



RESEARCH

Maersk Navigator Oil Spill in the Great Channel (Andaman Sea) in January 1993 and its Environmental Impact

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Observations on oil slicks, tar residues and dissolved petroleum hydrocarbons (DPH) 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). DPH were between 0.31 and 1.85 $\mu\text{g l}^{-1}$ in the area examined. Tar residues were absent throughout the study area. Prevailing NE wind with resultant SW surface current appears to have pushed the oil patches out towards the open Indian Ocean.

A follow-up survey of the same area was carried out in September–October 1993 and observations similar to those made during the earlier survey were recorded. The zooplankton biomass had increased considerably during the interval between the two surveys, but this was probably due to seasonal changes and natural variability.

The spill did not cause any perceptible impact on the environment. Copyright © 1996 Elsevier Science Ltd

On 21 January 1993, the Singapore registered Danish VLCC *Maersk Navigator* carrying 300,000 t of light crude from Oman to Japan, while negotiating her entry into the Strait of Malacca through the small islands lying north of the Indonesian island Sumatra, collided with another Singapore registered carrier *Sanko Honour* at latitude 06°09'N and longitude 94°59'E. The impact of the collision resulted in rupture of one of the tanks, spilling an estimated 18,000 t of oil on the sea. Driven by the prevailing winds and currents, the spill started spreading out and drifted to about 16 nautical miles (NM) south of Pygmalion Point (06°43'N and 93°49'E) at the southernmost tip of the Indian island Great Nicobar (Fig. 1).

A cruise on board ORV *Sagar Kanya* was undertaken from 28 January to 12 February 1993 to assess the fate and immediate impact of the oil spill on the marine environment in the Great Channel (southern Andaman Sea). Immediately after the spill, ships of the Indian Coast Guard CGS *Vikram* and *Akkadevi*,

along with their aircraft, were on site to combat the spill and to follow the dispersion and movements of the oil slick. Subsequently another cruise onboard FORV *Sagar Sampada* was undertaken from 21 September to 10 October 1993 to assess the long-term impact, if any, of the oil spill on the coral reefs and the exploitable marine living resources of the Indian EEZ in the Great Channel.

This paper describes our findings on oil-slicks, tar residues, dissolved petroleum hydrocarbons (DPH), zooplankton biomass, chlorophyll *a* values in water and DPH in bottom deposits and zooplankton along with a first approximation assessment of the eventual short- and long-term impacts of the spill based on the data collected during the two cruises.

Oceanographic Features of the Area

The area of the spill, the Great Channel, linking the Andaman Sea with the Bay of Bengal, lies in a region

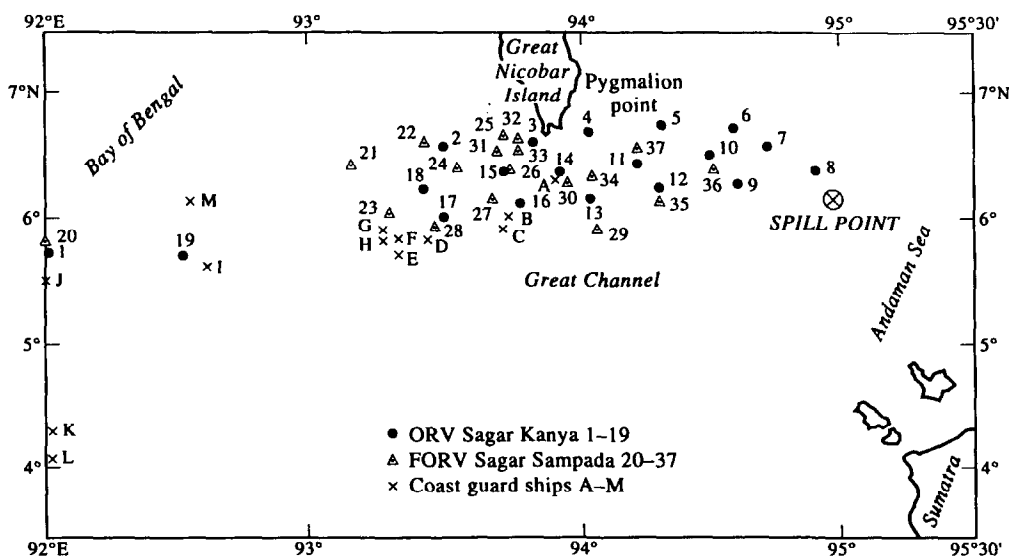


Fig. 1 Observation stations.

influenced both by the SW and NE monsoons (Fig. 1). This is also the place where many a weather system and depression develops. Consequently, the wind and the resultant surface drift can both be fairly strong. January, the month of the accident, is the period of the withdrawal phases of the NE monsoon season.

