

Zooplankton standing stock off south of Great Nicobar Island during an oil spill incident and after

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ABSTRACT

An intensive sampling was carried out in the oil plume area between lat. 5°56' to 6°42'N and long. 93°10' to 94°30'E. For a comparative study, samples were also collected along the international oil tanker route along the 5°45'N latitude from 82°E to 92°E longitude. The biomass values noted two weeks after the oil spill along the oil tanker route (negligible to 50 ml/100 m³) and in the vicinity of the island (2.45 to 70 ml/100 m³) suggested that the standing stock was not much affected as there was no trace of any oil in these areas after two weeks of the accident. This may be due to the natural dispersion and disintegration of oil, associated with the local winds and south-westerly currents. Zooplankton biomass was relatively high 8 months after the oil spill and it ranged from 5.62 to 72.3 ml/100 m³ along the tanker route and 2.32 to 83.3 ml/100 m³ at the oil spilled site. This may either be due to the full recovery of the environment or the normal seasonal variations. Later observations did not show any eventual damage to the fauna and flora as expected.

INTRODUCTION

An estimated amount of 18000 tonne of crude oil was spilled in the sea at the western entry to the strait of Malacca due to the collision of a Danish oil tanker VLCC *Maersk Navigator*, carrying 300000 tonne of light crude oil, with another tanker *Sanko Honour* on 21st Jan. 1993. As reported by the coast guard, if an oil patch of 90 km², just 16 nautical miles south of Indira Point (southern tip of the great Nicobar Island), detailed studies were carried out in the waters of the southern Nicobar area in the Bay of Bengal. The first phase of the study was conducted onboard *ORV Sagar Kanya* (cruise 81) during January/February 1993, to assess the immediate environmental impact of the oil spill and its consequent effect on the biota. The second phase was carried out during September/October 1993 onboard *FORV Sagar Sampada* (cruise 113) to estimate the possible long-term effects if any. Observations were made on the

zooplankton, oil slicks, floating tar balls, dissolved/dispersed petroleum hydrocarbons, sinking oil globules/tar particles, bacteria, yeasts and fungi. This paper gives an account on the zooplankton standing stock along the international oil tanker route in the southern Bay of Bengal and the areas to the south of the great Nicobar from where the oil patch was reported.

MATERIALS AND METHODS

During the first cruise, which was conducted two weeks after the oil spill (27-1-93 to 11-2-93), zooplankton samples were collected from 22 stations (Fig. 1) along the oil tanker route. The sampling was made from 82°00'E to 92°00'E longitude along 5°45'N latitude at 30 nautical miles intervals. These collections were made from the surface (0-15 cm) and subsurface (20-30 cm) layers using a Neuston net (300 μ) (Hydrobios, Germany) having a mouth area of 30x15' cm. From the area where the oil plume was noticed (between 93°10' to 94°30'E longitude and 5°56' to 6°42'N latitude), 17 samples were collected as cited above, at 15 nautical miles intervals. During the second cruise, 8 months after the oil spill (21-9-93 to 10-10-93), the same area was surveyed and sampling of subsurface (20-30 cm) zooplankton was carried out using Bongo net 300 μ (30 cm diameter). For comparative studies of the samples collected during the two cruises, subsurface samples from the Neuston net alone were considered. Neuston net could not be used for the second cruise due to operational difficulties. Though the gears used differ in design, the stratum sampled and the mesh size of the net used remained same and the values expressed are in terms of unit

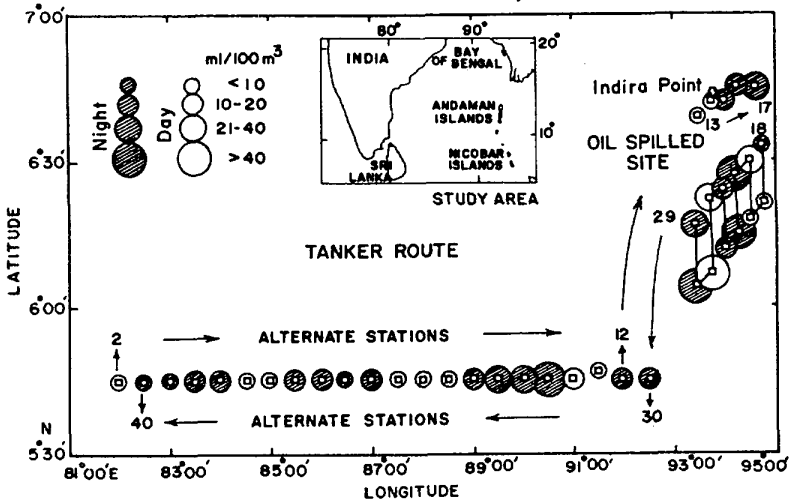


Fig. 1 - Density distribution of zooplankton biomass along the oil tanker route and oil spilled site, two weeks after the incident. (Sagar Kanya Cruise no.81)

