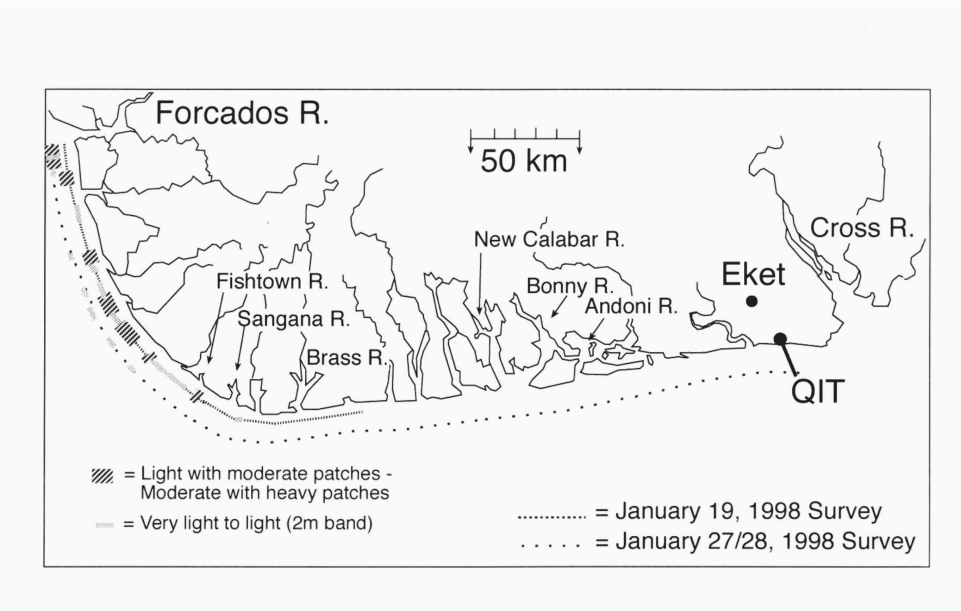

Figure 4. Shoreline oiling map of the Niger Delta area showing the results of aerial video surveys done 19 January 1998 and again on 27/28 January 1998.

A total of 10 locations had oil bands greater than 4 m which warranted shoreline cleanup activity. Table 3 summarizes the shoreline cleanup activity in terms of debris collected and manpower use. It is estimated that the shoreline cleanup recovered a total of about 1000 bbl of oily waste. Most of this was aquatic plant material from the Lagos Lagoon area with a high water content. Therefore, the actual oil residue recovered in the shoreline cleanup was less than 10% of the 1000 bbl of waste recovered.

Table 3. Summary of shoreline cleanup by area, with amount of debris recovered and manpower used.

Areas Cleaned	Area Reference (See Figure 1)	Oily Debris Collected	Manpower Used
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 drums/2 containers	250 men

The initial scientific response

Because of the local population's dependence on coastal resources a major concern of was the protection of those resources. The initial response was, therefore, a human resource based response (MPNU, 1998). A team of Nigerian University scientists, local and international consultants, and Mobil personnel was activated immediately following the spill to initiate scientific studies. Major elements of this team were in the field taking samples within 24 hours post-spill. Entities contributing personnel to the initial scientific response team included:

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

The goals of the initial scientific program were directed toward measuring oil spill impacts on those environmental resources important to local human activities (MPNU, 1998). There were two major elements to this response. The first was an offshore program designed to detect impacts on fisheries. The second element was based in the river estuaries and was designed to detect acute spill impacts on water and food resources used by local people. The results are summarized below.

The Offshore program: The offshore program consisted of sampling at 26 stations extending the length of the Nigerian coast from QIT to Lagos (Figure 1).