At this time of the year, there is a westward flowing North Equatorial Current in the Indian Ocean around 5°N latitude. The wind blows from NE to E (050°–090°) directions resulting in SW to W surface drift. During the period of observations (Jan–Feb 93), wind directions and speed ranged from 050°–085° and 5–15 knots, respectively. The resultant surface drift would be flowing in southwesterly to westerly directions.

This area lies at the eastern extremity of the international tanker route along 05°45'N latitude across the southern Bay of Bengal. Consequently, it is frequented by heavy tanker traffic on ballast westwards and on full load eastwards to and from the ports in the Gulf countries. In warm equatorial and tropical waters roughly half of the spilled oil can be expected to disappear during the first 24 h after an oil spill as a result of the combined effects of evaporation, dissolution/dispersion, photo-oxidation by UV-radiation, microbial degradation by naturally-occurring marine microflora, etc. (Sen Gupta *et al.*, 1993). Of course, the amount will vary with the oil type (its viscosity and density), temperature and sea state. We will, therefore, be dealing with the continuously degrading residues of around 9000 t of oil.

Sampling in the Area

Samplings during the first survey were carried out on board ORV *Sagar Kanya* from 2 to 5 February 1993 (13–16 days after the spill). Three transects,

parallel to one another and to the shores of Great Nicobar, covering a total of 17 stations, were established (Fig. 1). The area of observations was restricted to the 45 NM limit of the Indian EEZ in the 90 NM 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 93°24.3'E longitudes. The station # 8 (Fig. 1) at the easternmost point was about 30 NM northwest of the collision site at 06°09'N and 94°59'E. The nearest station to the *Pygmalion Point* (station # 3) was 5 NM south of it. An attempt was also made to locate any of the reported oil patches by scanning an area of about 900 km² at around 16 NM south of *Pygmalion Point*.

Observations were repeated in the same area on board FORV *Sagar Sampada* from 28 September to 1 October 1993 (Fig. 1). During this cruise apart from water and plankton samplings, bottom observations on a few banks (50–300 m) rising from deep ocean and bottom trawling at one station were also carried out.

Methodology

Tar residues

To collect floating tar and surface zooplankton during the first cruise, two Neuston nets (300 μ) having a mouth area of 30 \times 15 cm, each rigged on a catamaran arrangement were towed at the surface for 15 min with the ship steaming at 2 knots at every station. The strata sampled were 0–15 cm and 20–30 cm. For possible sinking tar balls, a net (500 μ) was weighted appropriately and towed at about 50 m water depth for 15 min at selected stations. During the second cruise a twin Bongo net (60 cm dia; 300 μ mesh) was similarly towed at the surface at all stations

for 15 min at 2 knots ship speed for the same collections.

Dissolved petroleum hydrocarbons (DPH)

Water samples were collected on *Sagar Kanya* to a maximum depth of 50 m using Hydro Bios TPN water sampler at intervals of 25 m. At a few stations a conductivity-temperature-depth (CTD) profiler fitted with a transmissometer (ID:129D measuring at 660 nm wavelength only) was also operated to a depth of around 100 m. On *Sagar Sampada* a CTD profiler with a rosette of 12 Niskin GO-FLO bottles was run to depths varying from 50 to 2000 m for sampling.

All the samples were analysed on board for their DPH content using Turner-430 (*Sagar Kanya*) and Perkin-Elmer LS-3 (*Sagar Sampada*) spectrofluorometers, using Saudi Arabian crude as standard (UNESCO, 1976). In addition to this, 13 surface water samples collected by the Coast Guard ships in the same area from 26 January to 3 February following movements of the floating oil patches were also analysed for their DPH contents.

Chlorophyll *a* analysis was performed at all the daytime stations after filtration of the water samples followed by fluorescence measurements (Strickland and Parsons, 1968). Zooplankton samples free of tar and other floating matter, were examined for their biomass.