volume of water filtered. Eleven samples were collected along the oil tanker route at 1° intervals (Fig.2 A) and from the oil plume area 14 samples were collected (Fig.2 B). Observations were also made on the shoreline, up to 15 km south of Campbell Bay, to assess the impact of the oil spill on the biota inhabiting the intertidal zone.

RESULTS AND DISCUSSION

All along the oil tanker route, the zooplankton biomass was relatively low (<10 to 20 ml/100 m³) except in the case of collections made closer to the great Nicobar area which had medium (21 - 40 ml/100 m³) to high (>40 ml/100 m³) biomass; whereas around 50% of the collections made from the oil plume area, in the vicinity of the island, revealed medium to high biomass (Fig.1, Table 1). Corresponding observations made 8 months after the accident showed comparatively higher values (>40 ml/100 m³) of biomass both along the tanker route and the oil spilled site (Fig.2, Table 2). Likewise, the numerical abundance of most of the taxa also showed considerable increase in their dominance in both the areas investigated (Figs. 3, 4 and Table 3). Numerical abundance of major taxa showed the following order of dominance. viz.

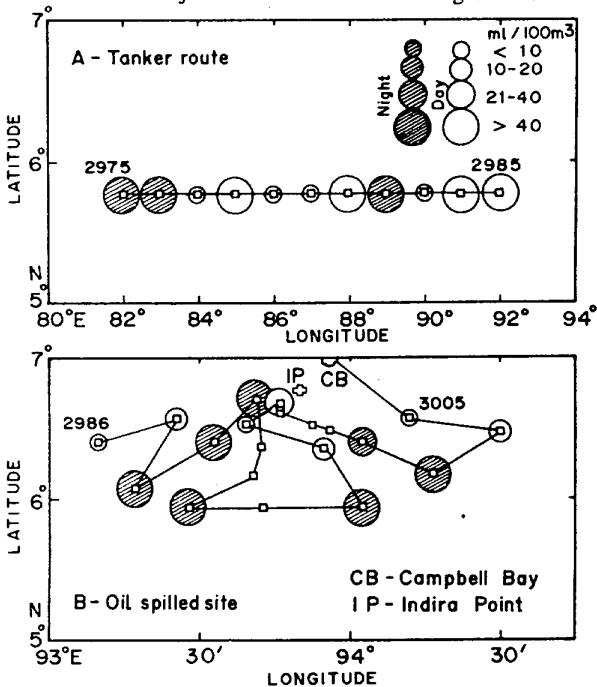


Fig.2 - Density distribution of zooplankton biomass along the oil tanker route and oil spilled site, eight months after the incident. (*Sagar Sampada* Cruise no.113)

Table 1 — Station locations and zooplankton biomass *ORV Sagor Kanya*
(Cruise - No.81)

