

Case Studies of Some Major Oil Spills Around India

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Abstract

Following the enormous oil spills resulting from the 1990-91 military conflict in the Gulf, much fear was expressed concerning the spread of oil from the Gulf into the Arabian Sea and the Indian Ocean. To investigate the contamination of the northern Arabian Sea with oil, two sampling cruises were undertaken during 1991. The sampling strategy was designed to investigate the most likely path of the outflowing water from the Gulf. Floating tar balls were enumerated and analyses performed to measure the petroleum residue in water and in sediment and in biota samples. Concentrations were found to be within the ranges reported for comparable pre-war surveys, and collectively the results indicated that in the areas investigated, negligible contamination had occurred due to the Gulf oil spills. It is considered probable that the prevailing physical oceanographic conditions within the Gulf favoured the dispersal of the spilled oil.

Similar observations on the oil slicks, tar residues and dissolved petroleum hydrocarbons, shortly after the oil spill resulting from the tanker accident in January 1993, showed negligible impact on the Indian EEZ of the Great Channel (Andaman Sea). Prevailing the NE wind and the resultant SW surface currents appear to have pushed the oil patches out towards the Indian Ocean. A repeat of the observations in October 1993 did not indicate any sign of the oil in the bottom coralline sands. However, zooplankton biomass increased considerably during the interval, probably due to the seasonal changes and natural variability. The spill did not cause any perceptible impact on the environment.

In May 1993, accidental rupture in an oil processing platform in the Bombay High resulted in a 1600 tonne oil spill. Due to the prevailing NW wind the spill spread towards the Konkan coast, south of Bombay, and resulted in tar deposits on the Murud beach. The beach had to be cleaned manually.

Sources of Oil Pollution in the Indian Ocean

Major source of oil pollution in the Indian Ocean is the transport of oil in large tankers starting from the oil terminals at the ports of Middle East countries along the two well-known tanker routes. One of these is across the Arabian Sea within the Indian EEZ, round Sri Lanka, *via* the southern Bay of Bengal through Malacca Strait to Far East and Japan (Fig. 1). The other one goes through the Strait of Mozambique, along the