During the *Sagar Sampada* cruise, as stated earlier, bottom observations and trawling operations were also carried out. A modified Petersen grab was operated at 8 stations. At four of these the grab came up without any sample indicating the banks to be rocky. At the other four (station # 25, 30, 31, 32) it brought up very coarse to coarse to fine coralline sand and a few bits of rock with overgrowth of red alga. No benthic animal was present in any of these samples, excepting a few live sponges at one station.

A bottom trawl was tried at one station (# 32, Fig. 1) at a water depth of 45–52 m but had to be hauled up after only 20 min as the net got damaged at the rocky bottom. However, about 25 kg of fish consisting mainly of rock perches were collected. These were *Gymnocranius grandoculis* (Val.), *Lethrinus microdon* (Val.), *Lethrinus conchyliatus* (Smith), *Pseudobalistes flavimarginatus* (Ruppel) and *Ostracion meleagris* (Shaw). The net also brought up a few live coral bits and a few strands of gorgonians (soft corals).

Results and Discussion

Sagar Kanya (SK) cruise

No floating tar particles were present either in horizontal or vertical tows. The general ranges of

concentrations of dissolved petroleum hydrocarbons (DPH) were 0.62–1.85, 0.31–1.54 and 0.31–1.54 $\mu\text{g l}^{-1}$ at 0, 25 and 50 m water depths, respectively in the entire area examined from 3–5 February (Table 1). High concentrations of DPH ranging from 0.33 to 5.40 ppm were observed in surface water samples collected in the area of the drifting oil patches from 26 January–3 February (6–14 days after the spill) by the Coast Guard (CG) ships (Table 2). Some of these samples collected from the centre of the oil patch had floating oil in them resulting in high contents in water underneath. Comparison of both sets of data indicated that the oil contents in water had decreased by 3 orders of magnitude after a few days. These observations, combined with the near-total absence of floating tar particles, indicated that the concentrations of oil in water decreased continuously and that the oil particles drifted in a west to southwesterly direction. This can be corroborated by data from the CG station I at 05°36'N, 92°34'E sampled on 30 January (Table 2) and the SK station # 19 at 05°45'N, 92°30'E (Table 1) sampled on 6 February about 9 NM away from the former (Fig. 1). The values of DPH were 0.41 ppm and 1.85 ppb, respectively. Besides, the CG station had about one-tenth concentration, as compared to the cluster of CG stations (A–H) (Table 2) around 60 NM away from it at NE direction (Fig. 1), while all *Sagar Kanya* stations had almost similar values at the surface (Table 1). Evidently, the patch moved about 60 NM in SW direction in 3–4 (29 January to 2 February) days reducing to 10% of its original concentration. This would give rates of the surface flow as 0.6–0.9 knots, which was almost around 10% of the prevailing wind speed during that period (5–15 kts). The direction of the drift can, perhaps, be confirmed by data from CG station J at 05°30'N, 91°57'E and SK station # 1 at 05°45'N, 92°00'E (Fig. 1) both sampled on the same day (2 Feb) and at about the same time. The CG station showed a value of 0.87 ppm and the SK station only 2.5 ppb for DPH with no trace of floating tar just 15 NM away to the north. Observations on zooplankton showed a fairly high biomass (3.5–40.5 ml/100 m³) in the surface layer (Table 1). Daytime collections, as expected, always had lower biomass as compared to evening or night collections.

Immediately after an oil spill, due to the blocking of air–sea exchange, the phytoplankton population gets severely depleted. Production of zooplankton is retarded as these will ingest more oil in their guts due to the availability of excess oil and which they are known to secrete when the source of oil is absent. Zooplankton ingest large quantities of small droplets of oil and eliminate them in the form of faecal matter (Conover, 1971). But these phenomena *vis-à-vis* oil spills are short-lived (about 2–3 days) as was observed

