

Hydrography & Circulation in the Vicinity of a Power Plant

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Physical aspects of the hydrographic survey conducted in the vicinity of the Tarapur Atomic Power Plant are presented. No spatial variation in temperatures has been noticed in the intake and discharge canal regions. The sediment load in the sea water varies inversely with the distance from the coast. Flow patterns more or less parallel to the coast with strong onshore components have been observed.

WITH increasing demand for cheaper power more and more power plants — thermal and nuclear — are being installed in many parts of the world. The vast cooling requirements compel these plants to be situated on those sites where adequate quantity of water is readily available. The water discharged after cooling the condensers of the plant generally has higher temperature than the intake water. Instances of serious environmental impairments due to the disposal of the waste heat into the environment have been reported by many workers¹⁻⁶. Opportunities for such studies have been made available when a request was made to NIO by the Tarapur Power Plant Authority for undertaking the studies to enable them to lay a submarine pipeline to release the low active waste from the power plant and the fuel reprocessing plant.

The Tarapur Atomic Power Plant is situated at the Tarapur point, about 95 km north of Bombay. The station consisting of 2 reactors with a power generating capacity of 420 MW was commissioned in 1969. It requires about 650 mgd of water for cooling purposes. This entire volume of water is being drawn from the sea. After cooling the condensers the water is discharged back into the sea through the north or south canal depending on the phase of the tide.

Comparatively little work has been done in the coastal waters of the region. Recent studies in the coastal region north of Bombay include that of Jayaraman and Gogte⁷ and Jayaraman *et al.*⁸. Nair⁹ studied the hydrobiological aspects in the Tarapur region. Kamath and Ganguly¹⁰ studied the environmental aspects of the release at Tarapur, and Sastry¹¹ made some theoretical estimates on the swell characteristics and an evaluation of littoral drift in the neighbourhood of Tarapur Atomic Power Plant and in the sea off Tarapur. During the present survey, physical, chemical, biological and geological aspects of the region were studied. This paper deals with the physical results of the study with special reference to the thermal status of the region as influenced by the waste heat disposal from the plant.

Materials and Methods

Since the investigations were mainly related to the proposed pipeline and the effect of the waste

heat disposal into the inshore waters, the area of the survey was limited up to 10 fm line. Three sections — one along the intake region and one each along the discharge regions — were selected. On each profile stations were fixed at 3, 7 and 10 fm contours (Fig. 1). Surface and subsurface (2 fm along the 3 fm contour and 5 fm along the 7 and 10 fm contours) samples were collected from all the stations. Surface temperatures were noted with ordinary thermometers and subsurface temperatures were measured with reversing Thermometers. Salinity values were estimated by titration. Turbidity measurements were made using the Secchi disc. Suspended sediment was estimated by filtering a known volume of sea water collected from the surface through a pre-weighed Whatman 42 filter paper. The residue left was dried at 60-70°C and weighed immediately after attaining the room temperature. The survey was conducted from 2 to 5 December 1972, 27 January to 4 February 1973, 30 March to 7 April and 18 to 21 May 1973.

Results and Discussion

Temperature — During December 1972, when the survey was started, the temperature values recorded were around 25.5°C. During January the temperatures began to fall and temperature values as low as 21°C were recorded during January and February 1973, beyond which the temperature showed a rising trend (Table 1). Maximum temperature of 31.5°C was recorded during May showing seasonal variations to the order of 10°C. Jayaraman *et al.*⁹ reported similar trend in the variations of temperature in the sea water near the lighthouse at Bombay. Along the nearshore waters off Bombay and Saurashtra coasts, Jayaraman and Gogte⁸ reported a similar trend of lowest temperatures in February and increases during March and April. So the high seasonal variations in temperatures recorded during the present study favourably compares with that of the early workers and it appears that the wide variations in temperature is purely a seasonal phenomenon present along the entire coast.