St. no.	Date	Time (hrs)	Lat. (N)	Long. (E)	Biomass (ml/100 m ³)
<i>Tanker route</i>					
2	30-1-93	1100	05°45'	82°00'	5.00
3	30-1-93	1905	05°45'	82°59'	6.25
4	31-1-93	0300	05°45'	84°00'	10.00
5	31-1-93	1045	05°45'	85°00'	5.00
6	31-1-93	1850	05°45'	85°58'	10.00
7	1-2-93	0255	05°45'	86°59'	10.00
8	1-2-93	1105	05°45'	87°59'	5.00
9	1-2-93	1940	05°43'	88°59'	12.50
10	2-2-93	0415	05°45'	90°00'	25.00
11	2-2-93	1200	05°45'	91°00'	10.00
12	2-2-93	2030	05°45'	92°00'	20.00
30	6-2-93	0615	05°45'	92°30'	17.50
31	6-2-93	1255	05°47'	91°30'	3.75
32	6-2-93	2020	05°45'	90°30'	50.00
33	7-2-93	0307	05°45'	89°30'	27.50
34	7-2-93	0954	05°45'	88°30'	5.00
35	7-2-93	1650	05°45'	87°30'	4.37
36	7-2-93	2326	05°44'	86°30'	7.50
37	8-2-93	0620	05°45'	85°30'	17.50
38	8-2-93	1248	05°45'	84°30'	Neg.
39	8-2-93	1930	05°45'	83°30'	10.00
40	9-2-93	0155	05°45'	82°30'	7.50
<i>Oil spilled site</i>					
13	3-2-93	1100	06°40'	93°29'	7.50
14	3-2-93	1415	06°42'	93°46'	7.50
15	3-2-93	1900	06°43'	94°02'	20.00
16	3-2-93	2240	06°44'	94°16'	20.00

Contd....

Table 1 — *Contd.....*

17	4-2-93	0230	06°44'	94°36'	25.00
18	4-2-93	0600	06°34'	94°44'	7.50
19	4-2-93	1100	06°23'	94°52'	5.00
20	4-2-93	1420	06°17'	94°35'	2.45
21	4-2-93	1655	06°30'	94°29'	25.00
22	4-2-93	2000	06°28'	94°12'	50.00
23	4-2-93	2300	06°15'	94°17'	50.00
24	5-2-93	0130	16°12'	04°04'	16.25
25	5-2-93	0345	06°24'	93°57'	10.00
26	5-2-93	1430	06°22'	93°41'	22.50
27	5-2-93	1730	06°07'	93°46'	60.00
28	5-2-93	2035	06°05'	93°30'	70.00
29	5-2-93	2310	06°17'	93°24'	37.50

Copepoda, Chaetognatha, Appendicularia, Euphausiacea, Siphonophora and Thaliacea etc. and the least being Sipunculida (Table 3). Among the tertiary producers, the fish larvae on an average were found to the tune of 0.04 to 0.42% and 0.09 to 0.20% along the tanker route and oil spilled site after 2 weeks and 8 months respectively, after the accident. Gonostomatid and Myetophid fish larvae constituted 90% of the fish larval population. At the same time catches from midwater trawling showed the successive dominance of fishes such as *Gymnocranius grandoculic*, *Lethrinus microdon*, *L. conchylitatus*, *Pseudobalistes flavimarginatus* and *Ostracion meleagris*. Corresponding values for fish eggs from the above cited areas and periods were 0.49 to 1.09% and 0.27 to 0.64% respectively. Contrary to the above, decapod larvae showed their dominance after the oil spill in both the areas compared to values after 8 months (Table 3). Among decapods, sergestids dominated, followed by brachyurans, carideans, penaeids and others. Tertiary production which is assumed as 10% of the secondary standing stock suggested a production of 0.44 to 5.00 g/m³ and 0.56 to 7.23 g/m³ during the two successive cruises along the tanker route and 0.25 to 7.00 g/m³ and 0.23 to 8.33 g/m³ in the oil spilled site respectively. It was interesting to note that the marine insect *Halobates* was found in good numbers all-over the area, more so along the tanker route.

The general trend noticed in the study was that the open ocean (tanker route) was relatively poor in zooplankton standing stock compared to the waters south of the great Nicobar Island. Fairly high production was noticed (>10ml/100 m³) from waters surrounding Sri Lanka, Andaman Sea and Bay of Bengal (Prasad, 1969; Panikkar & Rao, 1973). Areas near to the equator mostly showed poor production (<5ml/100 m³).

Table 2 — Station positions and zooplankton biomass *FORV Sagar Sampada* (Cruise - No. 113).