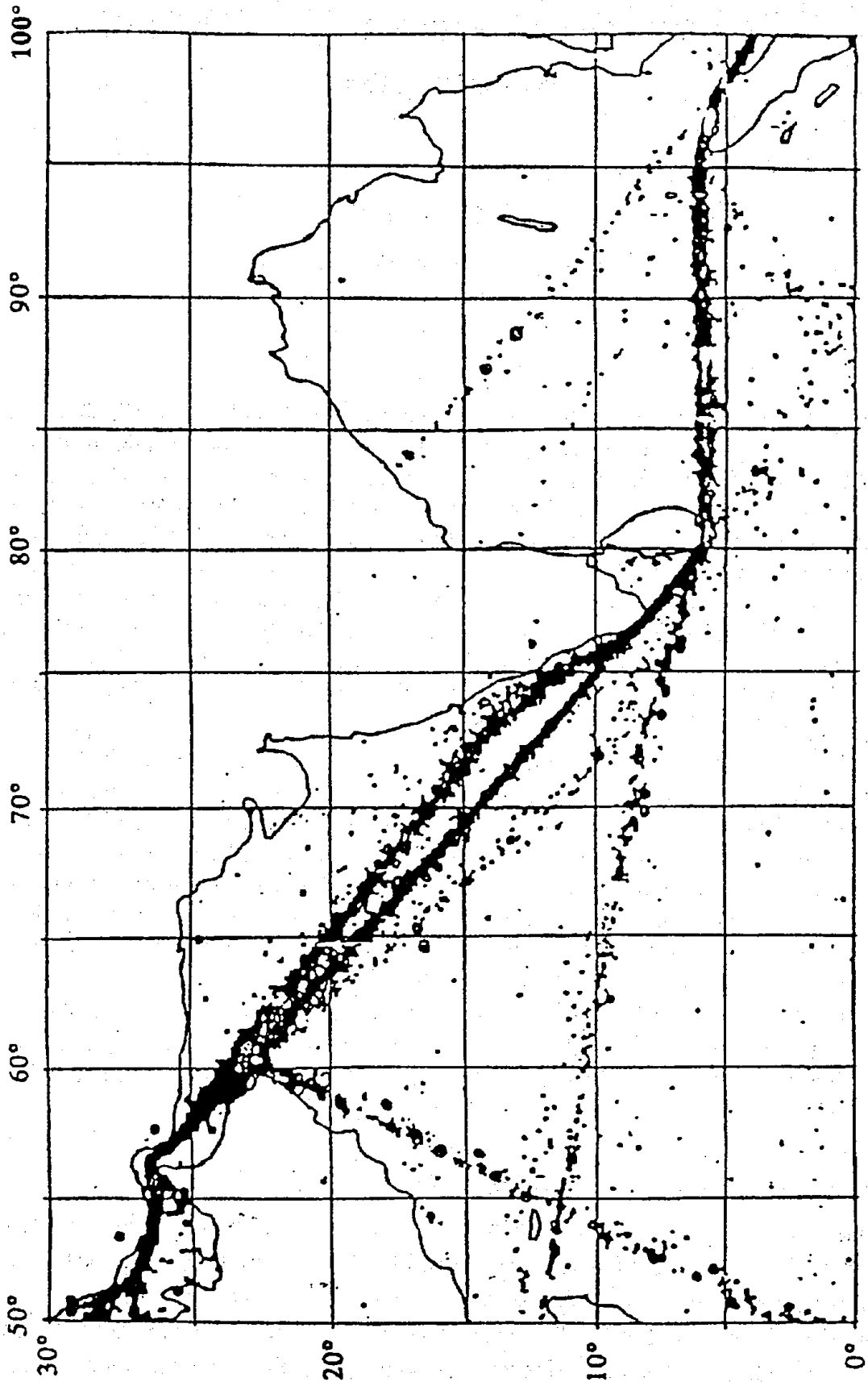


Fig. 1 : Oil tanker route and shipping lanes in the Arabian Sea (Reproduced from Sen Gupta and Kureishy, 1981)

coastal waters of Somalia, Kenya, Tanzania and Mozambique round South Africa to the Western Hemisphere (Sen Gupta & Kureishy, 1981). Tanker disasters along these two routes are frequent. About 21 accidents (Couper, 1983) have occurred along these routes from 1970 to 1981. However, oil enters predominantly into the Indian Ocean through operational discharges — bilge, bunker and ballast washings — oil well blow-outs from offshore exploration, and natural seepage from the sea bed.

Marine transport of oil from the Middle East countries during the period 1973-1993 (British Petroleum, 1994) along the Arabian Sea oil tanker routes varied from 35 to 61% of the global marine transport. After 1980, there was a gradual decrease in the Arabian Sea till 1985, which was probably due to protracted Iran-Iraq war. A similar decrease, however, did not occur after the Gulf War of 1991. A gradual increase of transport along the Bay of Bengal tanker route could be noted from 1982 onwards. This is because of the reopening of the Suez Canal, which was closed in 1967 after the Arab-Israel war. The Suez Canal was subsequently deepened for the passage of tankers upto 150,000 dwt at full load. This certainly reduced the sailing time of the ships of the Western Hemisphere as compared to the time taken to go round South Africa. About 20% of the world's oil cargo is transported across the Mediterranean (Goldberg, 1994).