Regarding the spatial variations of temperature in intake and discharge canal regions, no significant temperature difference was observed (Table 1). No significant difference between the surface and subsurface temperatures was noted. Thus, in

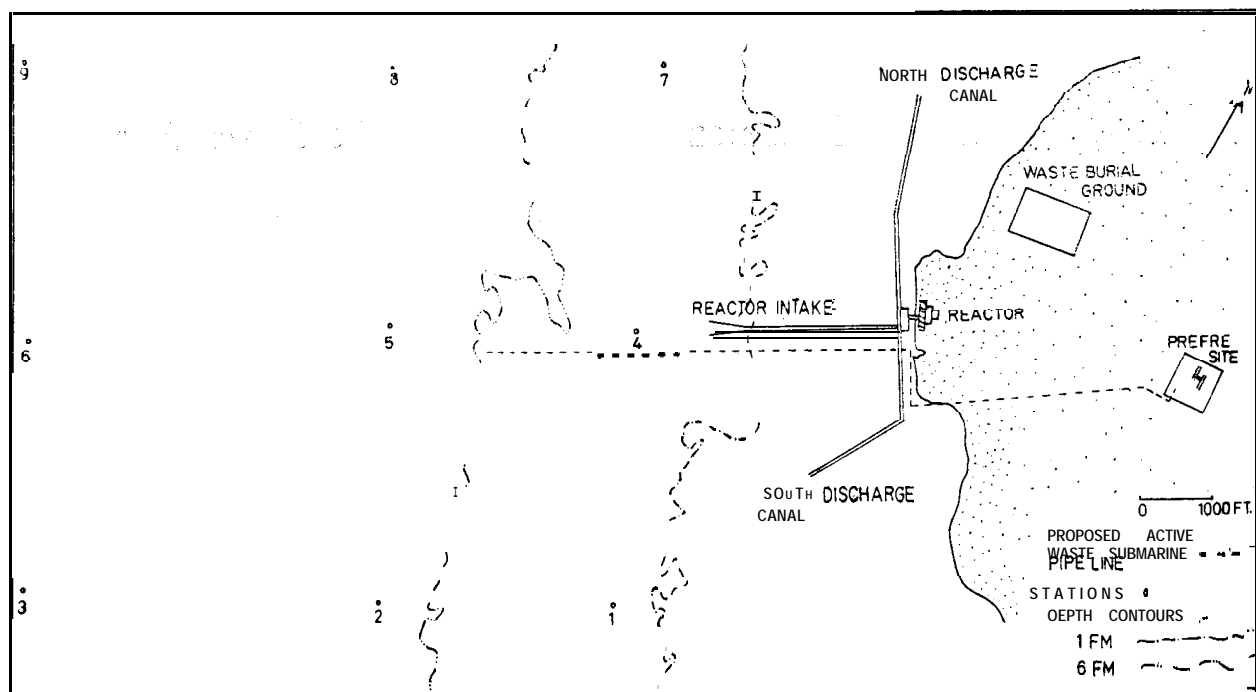


Fig. 1 → Location map showing stations

TABLE 1 — AVERAGE VALUES OF TEMPERATURE (°C) IN THE DISCHARGE AND INTAKE CANAL REGIONS

Period of collection	Southern discharge canal region		Intake canal region		Northern discharge canal region	
	S	SB	S	SB	S	SB
3 and 4 Dec. 1972	25.6	25.6	25.8	26.0	26.0	25.9
27 and 28 Jan. 1973	21.4	20.9	21.3	21.1	21.1	20.8
3 and 4 Feb. 1973	21.9	21.5	22.1	21.7	21.9	21.9
30 and 31 March 1973	28.6	28.4	28.7	28.0	28.6	28.4
6 and 7 April 1973	28.9	28.6	29.2	28.2	29.1	28.9
19 and 20 May 1973	30.9	30.6	31.2	31.1	31.0	29.8