St. no.	Date	Time (hrs)	Lat. (N)	Long. (E)	Biomass (ml/100 m ³)
<i>Tanker route</i>					
2975	24-9-93	2030	05°46'	82°09'	72.30
2976	25-9-93	0245	05°45'	83°00'	52.30
2977	25-9-93	1000	05°45'	84°00'	19.70
2978	25-9-83	1730	05°45'	85°00'	51.80
2979	26-9-93	0135	05°45'	86°00'	11.70
2980	26-9-93	0915	05°45'	87°00'	11.50
2981	26-9-93	1615	05°45'	88°00'	49.50
2982	26-9-93	2338	05°45'	89°00'	54.80
2983	27-9-93	0700	05°45'	90°00'	5.60
2984	27-9-93	1545	05°45'	91°00'	68.70
2985	27-9-93	2324	05°45'	92°00'	63.70
<i>Oil spilled site</i>					
2986	28-9-93	1017	06°24'	93°00'	7.50
2987	28-9-93	1420	06°34'	93°26'	15.60
2988	28-9-93	2123	06°05'	93°18'	75.30
2989	29-9-93	0215	06°24'	93°34'	73.00
2990	29-9-93	0640	06°42'	93°42'	47.80
2993	29-9-93	2104	06°22'	93°43'	83.30
2995	30-9-93	0355	06°09'	93°41'	16.80
2996	30-9-93	0724	05°56'	93°88'	2.30
2997	30-9-93	1152	05°56'	94°03'	36.60
2998	30-9-93	1600	06°21'	93°55'	10.60
3002	1-10-93	0000	06°24'	94°03'	25.50
3003	1-10-93	0353	16°10'	94°17'	77.60
3004	1-10-93	0820	06°28'	94°30'	11.90
3005	1-10-93	1205	06°34'	94°12'	8.60

Table 3 — Numerical abundance (NA) (no/100 m³) and relative percentage (RP) of different zooplankton group along the oil tanker route and oil spilled site after the incident

Group	Tanker route				Oil spilled site			
	After 2 weeks		After 8 months		After 2 weeks		After 8 months	
	NA	RP	NA	RP	NA	RP	NA	RP
1. Foraminifera	155	1.20	250	1.02	136	0.43	104	0.28
2. Hydromedusae	21	0.16	159	0.65	91	0.29	26	0.07
3. Siphonophora	114	0.85	60	0.24	567	1.79	230	0.61
4. Polycheta	3	0.02	6	0.02	215	0.68	450	1.20
5. Cladocera	66	0.49	170	0.69	555	1.75	1250	3.32
6. Ostracoda	5	0.04	12	0.05	61	0.19	150	0.40
7. Amphipoda	146	1.09	440	1.80	287	0.91	325	0.86
8. Copepoda	10062	75.30	14726	60.11	21777	68.84	28240	75.10
9. Sergestidae	53	0.40	992	4.05	73	0.23	244	0.65
10. Euphausiacea	129	0.97	1367	5.58	233	0.74	247	0.66
11. Mysidacea	107	0.80	36	0.15	174	0.55	350	0.93
12. Gastropoda	97	0.73	194	0.79	290	0.92	600	1.60
13. Heteropoda	43	0.32	489	1.99	121	0.38	344	0.91
14. Pteropoda	61	0.46	120	0.49	132	0.42	158	0.42
15. Cephalopoda	-	-	-	-	7	0.02	-	-
16. Chaetognatha	917	6.86	3284	13.41	2758	8.72	1458	3.88
17. Salps and doliolids	293	2.19	16	0.07	1572	4.97	30	0.08
18. Appendicularia	706	5.28	1500	6.12	1119	3.54	2250	5.98
19. Fish eggs	65	0.49	268	1.09	81	0.27	242	0.64
20. Fish larvae	5	0.04	108	0.42	29	0.09	76	0.20
21. Zoea larvae	58	0.43	52	0.21	120	0.38	75	0.20
22. Decapod larvae	199	1.49	126	0.51	1011	3.19	384	1.02
23. Echinoderm larvae	20	0.15	36	0.15	86	0.27	180	0.48
24. Polychete larvae	2	0.01	5	0.02	15	0.05	40	0.11
25. Alima larvae	18	0.13	5	0.02	25	0.08	1	0.003
26. Megalopa larvae	13	0.10	19	0.08	69	0.22	140	0.37

Contd....