Oil in the Sea

Immediately after a spill, oil spreads on the sea surface at a rate of 3% of the prevailing wind speed and at, approximately, 15° to the right of the wind direction. The oil having a lower surface tension than the seawater flows faster than the flow of water under it. In warm sea areas, lighter fractions of oil with carbon numbers less than 12 comprising around 40%, will evaporate within 24 hours after a spill. Photo-oxidation by solar UV radiation will account for a maximum of 1% per day of the total volume spilled. Heavier fractions will be broken down by oil-degrading bacteria, naturally occurring in seawater. The maximum possible rate for this is 2 g/d. A part of the oil will also be oxidized by the dissolved oxygen at the rate at 1 mg oil/3 mg O₂ (Gerlach, 1981). Barely 1% of the spilled oil may get dissolved/dispersed in the water. All these processes occur simultaneously and quite fast in warm water. One can, therefore, presume that in warm equatorial and tropical waters, roughly half of the spilled oil will disappear during the first 24 hours after an oil spill. The fate of the remaining amount will vary with the varying density and viscosity of the oil at source. However, all these processes will go on at a slower speed in colder waters of the sub-tropical and temperate regions of the oceans.

After the first 24 hours of the spill, depending upon the sea-state and warm temperature an emulsion called the water-in-oil mousse will be formed. This will be largely influenced by the prevailing wind and wave conditions. Thicker fractions will

absorb the dispersed particles present at the surface layers to form tar balls. Most of the tar balls sink and get deposited at the seabed. The remaining are washed ashore on the beaches. Such floating tar balls on the northern Indian Ocean (Arabian Sea and Bay of Bengal) have 'residence times' at the surface of around 3 to 4 months (Sen Gupta and Qasim, 1982). After about 100 hours of the spill, dispersion will exceed spreading.

Recent Major Oil Spills

On 19 January 1991 a huge volume of oil was spilled in the northwestern part of the Persian Gulf. The flow was ignited by missile attack, but it did little to stop the flow. Various estimates of the volume of dispersed oil were made. It was reported by Saudi Aramco after about two months of the spill that the volume was much smaller than what the media published. Most estimates of the spill ranged from 6-11 million barrels (Price & Sheppard, 1991). National, regional and international teams including several countries from outside the Gulf became involved with the assessment, containment and recovery of the oil. It was established by aerial surveys, using visual and radar techniques, that approximately 500,000 barrels (68,000 tonnes) oil in mousse and in other forms remained on the sea surface. Considerable damage was caused to the flora and fauna e.g. cormorants, sea cows, green turtles, and to the beaches of the Gulf. But as is well known, damage from the oil spills is not really irreversible.

Fears were expressed on the movement of the spilled oil from the Persian Gulf into the Arabian Sea and eventually to the Indian Ocean.

The Persian Gulf is a shallow embayment of the Arabian Sea. No sill, saddle or barrier restrict the circulation and the water exchange through the Strait of Hormuz with the Gulf of Oman (Fig. 2a). Because of this the "turn over/residence time" of the water in the Persian Gulf is 2.5 - 4 years (Brewer & Dyrssen, 1985).

The overall process of circulation inside the Gulf is counter-clockwise. Water moves westwards along the Iranian coast in the north and eastwards along the Emirates coast in the south. The surface water gains salt as it moves from the mouth inwards because of the increasing rate of evaporation inside the Gulf. Sinking of denser water starts in the northwestern part of the Gulf. Dense saline water migrates downwards in the shallow semi-enclosed lagoons along the Emirates coast. This water settles below the surface and flows into the Gulf of Oman through the Strait of Hormuz. Such an exchange of water is known as "Mediterranean - type" water exchange (Fig. 2b).

The outflowing water goes into the Arabian Sea and flows mainly east of 63°E longitude at 200-350 m water depth (Verma *et al.*, 1980). Thus, the oil originating from the spills in the Persian Gulf leaves the region only in dissolved/dispersed state with the deeper outflowing water, through the Strait of Hormuz into the Gulf of Oman and then into the Arabian Sea. Ultimately any oil-in-water will have its own density in

