

# NATURAL RESOURCE DAMAGE ASSESSMENT PROGRAMME FOR TASMAN SPIRIT OIL SPILL IN PAKISTAN

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## ABSTRACT

The oil tanker *Tasman Spirit* was grounded in the channel of the port of Karachi, Pakistan on 27, July 2003. The vessel was carrying a cargo of 67,535 tones of Iranian Light crude oil for delivery to the Pakistan Refinery Limited in Karachi when the grounding occurred. Significant quantities of oil were spilled when the *Tasman Spirit* broke up during the evening of August 13, 2003. By 18 August approximately 27,000 tones of cargo had been lost. The coastal environment in which the *Tasman Spirit* oil spill (TSOS) occurred is a rich and diverse tropical marine/estuarine ecosystem. It includes extensive mangrove forests, habitat for sea turtles, dolphins, porpoises, and beaked whales, and several species of lizards and sea snakes. The initial findings revealed that the initial impacted area covered about 1600 square kilometer and a coast line of 7.5 kilometer. Pakistan does not have the expertise to deal with oil spill disaster of this magnitude. The rapid assessment report was prepared with the assistance of United Nations Development Programme, United Nations Environment Programme and local experts. The report emphasized the need of carrying out a Natural Resource Damage Assessment (NRDA). This paper highlights important findings of the NRDA study describing the methodologies adapted for the systematic assessment of the extent and severity of the environmental damage and ecological injury resulting from the *Tasman Spirit* Oil Spill.

## DISCUSSIONS

### Background

An oil spill of about 31,000 tons of crude oil occurred in the Karachi Coast from an oil tanker "M. T. *Tasman Spirit*" (Figure 1) grounded at 1.5 nautical miles from shore.



FIGURE 1: OIL TANKER TASMAN SPIRIT

The oil tanker was carrying 67,535 tons of Iranian Light Crude Oil for delivery to Pakistan Refinery Limited in Karachi, Pakistan when it was grounded on 27th July 2003 adjacent to the approach channel of Karachi Harbour (Figure 2).

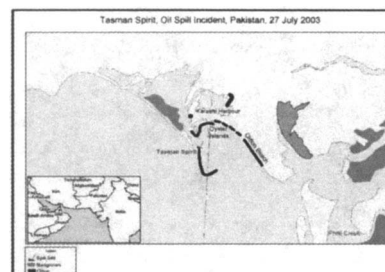


FIGURE 2: TASMAN SPIRIT OIL SPILL INCIDENT AT KARACHI HARBOUR, PAKISTAN

The oil spill continued from the tanker during the evening of 13th August 2003 up to the first week of September 2003. The ship was 24 years old, with perhaps weak engines, and therefore failed to overcome the external forces and deviated from the main course. Unsuccessful attempts were made to refloat the grounded ship using six tow ropes and a powerful ship. Later, oil started leaking from the ship. Efforts were made to plug the source of the leak but the leak could not be controlled. The ship sustained a serious crack on 13 August 2003 and extensive spillage of oil took place. Two compartments containing about 6000 tons each completely drained out. As a result, about 31,000 tons of the oil spilled into the shallow coastal waters of the Karachi Coast.

### Impact of *Tasman Spirit* Oil Spill

The most oil impacted coastal areas were Clifton and DHA Beaches, Karachi Harbor and the offshore area adjacent to Clifton and Defense Housing Authority (DHA) Beaches. The initial assessment reports estimated that about 11,000 tons of volatile organic compounds (VOCs) were released in the air from the oil spill. The residential areas along the Clifton and Sea View coast, up to 6 km inland was affected with elevated concentrations of VOCs for about three weeks. Despite a massive beach cleaning operation (Figure 3), oil contamination remained highly visible on the beaches and in adjacent seawater for the next 6 months and moderately visible for the next 12 months after the incident. Ecologically sensitive creek areas with mangroves are present on the southeastern coast of Karachi. To the west of the grounding site are known turtle nesting sites along Hawks Bay and Sand Pit.

Within the port of Karachi are salt ponds, mangrove forests and the harbor, mainly used for the shrimp fishery, as well as shipyard facilities, oil terminals, Pakistan Navy installations, and a sea water intake. These are all potentially sensitive to oil contamination. To the east of the grounding site are mangrove forests. This area and the area offshore of the grounding site are rich fishing grounds.