Table 1 Petroleum hydrocarbons in water and zooplankton biomass in the the spill area from 2–6 February 1993 (ORV *Sagar Kanya* Cruise)

| Station No. | Date | Position | | Time IST | Petroleum hydrocarbons $\mu\text{g l}^{-1}$ | | | Zooplankton* biomass $\text{ml } 100 \text{ m}^{-3}$ |
|-------------|--------|----------|---------|----------|---|------|------|--|
| | | Lat °N | Long °E | | 0 m | 25 m | 50 m | |
| 01 | 02 Feb | 05°45' | 92°00' | 2030 | 2.46 | 1.85 | — | 16.08 |
| 02 | 03 Feb | 06°40' | 93°29' | 1100 | 1.85 | 1.23 | 1.23 | 11.46 |
| 03 | -do- | 06°42' | 93°46' | 1415 | — | — | — | 4.36 |
| 04 | -do- | 06°43' | 94°02' | 1900 | 1.23 | 1.23 | 1.23 | 20.73 |
| 05 | -do- | 06°44' | 94°16' | 2240 | — | — | — | 22.79 |
| 06 | 4 Feb | 06°43' | 94°36' | 0230 | 0.92 | 0.62 | 0.62 | 16.63 |
| 07 | -do- | 06°34' | 90°44' | 0600 | 1.54 | 0.62 | 0.92 | 6.73 |
| 08 | -do- | 06°22' | 94°51' | 1100 | 1.23 | 1.23 | 1.23 | 4.43 |
| 09 | -do- | 06°17' | 94°34' | 1420 | 0.62 | 0.62 | 0.31 | 3.50 |
| 10 | -do- | 06°30' | 94°29' | 1655 | 1.23 | 0.62 | 0.31 | 21.89 |
| 11 | -do- | 06°28' | 94°12' | 2000 | 0.62 | 0.31 | 0.31 | 29.95 |
| 12 | -do- | 06°14' | 94°16' | 2330 | 0.32 | 0.62 | 0.62 | 23.88 |
| 13 | 5 Feb | 06°12' | 94°04' | 0130 | 1.23 | 0.31 | 0.31 | 9.58 |
| 14 | -do- | 06°23' | 93°56' | 0345 | 0.92 | 0.92 | 0.31 | 16.50 |
| 15 | -do- | 06°22' | 93°41' | 1430 | 1.54 | 0.62 | 0.62 | 15.07 |
| 16 | -do- | 06°07' | 93°46' | 1730 | 0.92 | 0.62 | 0.62 | 40.55 |
| 17 | -do- | 06°04' | 93°30' | 2035 | 1.54 | 1.23 | 1.23 | 38.17 |
| 18 | -do- | 06°17' | 93°24' | 2310 | 1.85 | 1.54 | 1.54 | 24.08 |
| 19 | 6 Feb | 05°45' | 92°30' | 0615 | 1.85 | 1.23 | 0.32 | 28.46 |

*Feb 1979: 1.8–14.4 ml 100 m⁻³ (Madhupratap *et al.*, 1981);

Jan 1980: 7.0–39.0 ml 100 m⁻³ (Goswami—unpublished data)

Both the sets are from vertical hauls over the entire Andaman Sea,

Averages around the Nicobar group of islands were 6.3 ml 100 m⁻³ (Feb 1979) and 14.6 ml 100 m⁻³ (Jan 1980), respectively.

Average of the present data set from the Great Channel is 18.7 ml 100 m⁻³

Table 2 Petroleum hydrocarbon concentrations in samples collected by Indian Coast Guard ships while following the oil patch from 26 January to 3 February 1993

| Ship CGS | Station | Date | Position | | Time IST | Petroleum hydrocarbons $\mu\text{g l}^{-1}$ |
|-----------------|---------|-------------|----------|----------|----------|---|
| | | | Lat °N | Long °E | | |
| <i>Vikram</i> | A | 26 Jan. '93 | 06°20'10 | 93°54'11 | 1430 | 3942 |
| -do- | B | -do- | 05°58'62 | 93°42'08 | 0855 | 4928 |
| <i>Akkadevi</i> | C | -do- | 05°59'54 | 93°44'06 | 1530 | 730 |
| <i>Vikram</i> | D | 27 Jan. | 05°52'26 | 93°24'38 | 0811 | 5400 |
| -do- | E | -do- | 05°45'10 | 93°21'49 | 1143 | 4435 |
| -do- | F | -do- | 05°50' | 93°21' | 0700 | 4312 |
| -do- | G | -do- | 05°55' | 93°16' | 0910 | 1016 |
| <i>Akkadevi</i> | H | -do- | 05°51'37 | 93°16'25 | 0945 | 330 |
| -do- | I | 30 Jan. '93 | 05°36'17 | 92°34'20 | 1528 | 409 |
| <i>Vikram</i> | J | 02 Feb. '93 | 05°30'35 | 91°57'47 | 0927 | 968 |
| <i>Akkadevi</i> | K | 03 Feb. '93 | 04°19'4 | 92°03'7 | 0740 | 862 |
| <i>Vikram</i> | L | -do- | 04°06'18 | 92°03'47 | 1115 | 696 |
| <i>Akkadevi</i> | M | 01 Feb. '93 | 06°07'43 | 92°33'10 | 0914 | 440 |