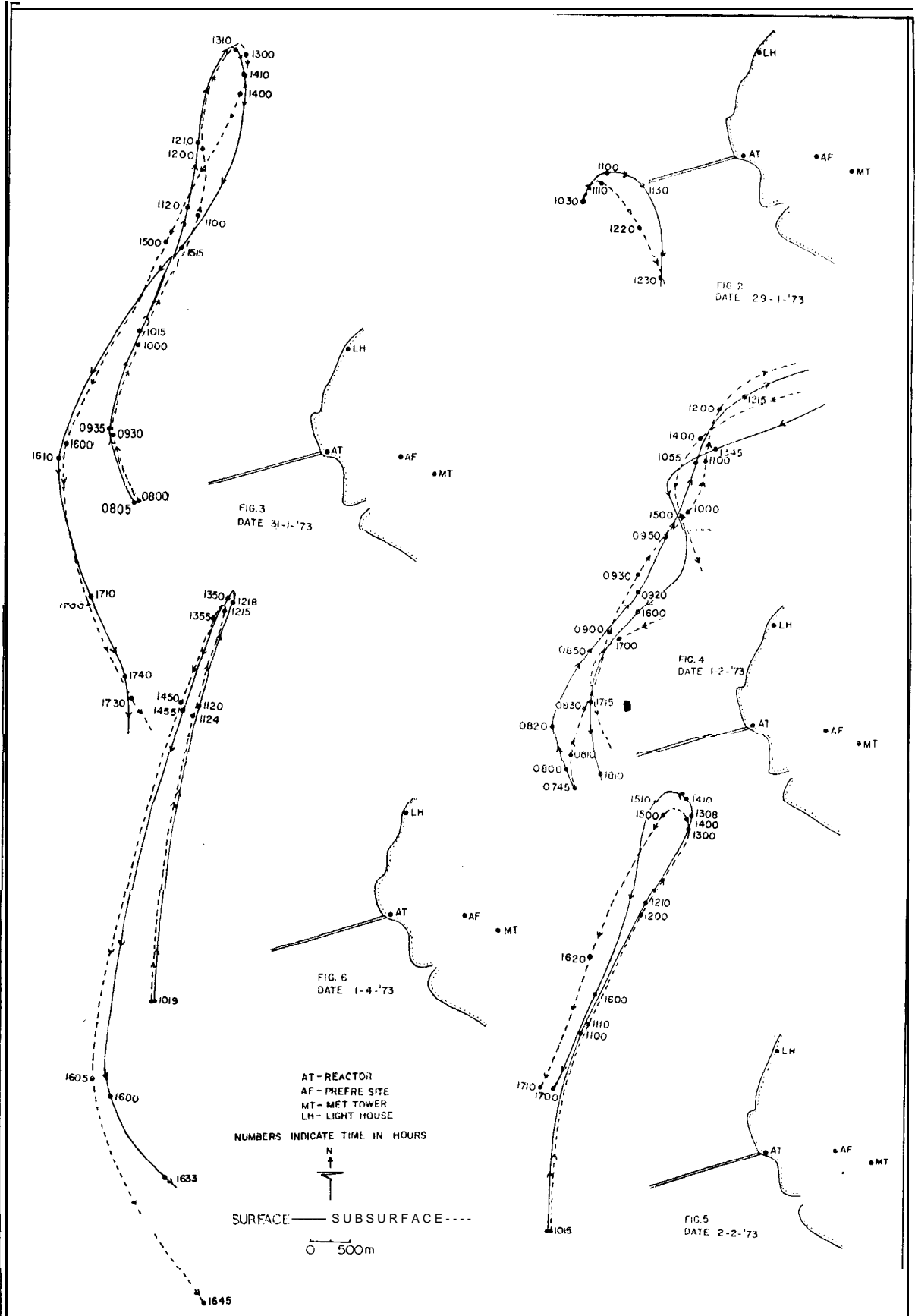
S = surface, and SB = subsurface.

general, the spatial distribution over a particular period was isothermal indicating that the thermal status of the region in the surroundings of the plant is not at all affected by the thermal discharge from the plant.