The Karachi coastal area impacted by the oil spill is one of the most productive areas of the coast. The area is known to be rich in biological productivity. It includes habitats for sea turtles, dolphins, porpoises, beaked whales, and several species of lizards and snakes. More than 200 species of fish are known to exist in the Karachi Coastal waters. Many fish and shrimp species that constitute commercial and artisanal fisheries use the oil impacted areas for feeding and nursery grounds. Over 50 species of birds (resident and migratory) utilize this area for feeding. The coastal area of Karachi impacted by the TSOS also includes ecologically sensitive mangrove ecosystems in Indus Delta creeks and Karachi Harbor areas. These provide feeding and nursery grounds for important components of the coastal marine food web.



FIGURE 3: KARACHI BEACH CLEANING OPERATIONS AFTER THE TASMAN SPIRIT OIL SPILL

### Oil Spill Response

Soon after grounding of the ship, the Karachi Port Trust (KPT) Marine Pollution Control Center approached the International Oil Tankers Pollution Federation (ITOPF) and called for emergency assistance. All oil spill response equipment available from the Port Qasim and Maritime Security Agency (MSA) were pooled and provided to the KPT for response operations. The KPT deployed booms and skimmers. Due to limited response capacity, the oil could not be completely contained. Oil mostly spread towards the east and exposed 10 to 11 km of coastline. KPT used booms and skimmers to protect the main channel to keep it open for vessel traffic. ITOPF started operations on 14 August 2003 after the oil had already exposed Clifton beach.

Efforts were also focused on the use of dispersants using aircraft, booming to keep oil from reaching the oil terminal piers, skimming, and manual cleanup of the floating oil debris in the port. Cleanup operations lasted several months.

### Formation of the Environmental Impact Evaluation Committee

The TSOS was a major pollution event. Pakistan does not have the expertise to deal with an oil spill disaster of this magnitude. An important task after cleanup was to investigate the long-term impacts of this incident, through assessment studies and monitoring, and to prepare restoration plans and implement them accordingly.

It was imperative to determine the extent of the environmental injuries by a scientific investigation covering the affected resources. A NRDA requires consideration of acute and long-term injury, sub-lethal injury, and ecosystem-wide effects. In general, all components of the potentially affected ecosystem were to be assessed for injury, including coastal habitats, air, water, fish, shellfish, plankton, sediments, marine mammals, terrestrial mammals, and birds.

On 15 August 2003, the Government of Pakistan formed an Environmental Impact Evaluation Committee (EIEC) to evaluate the impact caused by the TSOS, and to propose an appropriate restoration plan. The EIEC was composition of government agencies, non-governmental organizations, and natural resource specialists. The Ministry of Environment contacted United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP) and International Union of Conservation (IUCN) for assistance. Consequently, Professor Richard G. Steiner of University of Alaska and Mr. Stefan Micallae, Chief, Disasters Management Branch, UNEP, traveled to Pakistan to assist EIEC to prepare a report in consultation with local officials. The in-country office of the UNDP facilitated the work through monetary and technical support.

The EIEC submitted its preliminary assessment report on September 9, 2003. The report estimated that, despite response efforts, the area impacted by the spill covered at least 40 square kilometers. It reported extensive hydrocarbon contamination in seawater samples; counts of 1,000 dead fish at a single sampling station in a day; cell damage in phytoplankton communities; reduced numbers of polychaete worms, shellfish and starfish in the surface sands of Clifton Beach; and loss of a regeneration of mangrove growth, etc. The report emphasized the need to carrying out a full NRDA to:

- Determine the extent and severity of ecological injury from the spill;
- Provide detailed technical information upon which to base a claim;
- Develop and implement a restoration programme, and
- Inform the citizens of Pakistan, in an open public process and scientifically valid manner, the extent of the environmental damage resulting from the TSOS.