during one of our investigations after an oil spill in the offshore waters of Bombay (National Institute of Oceanography, 1993). This is, perhaps, indicated in our data on zooplankton biomass two weeks after the oil spill when all the oil was driven out of the Great Channel by the prevailing southwesterly surface flow towards the open Indian Ocean (3.5–40.5 ml/100 m³—Table 1).

The light transmission profiles, recorded at a few selected CTD stations, reveal an interesting feature. At station # 13, which was about 110 nautical miles away from the spill point and was worked at 15 days after the spill, there is a

small decrease in light transmission at about 40 metres water depth (Fig. 2). The transmissometer works at a wavelength of 660 nm. At this wavelength straight chain aliphatic hydrocarbons (—CH₂ group) absorb light. This decrease in light transmission was probably due to the sinking of continuously dispersing and degrading oil globules and/or oil-in-water emulsion. Absence of similar features at the other three stations (# 15, 18 and 19) at corresponding depth, though not very far from one another and sampled within one day (Table 1), would indicate that the dispersion of oil in water ceased not very far from the spill point.

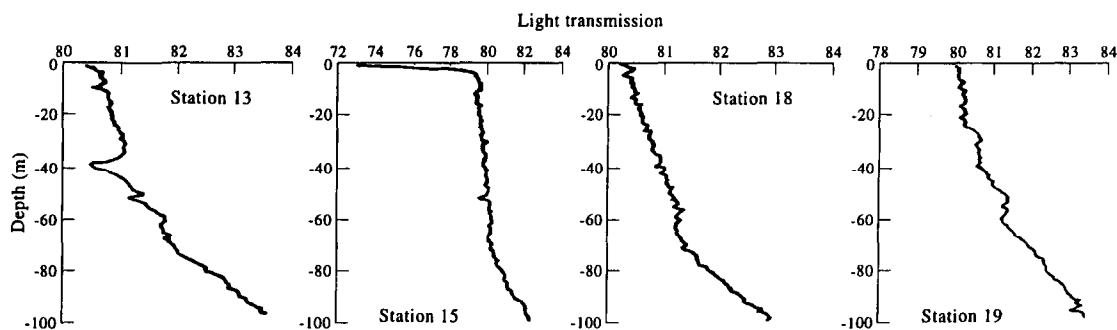


Fig. 2 Vertical profiles of light transmission (%) up to 100 m water depth at 660 nm wavelength.

Sagar Sampada cruise

No floating tar particles could be observed in the study area during this cruise as well. Dissolved petroleum hydrocarbons ranged from 0.67–9.10, 0.85–2.67 and 0.64–3.37 $\mu\text{g l}^{-1}$ at 0, 25 and 50 m, respectively, omitting station # 20 from the comparison since it was on the oil tanker route where occasional high values can be expected (Table 3). These were comparable with those of the earlier cruise (Table 1). Zooplankton biomass ranged from 2.3–83.3 ml/100 m^3 (Table 3) with the expected differences between daytime and night time collections. These were higher than the February values, when the organisms were recovering from the after effects of the oil spill and probably represent the normal population. Chlorophyll *a* values at all the daytime stations were between 0.008 and 0.043 mg m^{-3} (Table 3) at a depth range of 0–50 m. PHC in zooplankton were 96.2–198.6 ppm dry wt (Table 4), which is quite comparable with our values of 0.63–144.7 ppm dry wt from the Arabian Sea oil tanker route (Sen Gupta *et al.*, 1993). The higher value of the minimum, as observed in the Great Channel zooplankton could be the result of the frequency and density of tanker movements in a narrow area.

IR spectra of the sediment samples at wavenumbers 720, 810, and 1375 cm^{-1} which characterize petroleum hydrocarbons (PHC) indicated their near- or total absence when compared with those of degraded oil, in the form of mousse, collected during the January–February observations. Suspended particulate matter obtained by filtering water samples (200–500 m) also showed no presence of PHC in IR spectra at similar wavenumbers.