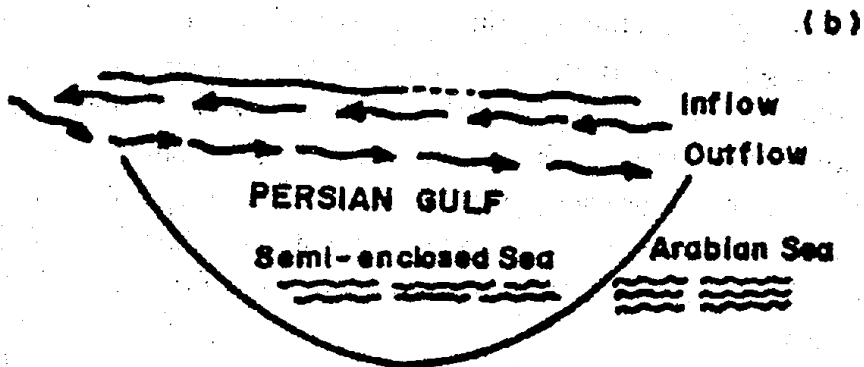
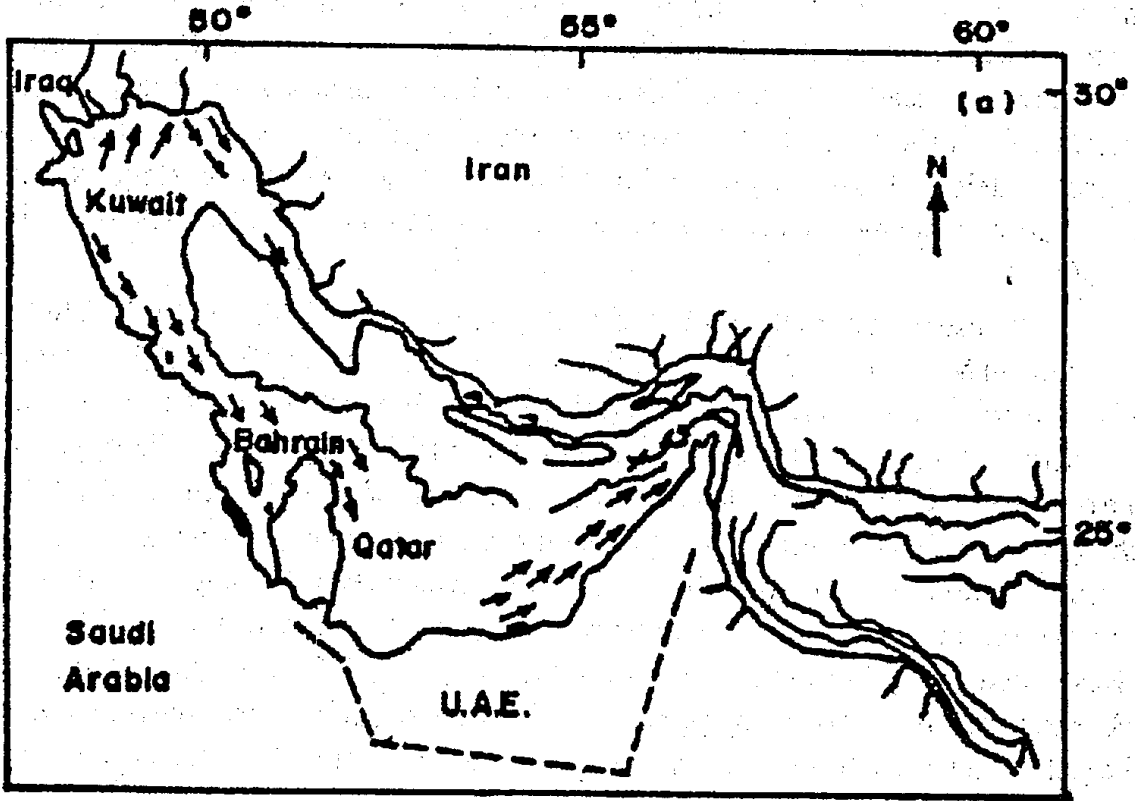


Fig. 2: (a) The Persian Gulf showing the course of circulation of water.
(b) Schematic representation of the Mediterranean type water exchange in Persian Gulf.

the watermass at 200-350 m depth in the Arabian Sea and will flow in a southeasterly direction east of 63°E longitude. Floating tar balls are unlikely to enter the Gulf of Oman because of the gyral nature of surface circulation inside the Gulf. The distance from the place of occurrence of the oil spill in the Gulf to Mumbai is approximately 2600 km. Any part of the oil spill to cover this distance, at the existing maximum and minimum current velocities present in the Gulf of Oman, would require 90-300 days.