Table 3 — *Contd.....*

27.	Lamellibranch larvae	-	-	-	-	3	0.01	-	-
28.	Brachiopod larvae	-	-	-	-	9	0.03	-	-
29.	Cirriped larvae	-	-	-	-	4	0.01	-	-
30.	Sipunculida	3	0.02	-	-	10	0.03	-	-
31.	Halobates	1	0.01	57	0.23	3	0.01	11	0.03
	Total	13362		24497		31633		37605	

It was observed that when Arabian Sea on an average had a biomass of 28.5 ml/100 m³, the zooplankton standing stock in the eastern region of the Indian Ocean and Java Sea ranged between 7.7 to 18 ml/100 m³ (Prasad, 1969). General trend noticed was that, the eastern portion of the Indian Ocean becomes highly productive during northeast monsoon (December - February) (Panikkar & Rao, 1973). High biomass values overlapped areas of shallow surface layer in regions of upwelling. Bay of Bengal has been noticed for its high abundance of fish eggs and larvae and their present abundance towards the coastal areas suggest the possibility of their breeding grounds (Panikkar & Rao, 1973). Maximum zooplankton production reported in Andaman Sea was 100 - 150 ml/100 m³ (Anon, 1988; Desai & Kesavadas 1988). Biomass of 164.04 ml/1000 m³ have been noted for the shelf area (EEZ) of both east and west coasts of India and Andaman and Nicobar Islands together (Mathew *et al.* 1990). Oceanic areas of the Bay of Bengal, on an average had a biomass of only 36.65 ml/1000 m³, which was almost half when compared to corresponding areas in the Arabian Sea (Mathew *et al.* 1990). Earlier works from the Andaman Nicobar areas have reported an average biomass of 5.6 ml/100 m³ (1.8 to 14.4 ml/100 m³) (Madhupratap *et al.* 1981 a, b) which is very poor when compared to later reports. Unlike the present finding, the above workers noted crustacea as the bulk constituent of the zooplankton. In their collections ostracods were present in 97% of the samples, whereas in the present collections they were totally absent. Of the estimated 7-9 million tonnes of fish production from the EEZ of India, Andaman and Nicobar waters had a share of 1.39 million tonne, though the present catch from the latter area is only 1500 tonne. A comparison of the zooplankton biomass data of the present observations in the oil spilled site with that of the earlier reports from the same area showed that the impact of the oil spill, either short-term or long-term, is not pronounced.

Arabian Sea and Bay of Bengal are important sea routes for most of the oil moving from the Gulf to the Far East and thus vulnerable to oil discharge either accidentally or on account of routine shipping activities (Desai & Kesavadas, 1988). Arabian Sea is the world's busiest tanker route with maximum oil slick (Sengupta & Qasim, 1982).

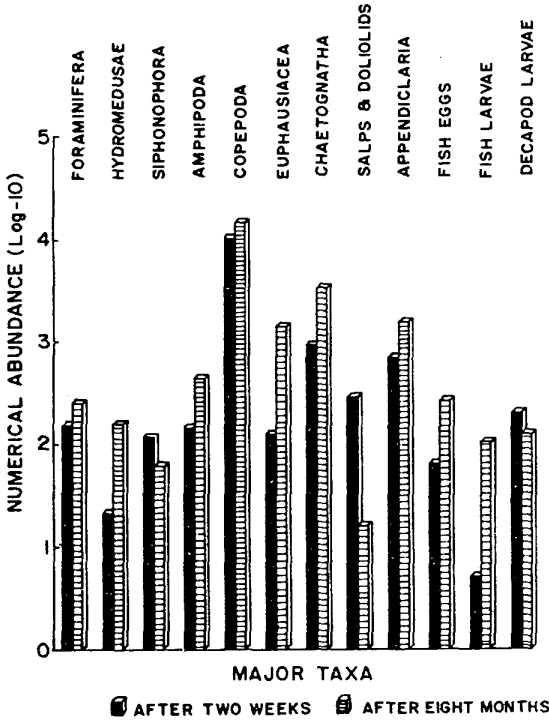


Fig. 3 - Numerical abundance of major zooplankton groups-oil tanker route

Compared to Arabian Sea, Bay of Bengal is less polluted in terms of oil slicks and related floating tar balls as evidenced by the present and earlier studies.