The bottom samples consisting of coralline sand showed petroleum hydrocarbon concentrations from 0.19 to 1.50 $\mu\text{g g}^{-1}$ dry wt, which are fairly low to be of any consequence (Table 4). This is because of the coralline sand texture of the bottom. Concentrations from 0.63–5.81 $\mu\text{g g}^{-1}$ dry wt were recorded in the silty-clay sediment at the seabed of the tanker route off the west coast of India (Sen Gupta *et al.*, 1993). Clay is

known to have a higher capacity to absorb organic compounds because of its higher surface area compared to sand and to retain them for a long time as a signature of oil spills at the surface (Blumer and Sass, 1972). It is not possible for spills in the Great Channel to leave any signature at the seabed because of the sandy bottom.

There are no published data available on chlorophyll *a* values from the study area. However, the present values on chlorophyll *a* are comparable to those available (0.03 mg m^{-3}) from an area close-by (05°N, 77°–87°E). Zooplankton biomass in the entire marine area around the Andaman and Nicobar islands were observed to be 1.80–14.40 ml/100 m^3 during January–February 1979 (Madhupratap *et al.*, 1981). Similar values from the same area during January–February 1980 were 7.0–39.0 ml/100 m^3 (Dr. S.C. Goswami—unpublished data). These data, though predominantly from the Andaman Sea, also included a few observations in the Great Channel. Our data during February 1993 from the study area were 1.0–40.0 ml/100 m^3 and those during September 1993 were 2.3–83.3 ml/100 m^3 .

Perhaps it will not be very appropriate to compare the earlier zooplankton biomass data with the present ones. Earlier data were obtained from instantaneous vertical hauls from 30 to 200 m depth upto the surface using a Heron-Tranter net (mouth 50 cm \times 50 cm, mesh 500 μm) while our values are exclusively from surface tows over a distance of around 900 m (ship's run: 15 min at 2 knots speed) at every station. Both during February 1979 and January 1980 only two stations were sampled around the Great Nicobar island (Sarupria *et al.*, 1993). Random vertical hauls from 50 m to surface at three stations in September 1993 gave values from 5.3–12.0 ml/100 m^3 (Table 3). Average around the Nicobar group of islands were 6.3 ml/100 m^3 in February 1979 (Madhupratap *et al.*, 1981) and 14.6 ml/100 m^3 in January 1980 (Goswami—unpublished). It will be very approximate to interpret such a variation of more than a factor of two as only due to inter-annual variability. Average surface biomass during the *Sagar Kanya* cruise (2–6

Table 3 Petroleum hydrocarbons in water and zooplankton biomass in the spill area from 27 September to 1 October 1993 (FORV Sagar Sampada cruise)

| Station No. | Date | Position | | Time IST | Petroleum hydrocarbons $\mu\text{g l}^{-1}$ | | | | Zooplankton* biomass ml. 100 m ⁻³ | Chlorophyll <i>a</i> mg m ⁻³ | | |
|-------------|---------|----------|---------|----------|---|------|-------|-------|--|---|-------|-------|
| | | Lat °N | Long °E | | 0 m | 25 m | 50 m | 100 m | | 0 m | 25 m | 50 m |
| 20 | 27 Sept | 05°45' | 92°00' | 2325 | 1.36 | 8.79 | 21.04 | - | 63.7 | - | - | - |
| 21 | 28 Sept | 06°24' | 93°10' | 1020 | 1.32 | - | 1.21 | - | 7.5 (6.0) | - | - | 0.04 |
| 22 | -do- | 06°34' | 93°26' | 1420 | 0.67 | 1.30 | 0.64 | - | 15.6 (12.0) | 0.02 | 0.02 | 0.04 |
| 23 | -do- | 06°05' | 93°18' | 2125 | 0.83 | 1.68 | 2.27 | 2.01 | 75.3 | - | - | - |
| 24 | 29 Sept | 06°24' | 93°34' | 0215 | 0.97 | 1.54 | 0.82 | 0.64 | 73.0 | - | - | - |
| 25 | -do- | 06°42' | 93°42' | 0640 | 0.99 | 0.88 | 1.07 | 1.41 | 47.8 | - | - | - |
| 26 | -do- | 06°22' | 93°43' | 2105 | 1.25 | 0.85 | 0.83 | 1.41 | 83.3 | - | - | - |
| 27 | 30 Sept | 06°09' | 93°41' | 0355 | 0.81 | - | 1.41 | 1.33 | 16.8 (5.3) | 0.011 | 0.013 | 0.013 |
| 28 | -do- | 05°56' | 93°28' | 0725 | - | - | - | - | 2.3 | - | - | - |
| 29 | -do- | 05°56' | 94°03' | 1150 | 1.01 | 2.67 | 0.92 | - | 36.6 | 0.015 | 0.017 | 0.043 |
| 30 | -do- | 06°21' | 93°55' | 1600 | 1.44 | 2.13 | 1.14 | - | 10.6 | 0.008 | 0.019 | 0.022 |
| 34 | 1 Oct | 06°24' | 94°03' | 0000 | 1.59 | 1.41 | - | 1.58 | 25.5 | - | - | - |
| 35 | -do- | 06°10' | 94°17' | 0355 | 9.10 | 2.18 | 3.37 | - | 77.6 | - | - | - |
| 36 | -do- | 06°28' | 94°30' | 0820 | - | - | - | - | 11.9 | 0.013 | 0.043 | 0.017 |
| 37 | -do- | 06°34' | 94°12' | 1205 | 12.6 | 4.86 | 12.70 | - | 8.6 | - | - | - |