- Microbiology: Eleven of the 26 offshore stations were sampled for bacteria. The offshore surface waters were very rich in heterotrophic bacteria. Total counts ranged from 8 x 10^6/100ml to 6 x 10^8/100ml. Total 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. However, hydrocarbon metabolizing bacteria 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 and that relatively little of it was derived from hydrocarbons.
- Plankton: A total of 13 sites were sampled for plankton. Phytoplankton abundance and biomass was low. The zooplankton community was rich and diverse. It contained oil sensitive groups such as crab zoea and juvenile copepods.
- Water column total extractable lipids: Surface water samples were taken at 30 stations. They were analyzed for total extractable lipids. 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 lipids.
- Offshore benthos: 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 were found in a sample. One sample off the Sangana River contained no organisms at all. These results are reasonable in light of 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 associated with low densities of infauna. In a 1996 environmental impact assessment study offshore of the Bonny River (MPNU, 1997), a total of 15 offshore sediment samples were taken and analyzed. Median values for TOC (16.6%), Sand (20.3%), Silt (22.1%) and Clay (50.5%) were obtained. The sediments described for offshore of the Bonny River are so fine grained and so loaded with TOC that they are highly reduced and do not support an abundant infauna as observed for the same general area in this 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 bacteriological 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; it is not an effect of the IDOHO oil spill.

The Rivers/Estuaries program: There were two elements comprising the estuaries program, ambient water quality and fisheries. They were both directly concerned with determining any impact of the spill on those aspects of the environment which affect the local population in their daily lives.

- Ambient water quality: A total of 25 rivers were sampled for water quality, including 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) were sampled seven times during the spill. Figure 5 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 5 that the concentration of total extractable lipids in the water is not related to proximity to IDOHO; rather it is a property of the various rivers. The Middleton River (Figure 1) has the highest total extractable lipid values observed except for those waters offshore of the Mahin mud beach. The Middleton River also supports the highest population

of hydrocarbon degrading bacteria. Waters offshore of the Mahin mud beach (Figure 1) had the highest levels of total extractable lipids. This probably reflects the large suspended sediment load in the 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 (FEPA, 1991). 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.

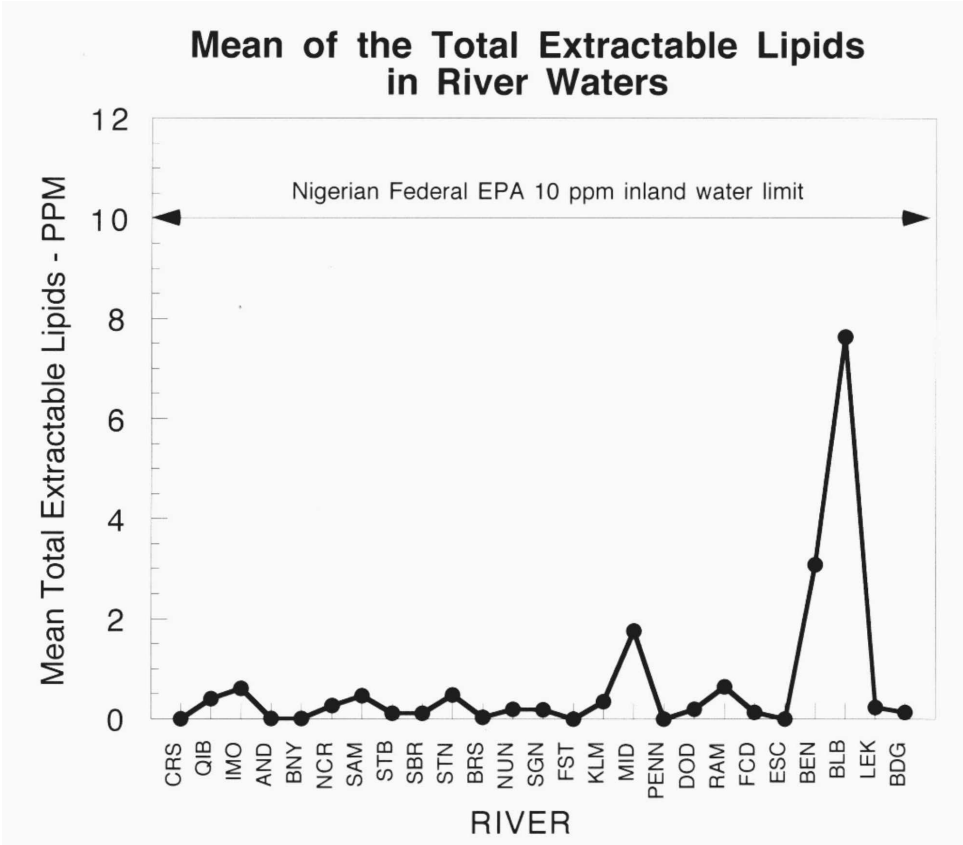

Figure 5. Mean total lipids extractable in river mouth waters sampled in January 1998. The rivers in the figure run from east (Cross River) to west (Lagos Lagoon). Abbreviations for river names are: Cross River (CRS); Qua Iboe River (QIB); Imo River (IMO); Andoni River (AND); Bonny River (BNY); New Calabar River (NCR); Sambreiro River (SAM); St. Bartholomeo (STB); Santa Barbara River (SBR); St. Nicholas River (STN); Brass River (BRS); Nun River (NUN); Sangana 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).