Two cruises on board the Fishery Oceanography Research Vessel (FORV) Sagar Sampada in March (55-65 days after the spill) and September 1991 (237-247 days after the spill) were undertaken to enumerate the floating tarballs and to analyse petroleum residues in water, plankton, sediments and fish along the most likely path of the outflowing Gulf water in the northern Arabian Sea (Sen Gupta *et al.*, 1993). Little change in the concentrations of the variables related to oil pollution was observed during the interval of six months as these were well within the range reported for comparable pre-war surveys. Collectively, the results indicate that in the areas investigated, negligible contamination was found due to the Gulf oil spills. Obviously, the prevailing physical oceanographic conditions in the Gulf favoured the retention of the spilled oil within the Gulf. Thus, the Gulf oil spill of 1991 had no effect at all on the northern Arabian Sea.

On 21 January 1993, a super-tanker (Maersk Navigator) carrying 300,000 metric tonnes (MT) of light crude oil from Oman to Japan, while manoeuvring its entry into the Strait of Malacca through the narrow passage in between the small islands, north of the Indonesian island Sumatra, collided with another super-tanker (Sanko Honour) sailing with ballast in the opposite direction (Fig. 3). The impact of the collision ruptured one of the tanks of the oil tanker spilling an estimated amount of 18000 tonnes of crude oil in the sea. A part of the oil in the ruptured tank spread on the sea surface caught fire due to the violent impact of the collision. The oil however, was controlled within a short time by salvage ships, which arrived at the site of the accident from Singapore. Driven by the prevailing winds and currents, the spill started spreading out and drifted to about 16 nautical miles (NM) south of Pygmalion Point (Indira Point — lat. 06°43'N; long. 93°49'E) at the southernmost tip of the Great Nicobar island (Indian territory).

The area of the spill was the Great Channel which links the Andaman Sea with the Bay of Bengal. It lies in a region which is influenced both by the SW and NE monsoons. This is also a place where changes in the weather system and depressions develop. Consequently, the wind and the resultant surface drift can both be fairly strong. In the month of January, when the accident occurred, the time of NE monsoon season withdraws.