*Values in brackets are for vertical hauls from 50 m to surface. Average of the present data set is 37.1 ml/100 m³

Table 4 Concentrations of petroleum hydrocarbons in zooplankton and surficial sediments of the spill area

| Station No. | Concentrations in zooplankton $\mu\text{g g}^{-1}$ (dry wt) | Concentrations in sediments* $\mu\text{g g}^{-1}$ (dry wt) |
|--------------|---|--|
| # 20 | 96.2 | - |
| # 23 | 129.3 | - |
| # 25 | 198.6 | 0.19 |
| # 28 | 152.1 | - |
| # 30 | 113.5 | - |
| # 31 | - | 0.40 |
| # 32 | - | 0.62 |
| # 33 | - | 0.34 |
| # 35 | 160.0 | - |
| Campbell Bay | - | 1.50 |

*Texture: Coralline Sand.

February 1993) at only the Great Channel was 18.7 ml/100 m³ (Table 1) while that during the *Sagar Sampada* cruise (27 September–1 October 1993) was 37.1 ml/100 m³ (Table 3). In the absence of similar data during the other years from the Great Channel, we leave this variation as being seasonal—though with reservation. Such a change in the secondary production should result from a corresponding change in the primary production caused, among others, by the degradation products of petroleum hydrocarbons from discharges or spills of the same by oil tankers sailing along the Great Channel. In fact, certain components of weathered oil have been observed to be beneficial to phytoplankton growth (Shailaja, 1988). Anyway, it will not be very practical or meaningful to draw conclusions from a comparison of our surface biomass values with the existing data from vertical hauls. Data from the few vertical hauls during the *Sagar Sampada* cruise and their comparisons with the corresponding surface hauls (Table 3) should lend credence to this view. We do hope, however, that our data should be useful to assess the impacts of any eventual future oil spill in the same area, at least at a first approximation.

Environmental Impact

We have made an attempt to assess the environmental impact of the spill in the environs of the Great Channel and the Great Nicobar island. This island lies close to the tanker route to the Far East and is constantly exposed to the risks and hazards of oil spills. It is extremely difficult to attribute environmental impact to any particular spill. Presumably, most of the damages are cumulative effects of several oil spills. Moreover, this area lies on the seismically active ridge extending from Tenasserim Yoma in Myanmar (Burma) to the Indonesian Archipelago. Consequently, the possibility of natural seepage of oil from the seabed cannot be ruled out. One of the

reasons for the higher values of DPH observed during the *Sagar Sampada* cruise (Table 3) could be due to these effects.

Coral reefs around the A and N islands are fringing reefs on the eastern side and fringing/barrier reefs on the western side. Corals in the nearshore areas of Great Nicobar are dead due to siltation caused by land runoff. Some of them are believed to have been rejuvenated subsequently by natural processes. Healthy coral reefs abound a little away from the shore.

Visits to some of the coral reefs, including a reef of rare red corals, did not reveal any impact of oil spills. Similar conclusions were drawn after a visit to some of the mangroves at mouths of a few rivulets. The absence of any significant impact associated with this spill can be attributed to the rapid evaporation and dispersion processes which evidently occurred, combined with a favourable NE wind which pushed any oil residues towards the open Indian Ocean.

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