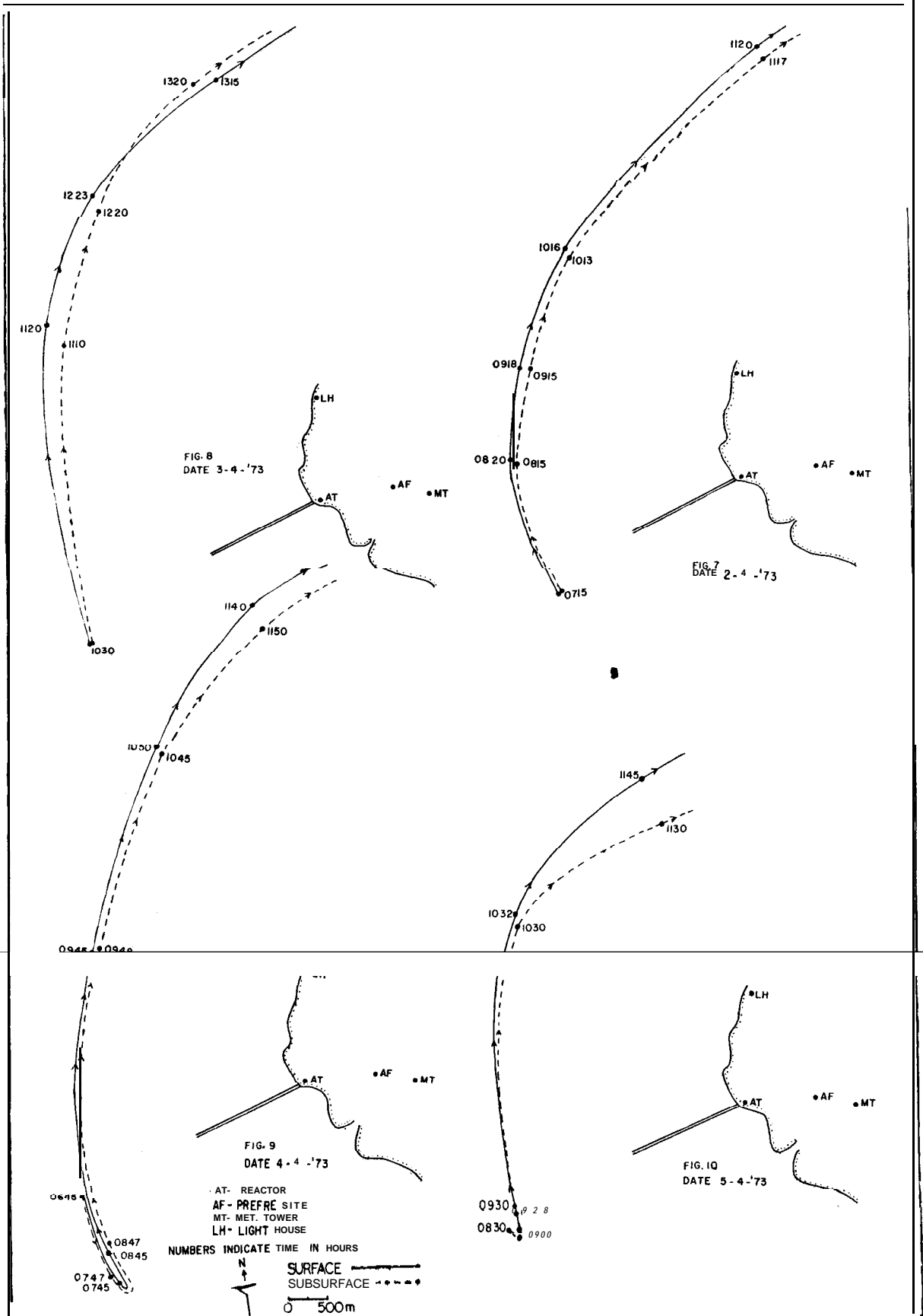
Salinity — Salinity values during the period of the survey varied within very small ranges (Table 2). Lowest salinity of 35.81‰ was recorded during December 1972 and the highest of 36.95‰ during May 1973, thus indicating no significant spatial or temporal variations in salinity. Nair⁹ reported higher values ranging from 36.15 to 37.29‰ during March. During the present study the salinity values varied from 35.81 to 36.95‰. Jayaraman and Gogte⁷ reported salinity values ranging from 36.04 to 35.82‰ during May along the 20°N. Thus the values observed during the present study are in favourable comparison with the earlier values reported when the highly unstable conditions of the nearshore environment are taken into consideration. Hence it can be safely concluded that the existence

of the power plant does not have any considerable impact on the environment as far as the salient hydrographic features are concerned.