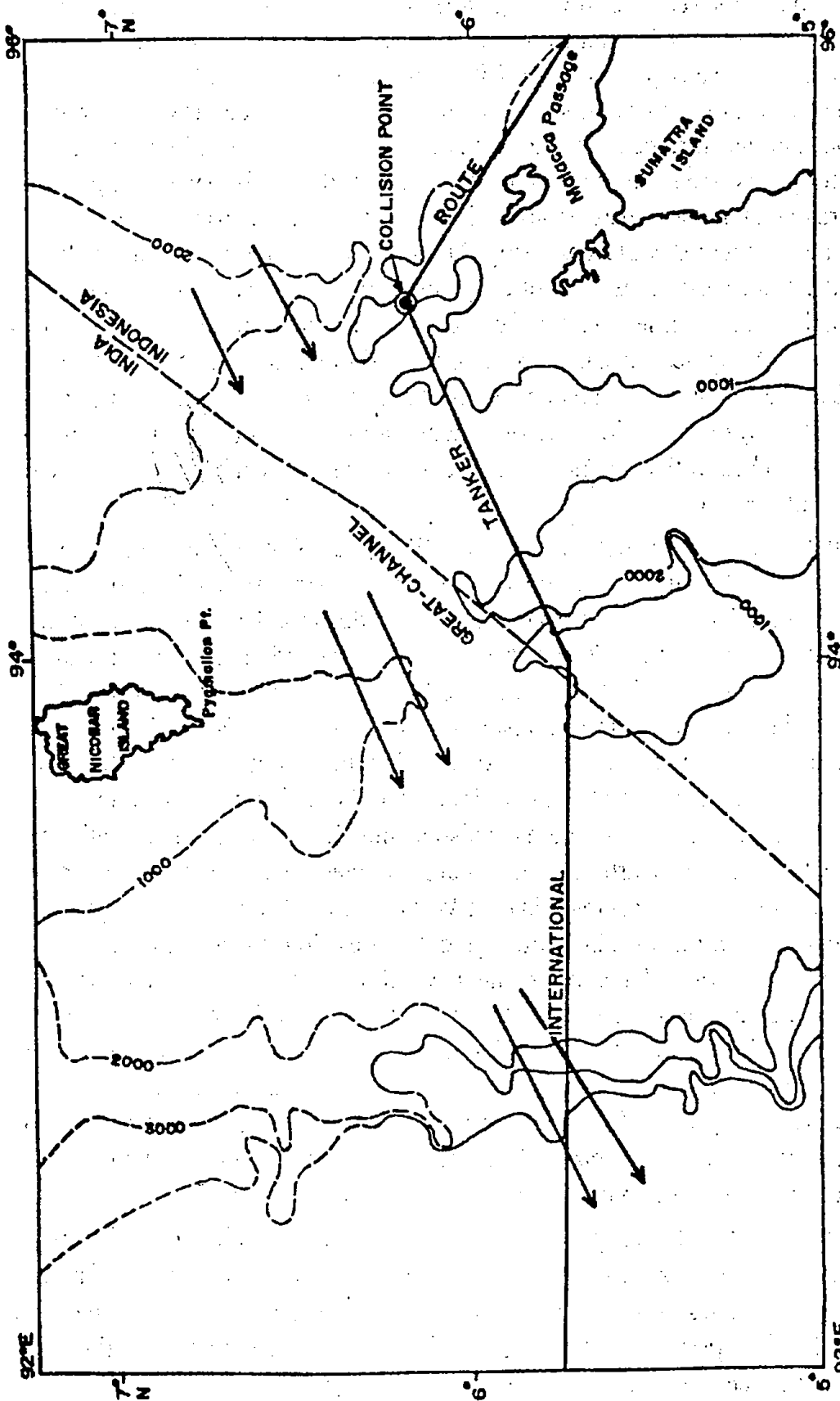


Fig. 3 : The Great Channel showing the Collision Point, the International Tanker Route and the demarcation line between the Indian and the Indonesian Exclusive Economic Zones.

At this time of the year, the North Equatorial Current flows westward in the Indian Ocean at the location of 5°N latitude. The wind blows from NE to E (050°-090°) direction resulting in SW to W surface drift. During the period of observations (Jan-Feb 1993), wind directions and speed from 050°-085° ranged between 5 and 15 knots. The resultant surface drift at the rate of 0.5-1.5 knots would be flowing from southwesterly to westerly direction. The sea state varied from 2-3 (wave height 1-1.5 m). This area lies at the eastern extremity of the international tanker route along 05°45'N latitude in the southern Bay of Bengal (Fig. 3). Consequently, it is frequented by heavy tanker traffic going westwards without cargo and with full load eastwards to and from the ports in the Gulf countries. As stated earlier, in warm equatorial and tropical waters roughly half of the spilled oil can be expected to disappear during the first 24 hours after an oil spill as a result of combined effects of evaporation, dissolution / dispersion, photo-oxidation by UV radiation, microbial degradation by naturally occurring marine microflora etc. Thus, with the continuously degrading residues, the figure of spilled oil come to about 9000 tonnes.