### Commencement of NRDA and Methodology

In line with the recommendations of the EIEC, a comprehensive NRDA programme was initiated by the Pakistan Environmental Protection Agency (Pak EPA), Ministry of Environment in collaboration with the UNDP. The objective of the NRDA programme was to conduct the phased NRDA, including preparing a restoration plan, and to initiate a national system for spill preparedness and response. The NRDA Phase 1 was completed in June 2004. Most activities planned for Phase-II were included in Phase-I in view of their importance, and in order to reach a logical figure for total damages due for the TSOS. The following studies were carried out under NRDA:

- Oil Spill Trajectory Analysis
- Sediment Study
- Seawater Study
- Biological Study
- Fish/ Shellfish Study
- Birds/ Marine/Mammals/Carcass Survey
- Sea Turtles Study
- Mangroves Study
- Socio-economic Impacts Study

## RESULTS

### Seawater Contamination

Poor water quality in an area of about 2,000 sq km area was documented offshore of Karachi. The poor water quality affected the entire ecosystem and virtually all the living organisms in that area including commercial species of fish and shellfish as well as the marine food chain. The water quality remained un-acceptable for more than six months. During the initial phase of the NRDA program the concentration of oil in the surface seawater was observed to be 5-10 mg/l (parts per million) in the near-shore areas, although even higher concentrations were reported immediately after the spill. Phytoplankton productivity in heavily oiled areas such as Manora Channel was reduced due to reduced light penetration into the water column. The oil concentrations remained high in the seawater for about six months after the spill.

### Sediment Contamination

During the initial phase of NRDA the concentration of oil in the bottom sediment ranged from 100 ppm (parts per million)—350 ppm in the near-shore areas. The oil concentrations remained high in the sediment even three months after the spill. It has now been observed that the oil concentrations in the seabed sediments of an area of about 270 sq km is high, and this oil has been positively fingerprinted as TSOS. The oil content also affected the dissolved oxygen content of seawater in the affected area. The NRDA studies estimated the amount of Tasman Spirit oil that sunk to the seabed was over 16,000 tons—about 51% of the total spill volume. This oil deposition occurred because of the extreme turbulent mixing of the sea by strong monsoon winds after the spill, which caused the oil to attach to the suspended sediment and sink to the seabed. The seabed remains heavily contaminated.

### Sub-tidal Habitat

The polluted water and sediment habitats are expected to lead to both lethal and sub-lethal injury to sub-tidal habitat on a long-term basis. The severe short-term impacts on habitats make them ecologically unsuitable for the normal growth and propagation of many marine organisms. The long-term effects of oil-polluted habitat are usually delayed and become noticeable on the resident fauna and flora of the oil polluted marine environment usually after one to several years of exposure to oiled environment. It is therefore, likely that the oil-impacted region may continue for several years to exhibit a reduction in the species diversity, reduction / depletion of wild stocks of vulnerable species, reduction in reproductive capacities, disruption in growth rates, accumulation of toxic fractions of hydrocarbons such as Polynuclear Aromatic Hydrocarbons (PAHs), and may also produce synergistic negative effects on the metabolic processes and reproductive physiology of the marine organisms living in the oil polluted habitats. High levels of PAHs were reported in many tissues sampled, up to 74 ppb (parts per billion) in some organisms. Studies elsewhere have demonstrated that PAH levels as low as 1 ppb are known to produce toxic, long-term effects.

### Coastal Fisheries

The oil significantly affected fish and shellfish populations and commercial fisheries in the coastal area of Karachi, and resulted in both lethal and sub-lethal to their food in the marine area within the oil-impacted zone. Studies reported a complete loss of the small-scale fishery for some time in the oil-spill affected zone. Although not studied specifically, researchers suspect that there will be damage to eggs and larvae of commercial fishes in the affected zone, resulting in loss of future recruitment in fisheries stocks from this area. Based on the data from bottom trawling,

the immediate effect of the oil spill caused mass mortality among the coastal fishes resulting in a drastic reduction in flat fishes and mullet populations in the area. The oil spill eliminated many fish from the area. At shallow depth (3-5 meter) all important indicator species were absent during sampling, except Sole (*Solae elongata*, *Cynoglossus sp*), and Green weeds (*Cheatomorphau sp*). Reduced fish catches of a few coastal species during the post-spill period have been observed particularly for the Indian Mackerel (*Restrillegger kanagurta*—local name Bangra). Reduced species diversity and richness in the fish and crab community composition was reported, and there appears to be a significant reduction in the squid fishery to date. High concentrations of toxic PAHs were observed in all the fishes caught from the oil-impacted area. Considering the cumulative effects in this case, the expected time for full recovery of fisheries is 5 -7 years.