Suspended sediment — Suspended load in the region is of serious concern when the silting problems along the canals and circulating system are taken into consideration. Due to its comparatively high sediment content, the sea water is kept in the coffer dam at the inner end of the channel in a very slow, or no motion before it is being pumped up into the plant. Water is being filtered for heavier and floating objects. However, it is observed that this reservoir is getting silted up due to suspended sediment. In general the coastal waters in the region were highly turbid. Secchi disc visibility, as low as 35 cm, was observed during January at 3 fm line, when the maximum suspended load of 160 mg/litre was recorded (Table 2). Suspended sediment was found to be decreasing towards offshore. Minimum suspended load of 31 mg/litre was observed during March at station 9.



Figs. 2 to 6 -Drift trajectories



Figs. 7 to 10 -Drift trajectories

TABLE 2 -MAXIMUM AND MINIMUM VALUES OF TEMPERATURE, SALINITY, SECCHI DISC READING AND SUSPENDED SEDIMENTS DURING THE SURVEY

Period of collection	Temperature, °C				Salinity ‰				Secchi disc cm		Susp. sedi. mg/litre	
	Max.		Min.		Max.		Min.		Max.	Min.	Max.	Min.
	S	SB	S	SB	S	SB	S	SB				
3 and 4 Dec. 1972	26.1	26.1	25.3	25.0	35.99	35.97	35.97	35.91	85	35	117	65
27 and 28 Jan. 1973	21.7	21.2	20.9	20.8	36.85	36.85	35.87	36.31	90	60	160	64
3 and 4 Feb. 1973	22.5	22.2	21.9	21.4	36.49	36.31	36.31	36.13			123	60
30 and 31 March 1973	29.0	28.4	28.2	28.0	36.33	36.17	35.95	35.95	120	60	138	31
6 and 7 April 1973	29.6	29.1	28.8	28.6	36.33	36.17	35.95	35.81	140	80	120	42
19 and 20 May 1973	31.1	31.3	30.5	30.1	36.95	36.85	36.17	35.81	110	7.5	148	75

S = surface, and SB = subsurface.

Maximum disc visibility of 140 cm was observed along 10 fm line during April. Nair⁹ reported comparatively lower values of suspended sediment varying from 27.2 mg/litre at 10 fm line to 8.5 mg/litre at a point about 5 km offshore from 10 fm contour, during October. This discrepancy may partly be due to the different procedures of analysis and partly due to the seasonal variations. He used millipore filters and the residue were dried and weighed at 100°C. Cartwright and Spanne¹² reported considerably high values of seston (256 to 1008 mg/litre at 8 in. above the bottom at a station 12 ft deep and 2000 ft away from the coast). The varying nature and the durability of the winds are also liable for the differences observed in the suspended sediment.

Currents-Flow patterns in the region were studied to assess how the dumped material would be transported by the currents. Free drifting biplane drogues made of aluminium sheets (2x 3 ft) with neutrally buoyant floats were released. They were made to float at 1 and 3 m depth. These floats were released at various distances from the shore ranging from 1/2 to 7 km and were tracked over a tidal cycle. Location fixings were made at 30 min intervals using sextant except in the initial stages of the tide when the location fixings were made at shorter intervals.

Most of the floats released closer to the shore were carried shoreward indicating a strong onshore component. The floats which were released at about 3 km or more from the shore followed a course more or less parallel to the coast (Figs. 2 to 10). The onshore component was found to be reducing in the offshore direction. Maximum tidal displacements were observed in the 3rd and 4th hours of the tide in almost all cases, when the average velocity was about 2 to 3 knots. The floats were carried

over a distance of 15 to 18 km during a single tide. On the turn of the tide the floats followed more or less the same path. The differences between the surface and subsurface flow patterns were negligible.

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