The first cruise was undertaken on board ORV Sagar Kanya shortly after the spill (2-5 February 1993). The areas of observations was restricted to 45 nautical miles within the Indian EEZ along the 90 nautical miles wide Great Channel. The northern and southern limits were at 06°43' and 06°04.5'N latitudes and the eastern and western limits were at 94°51.8' and 94°24.3' E longitudes. The easternmost point was about 30 nautical miles northwest of the collision site at 06°09'N and 94°59'E. Almost all the oil pollution parameters were found to be within the acceptable limits. An Indian Coast Guard Ship and an aircraft followed the drift of the oil patch, collecting water samples and spraying non-toxic chemical dispersants. Decreasing concentrations of dissolved petroleum hydrocarbon in these water samples clearly indicated that the oil patch moved about 60 nautical miles in the SW direction in 3-4 days reducing to 10% of its original concentration. This would give the rate of the surface flow as 0.6-0.9 knots, which was almost 10% of the prevailing wind speed (5-15 knots). The direction of the drift could be confirmed by the data obtained from the CG station J at 05°30'N, 91°57'NE and SK station #1 at 05°45'N, 92°00'E (Fig. 4) both sampled on the same day and at about the same time. The CG station showed a value of 0.87 ppm of oil and the SK station only 2.5 ppm just 15 nautical mile away to the north. It is clear that winds, currents and swells broke the dispersant-treated oil spill to patches which drifted southwest in the open Indian Ocean (Sen Gupta *et al.*, 1995).

Thus, the effect of the oil spill was short-lived within the Indian EEZ. Probably some damages to phytoplankton productivity and associated decrease in zooplankton abundance resulting in short-time losses in the exploitable marine living resources can be expected to take place. These were quantified during another cruise in the same area during September-October 1993 on board FORV Sagar Sampada. It was