### Birds

Although only six dead Herring Gulls were observed in the post-spill carcass survey, this number represents only a small fraction of total acute bird mortality as most dead seabirds were likely lost at-sea and never recovered. Sub-lethal effects are expected to manifest in the affected bird population as long-term impacts. Bird populations feeding in waters within sea area of about 200 sq km contaminated with oil will continue to be contamination by ingestion of oil fractions, as well as potentially exhibit other food chain impacts. The bird study documented significant avoidance by birds of oil impacted beaches for feeding and breeding, thus it remains plausible that there will be a reduction in growth and reproduction of bird populations—both resident and migrant—in the oil impacted zone in years to come.

### Marine Mammals

Several direct mortalities of dolphins in the affected area were observed, and investigators feel there is probability of sub-lethal effects in the black finless porpoise population over the long-term, as well as a potential for continued displacement from contaminated habitat areas near Karachi. Black finless porpoise were not reported in their normal range during the sampling period. There is a real possibility of porpoises and dolphins ingesting oil-contaminated fish prey, and developing physiological and reproductive impairment in the future.

### Sea Turtles

Direct mortality was observed for a few sea turtles recovered in the carcass surveys. Sub-lethal effects are expected in the affected turtle population as long-term impacts, as turtles feeding in waters within sea area of about 200 sq km could still be contaminated with oil. This could cause a future reduction in egg hatching success in the affected population of turtles, as well as an accumulation of PAHs in sea turtle blood, organ tissues, and eggs. Significant levels of PAHs were detected in turtles blood and egg tissue samples subsequent in the 2003 nesting period. Long-term impacts on sea turtles leading to delayed mortalities and reduction in reproductive fitness are possible.

### Mangroves

Oiled impacted a mangrove forest area estimated at approximately 786 hectares (or 2435 acres). Mangrove seedling survival rate dropped from 30% to 10 %—a loss of 51,135,000 seedlings for the mangrove *Avicennia marina*. Lethal and sub-lethal toxic effects on mangroves were reported. The lethal toxic effects caused mortalities of the mangroves by heavy oil that covered the tree's breathing pores, propagules and seedlings. The sub-lethal effects may lead to impairment of the salt exclusion by the toxicity of substances in the oil. The death of millions of propagules and

seedlings due to toxicity of the crude oil from TSOS may lead to disturbed / hampered natural regeneration process in the mangroves along the coast of Karachi. Loss of expected production of 2526 tons of shrimp and fish per year in the lost mangrove area would result.

### Socio-economic injury

The studies documented extensive and profound effects of the Tasman Spirit spill on the human populations living in the area. As an estimated 12,000 tons of the spill volume evaporated while there were strong onshore winds, and the plume of that toxic component of oil drifted over the coastal population. With some 300,000 people exposed to petroleum hydrocarbon vapours, this likely represents the largest exposure of humans in any oil spill in history. Health, psychological, and social effects were immediate and significant. Studies documented an increase in anxiety disorders, hopelessness, depression, etc. The health impacts such as nosebleeds, nausea, fainting, memory loss, and chest pain were reported to increase immediately after the spill. The most affected group of residents was coastal fishermen, who reported a 100% loss of income during the 6 months subsequent to the TSOS.

### Projected Environmental Recovery Time

Although surface water quality has improved dramatically, sediments remain heavily contaminated and it is not feasible to dredge and clean the vast area that is contaminated. Likewise, it would be very difficult to get the spilled oil out of the sediments in mangrove forests in the creek environment and backwaters. Natural cleaning and bio-degradation processes take much longer time to clean / degrade oil in these environments than at the more dynamic open coastal environment at the open coast beaches. Considering the various ecological parameters, biological degradation rates, high temperatures, organic matter content in water and sediments, and recovery periods for other oil-spills in tropical environments, the water quality off Karachi is expected to recover in relatively quickly. However, full recovery is not expected to take place until all of the spilled oil from the Tasman Spirit in seabed sediments is gone and/or stops leaching out the water column above. This is expected to take 5-7 years, but in some areas, the oil may remain buried in the seabed sediments for longer periods and full recovery may take longer. Full ecological recovery is expected to take place when there is a fully functional coastal ecosystem present, the injured populations have returned to pre-spill abundance and distribution, and all Tasman Spirit oil is gone from the environment. Full ecological recovery from the Tasman Spirit Oil Spill is expected to take 5 - 10 years.