- Fisheries: Total extractable lipids in fish used for food by local populations was measured in fish of various species obtained from local fishermen in six rivers within the spill zone and two rivers outside the spill zone. This fairly represented the range of fish being eaten by the local population. A total of 96 individual fish representing 41 individual species were collected. Only 1 of the 96 individuals exceeded the United Nations 25 ppm (GESAMP, 1977; FAO 1976) threshold for hydrocarbons in fish. That individual was a *Polydactylus quadrifilis* from Sangana 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; the fish in the Sangana River may have accumulated some hydrocarbons over time and the slightly elevated total extractable lipid level may have no relation to the IDOHO spill. 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.

Beyond the Initial Scientific Response

The goal of the longer term scientific study is to assess whether injury from the oil spill can be detected in the environmental and human resources of the spill zone. Field

sampling is planned to start in August/September 1998. The study plan is designed to enable comparison 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 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 will be 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. Stratified benthic sediment cores will be sampled and analyzed for hydrocarbons to provide pre-spill information.
- Coastal/Beach Survey: Most of the shoreline affected by the spill was exposed sand beaches. Because of the use of these beaches in many locations by indigenous people, it is important to determine the persistence and effects of spill residues in this habitat. The objective of this element of the program 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. These will be used to select 26 initially-oiled and unoiled beach areas for sampling within the shoreline impact zone in the Niger Delta region (Figure 1). Sediment samples will be 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) will be sampled as controls.
- River/Estuary Survey: An intricate system of rivers and estuaries dissect the coastal sand and mud beaches of Nigeria. This system 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 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 will be sampled for water quality (microbiology, total extractables). Benthic and creek bank stations in mangrove creeks near the mouths of oiled and unoiled rivers will be 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 will be done. The health and abundance of estuarine fish stocks will be 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. 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. Respondents will be asked a series of questions as to their knowledge of the incident and its effect on their lifestyle (perceived and actual).
- 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 documented and mapped.

Conclusions

1. Successful dispersal of approximately 60% of the spilled oil at sea by natural processes (c.a. 45%) and the application of dispersing agents (c.a. 15%) prevented extensive shoreline oiling. Evaporation at sea reduced the original volume of the spilled oil by approximately an additional 40%. Less than 1% of the original spill was estimated to have reached the shoreline.
2. Visible 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.
3. The 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.
4. A human resource-directed initial impact assessment provided valuable information on short term impacts and also served as a basis for the longer term fate and effects program.

Acknowledgements

The authors would like to thank the scientific support team, Dr. Edward Gilfillan, Dr. Erich Gundlach and Dr. David Page, for their help in the scientific response and the preparation of this manuscript.

References

1. Dublin-Green, C.O., A. Awobamise and E.A. Ajao. 1997. Coastal profile of Nigeria. Large Marine Ecosystem Project for the Gulf of Guinea. FEPA, Surulere Secreteriat.
2. FAO 1976. Water Quality Criteria for European Fresh Water Fish. EIFCAC TECH. PAP. 27: 321 pp.
3. FEPA 1991. Guidelines and Standards for Environmental Pollution Control in Nigeria. Federal Environmental Protection Agency. 239 pp.
4. GESAMP 1977. Joint Group of Experts for the Scientific Aspects of Marine Pollution. Report No. 6.
5. MPNU. 1997. Environmental Impact Assessment: Capital Dredging of Approach Channel, Offshore Bonny, Rivers State. Lagos. xxiv & 91 pp.
6. MPNU. 1998. 24" IDOHO-QIT Pipeline Rupture Oil Spill (January 12, 1998). Mobil Producing Nigeria, Lagos. 106 pp.