The various physico-chemical changes that take place when crude oil is spilled at the sea and its effect on marine biota are explained by various workers (Bonsdorff, 1981; Gerlach, 1981). Andaman waters are not influenced by oil tanker traffic or significant oil pollutants from sewage or land run off (Topgi *et al.* 1981). Data based on the above 1979 observations in this area, showed that the dissolved petroleum hydrocarbon concentrations ranged between 28 and 83 $\mu\text{g/l}$ at 0-10 m and the average being 51 ± 1 and $55 \pm 1.2 \mu\text{g/l}$ respectively. In another observation the authors have reported 73 ± 1.3 and $61 \pm 1.4 \mu\text{g/l}$ at the surface and 10 m respectively from the oil tanker route across the Bay of Bengal which are higher compared to Goan waters (Fondekar *et al.* 1980). The global range estimated is 0-100 $\mu\text{g/l}$ (Farrington & Mayer, 1975). The range of floating tar balls in the oil tanker route in the Bay of Bengal was 0-69.75 mg/m^2 and the mean concentration of dissolved and dispersed hydrocarbons

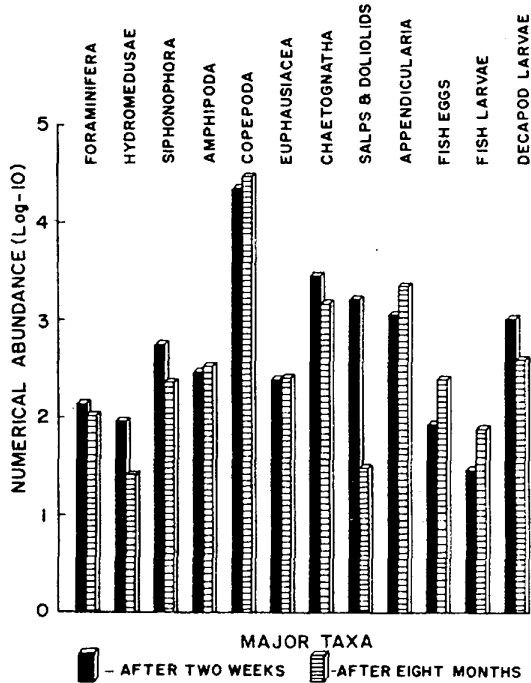


Fig.4 - Numerical abundance of major zooplankton groups - oil spilled site

for 0-20 m was $24.1 \mu\text{g/l}$ (Sengupta & Kureishy, 1981). North of this route, Bay of Bengal was relatively free from floating tar balls. The dissolved petroleum hydrocarbons along the oil tanker route in the southern Bay of Bengal at 0, 10 and 20 m was 19.95 ± 3.38 , 16.78 ± 2.53 and $13.45 \pm 2.17 \mu\text{g/l}$ respectively (Topgi *et al.* 1982). In any case, the oil tanker route in the Bay of Bengal is far less contaminated as compared to many oil tanker routes in various geographical areas.

The present study in the Nicobar area conducted after the oil spill showed that the dissolved petroleum hydrocarbons got reduced remarkably from a maximum of 5.4 mg/l to $0.31 \mu\text{l}$ over a span of 8 days and in the tanker route, it reduced from 15.4 to $0.31 \mu\text{g/l}$ (Anon, 1993). Tar balls were absent in all the stations of the spill area and it was present in a few stations in the tanker route. Zooplankton samples collected during the second cruise from the spilled site showed double concentration of aliphatic hydrocarbon (0.60% of dry weight) when compared to samples from tanker route. Coral debris collected 15 km south of Campbell Bay also showed traces of aliphatic hydrocarbons (0.003% of dry weight) (Anon, 1993). Aromatic hydrocarbons

did not show much variations in zooplankton from the oil spilled site (0.16% of dry weight) and the tanker route (0.098% of dry weight).

Immediately after an oil spill zooplankton will ingest oil, but this phenomena is short lived. Traces of aliphatic and aromatic hydrocarbons noticed in the mixed zooplankton collected from areas south of great Nicobar did not show any pronounced effect on the zooplankton standing stock as evidenced by their dense concentrations. The regular wash and spill from the oil tankers along the tanker route might get accumulated in these areas during this time of the season (September-November) which is a transitional period for both prevailing winds and currents (Wyrтки, 1973) thereby allowing more residence time for the petroleum products to disperse and disintegrate.

From the studies made, one can confidently conclude that the oil spill in the Nicobar waters might not have inflicted any serious lethal effect on the biota or any ecological distortions whether short or long-term. The oil patch traced to the south of great Nicobar was broken into patches by winds, currents and waves and it got drifted towards the west-south westerly direction with decreasing concentrations away from the accident site towards the open ocean.

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