### CONCLUSION

The assessment of damages to natural resources requires consideration of immediate (acute) injury, long-term injury, sub-lethal injury and ecosystem-wide effects. In general, all components of the potentially affected ecosystem should be assessed for their injury, including coastal habitat, air and water, fish, shellfish, plankton, sediments, marine mammals, terrestrial mammals, and birds. The NRDA Phase I report includes a synthesis of the findings, including the extent of the damages due to the TSOS, injury determination and quantification, expected recovery periods, restoration potential, and identification of priority projects for implementation in next phase.

The NRDA Phase I studies revealed that the total area of marine waters impacted by oil is more than 2,000 sq km. An estimated 11,000 tons of volatile organic compounds (VOCs) were released into the air from the oil spill. The worst impacted areas of the Karachi Coast included the most popular recreational beaches of Clifton and DHA beaches covering about 16 km of coastline.

Residential areas along the Clifton and Sea View coast, up to 6 km inland, remained affected with air having high concentrations of VOCs for about three weeks. Despite a large beach cleaning operation, the oil on the beaches and adjacent seawater remained prominently visible for the next 6 months, and somewhat visible for 12 months after the TSOS incident. This spill severely damaged the marine ecosystem of Karachi Harbor and Clifton and DHA coastline up to the western coastline of Bundal Island.

Short term impacts of the TSOS included large scale mortalities of benthic fauna, flora, and fisheries, including commercial fish and marine invertebrate species. Injuries to birds, mammals, sea turtles, and mangroves were documented in the oil-impacted zone. Socio-economic (human use) losses, particularly public health issues, affected the coastal human population of about 300,000 in the affected areas, were documented.

The report concludes that it is expected to take a minimum of 5-7 years for the short term marine ecosystem injury to recover, and 7-10 years for recovery of the long term injuries. The public health impacts may take more than 10 years to recover. The NRDA Phase I report also includes restoration planning to facilitate recovery of the injured ecological health of the impacted area and identifies priority projects for implementation.

### BIOGRAPHY

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### REFERENCES

- Amjad, S. and Rizvi, S. H. N.** 2002. Pakistan's National Action Programme under the "Global Action Programme (GPA) for the protection of marine resources from land based pollution sources". Ministry of Environment and Local Government and the National Institute of Oceanography, Karachi, Pakistan. 180 pages.
- Ghazala Rubab Aftab.** Defence Housing Authority. (2004). NRDA-Socio-Economic Analysis .p. 4-22.
- Hamid Iqbal Javed.** Zoological Survey Department. (2004). NRDA-Study on Birds, Marine Mammals and Carcass, p. 2-15
- IUCN, UNEP, UNDP, GOP,GOS.** (2003).Tasman Spirit Oil Spill-Assessment Report, p. 2-22
- Mohammad Tahir Qureshi.** IUCN-Pakistan. (2004). NRDA-Mangrove Resource Study, p.3-7.
- NIO, (2004).** NRDA-Consolidated Report, p. 03-118.
- NIO, (2003).** Preliminary Report on Impact of oil spill from "Tasman Spirit" on marine environment with special reference to marine organisms. p. 1-50.
- NIO, (2004).** NRDA-Simulation of Oil Spill Trajectory and Dispersion in Karachi Coast, Pakistan, p. 3-18.
- NIO, (2004).** NRDA-Biological Analysis of Oil Impacted Area, p. 5-21
- NIO, (2004).** NRDA-Water Quality, Total Hydrocarbons, PAHs, and Finger Printinting of Oil in Sediments, p. 3-12
- NIO, (2004).** NRDA-Sediment Study, p. 2-12
- Pak EPA/ NEAP-SP2,** 2003. Natural Resource Damage Assessment (NRDA) Project for Tasman Spirit Oil Spill. National Environmental Action Plan-Support Program, Sub Programme "Pollution Control" Pages 34.
- Waheed Ahmed.** Fisheries Department, Government of Sindh. (2004). NRDA-Study on Fish and Shell Fish, p.3-17.