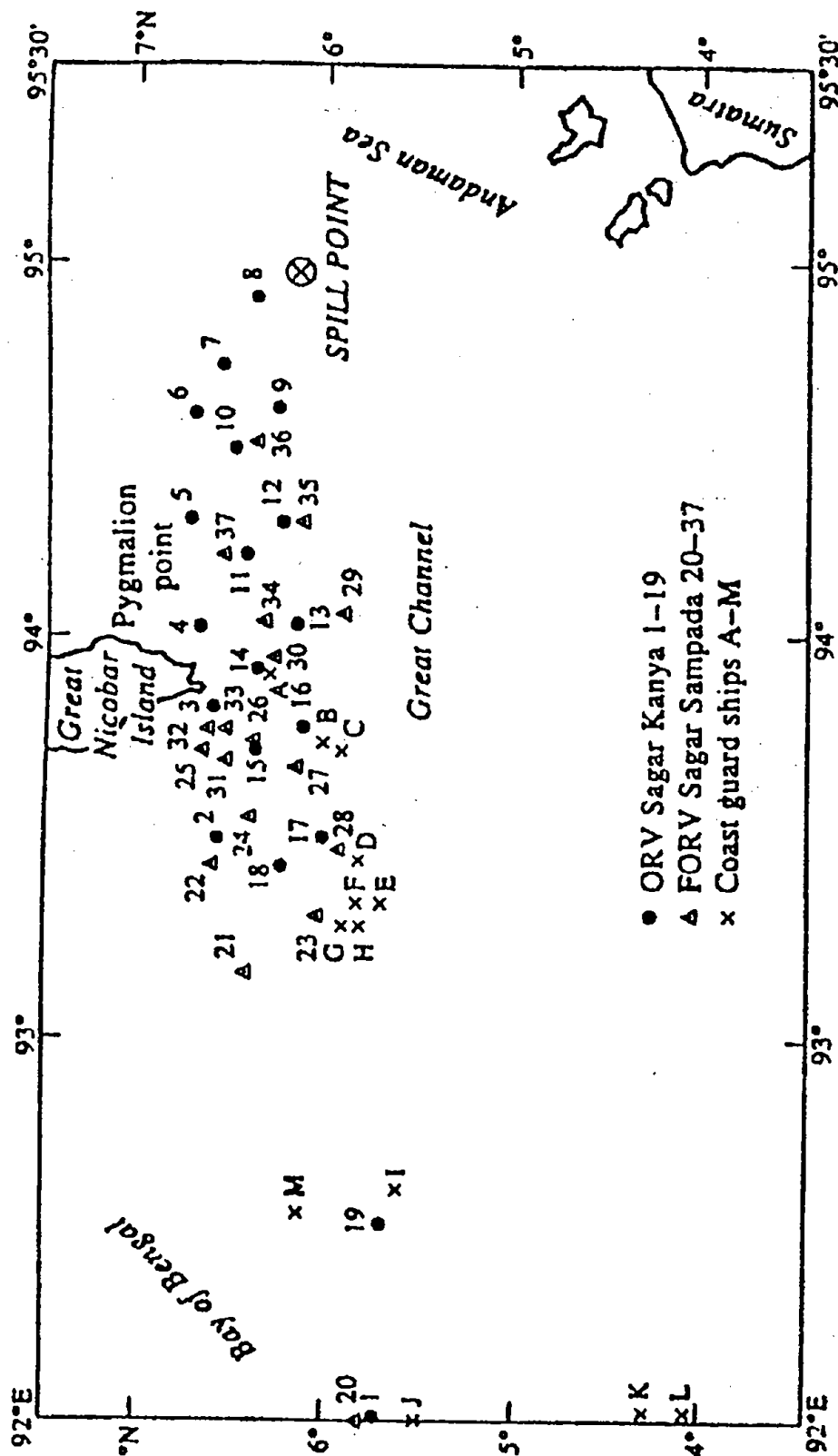


Fig. 4 : Observation stations in the Great Channel

estimated, indirectly, from the difference on zooplankton production between the two cruises and converting 10% of secondary production to tertiary production that around 1500 to 2250 metric-tonnes of potential marine living resources might have been lost in the Indian EEZ due to the oil spill. A claim for compensation of Rupees 22 crores has been submitted by the Ministry of Surface Transport (MoST), Government of India to the Protection and Indemnity Club (PI Club) of the International Tanker Owners Pollution Federation (ITOPF).

On 17 May 1993, a 75 cm diameter oil trunkline riser of the processing platform of the Bombay High North (BHN) offshore complex of the Oil and Natural Gas Corporation (ONGC), located in the Arabian Sea at 180 km northwest off Mumbai, ruptured developing a crack at a point 60 cm above the sea surface (waterline). This resulted in a spill of about 1600 tonnes of crude oil.

About half of the oil probably evaporated during the first 24 hours after the spill. Chemical dispersant was immediately sprayed on the spill by an aircraft of the Indian Coast Guard. The remainder should not have been more than 800 tonnes of continuously degrading drifting patches of oil, driven by wind and waves. The drift was in south-easterly direction.

During May, the alongshore currents in the coastal Arabian Sea off India starts developing its east flowing shoreward component (Gouveia & Kurup, 1977; Kurup, 1983). During this period, any oil spill at Bombay High will have its effect on land at least a fortnight after the spill somewhere along the north Konkan coast. A part of the floating tar lumps, as expected, was washed ashore after 12 days, on 29 May 1993, on a few beaches in the Raigad district of Maharashtra on the north Konkan coast.

The deposited tar lumps, amounting to around 200 tonnes, were manually cleaned up. A post clean-up survey of the affected beaches did not indicate any significant damage to the organisms living in the beach. However, instantaneous damages to the flora and fauna in the sea did take place as was evidenced during a survey (NIO, 1993). These instantaneous damages barely last beyond 3-4 days after which the sea recovers to its normal healthy state.

It should, however, always be borne in mind that any oil spill in the sea forms just cosmetics of marine pollution. It is visible and spreads on the sea surface in micrometer thin layers like cosmetics on a human face. Similar to cosmetics an oil spill cannot last long and damages caused by it can never be permanent or irreversible.

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