QUATERNARY SEA-LEVEL VARIATION, SHORELINE DISPLACEMENT AND COASTAL ENVIRNMENT

Editors

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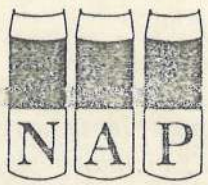

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Beach Dynamics at Pudhuvalasai in Palk Bay

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ABSTRACT

The dynamic process of the Tamil Nadu coast distinctly differ from other coastal states due to the presence of Sri Lankan Island, Palk Bay and Gulf of Mannar. Most of the time Palk Bay is protected from active wave climate of the Bay of Bengal. During November to February waves reach the inner Bay. For a better understanding of the coastal dynamics in the Palk Bay region, nearshore profiles, longshore currents and surf zone parameters were measured every month at Pudhuvalasai from April 1995 to April 1996. Sea floor changes were surveyed at three seasons from an area 1000 m x 600 m, to study sediment depositional features. The study shows that over an annual cycle sediments are being deposited in this region. The probable reason may be the occurrence of cyclonic storms in the Bay of Bengal during north east monsoon, which increases the volume of littoral drift along the north Tamil Nadu coast in a southerly direction and Palk Bay serves as a sediment sink.

Key Words : Beach Dynamics.

INTRODUCTION

Pudhuvalasai is a long stretch of sandy beach close to the Vaigai river confluence, outlet / estuary on the northern side of the Pamban Pass in the southwest part of Palk Bay. The oceanographic parameters are quite complex in this region due to the presence of several islands and shoals. In spite of abundant resources found over this region, the available information on the dynamics of the coastal processes are practically unknown. In the present study, field studies were carried out at Pudhuvalasai on littoral environments, variations in beach profiels and sea bed variations from April 1995 to April 1996. The longshore sediment transport has been estimated and discussed in relation to beach profile variation and the sea floor variations.

MORPHOLOGY OF THE REGION

Palk Bay is a shallow bay with a maximum depth of 13 m, and covers an area of about 600 km^2. Palk Strait is about 75 km wide between India and Sri Lanka with a water depth of 9-13 m except where the local reef rises above sea level. Pambar on the northwestern side, Kottakkarai on the west and the Vaigai on the southwestern side are the three streams flowing into the Bay (Vasudevan and Seetaramaswamy, 1983).

Palk Strait, forming the north entrance to Palk Bay, lies between the north coast of Sri Lanka and the east coast of India. The Strait is largely occupied by banks and numerous shoals. There are three principal entrance channels viz., the south, the middle and the north channels. The southern shore of Palk Strait is formed by the northern coast of Jaffna Peninsula which extends 34 km west southwest from Point Pedro. This stretch of the coast is sandy and backed by salt water lagoons and stony plains and is generally low with some cliffs and sand hills. The northwest shore of Palk Strait is formed by the low-lying coast between Vedaraniyam and a low point projecting east near Manamelkudi. The south shore of Palk Strait is bounded by Sri Lanka on the east, by Mannar Island and Pamban Island on the south and by the coastal districts of Tamil Nadu state on the west.

From Kalmunai Point on the east, it forms a wide bight until Devil's Point and then another bight to the east and till Mannar Island. Both of these bights are much encumbered with shoals, banks of mud and sand, and some islets. Kakerativu, Palativu, Iranativu North (Tranitivu), Irantivu South (Sinnativu) and Jaffna are present in this region.

Palk Bay is separated from the Gulf of Mannar by Pamban and a number of smaller islands. Both on the north and south of Rameshwaram promontory rocky beaches, and coral reefs are present. The rocky islands or banks between Sri Lanka and India near Rameshwaram, often known as Pearl Banks, are composed of coral lime and other limestones and coral reefs (Ahmad, 1972).

The mixing of waters of Palk Bay and the Gulf of Mannar takes place through the Pamban pass and also through "Adam's Bridge" between Dhanuskodi and west coast of Sri Lanka (Balachandran, 1995). The spring tidal

range in this region is about 0.6 m and the neap tidal range is about 0.2 m.

METHODS OF STUDY

The littoral environmental observation was carried out at Pudhuvalasai (Fig.1) every month from April 1995 to April 1996. The magnitude and direction of the longshore currents were measured by releasing fluorescent tracers in the surfzone and noting the distance it travelled for 2 minutes. Breaking wave height and wave period were visually observed following the CERC (Basco, 1982) procedure. The breaking wave angle with respect to the coastline was measured using a surveyor's magnetic compass. Surfzone width was measured visually.

Variation in beach levels were measured, at every 5 m intervals along a transact from backshore to seaward up to the 1 m water depth every month. Nearshore bathymetry was carried out from the water line to 600 m seaward every month covering 1 km along the coastline and were reduced to Chart Datum.

From the observed data on the monthly average surf zone parameters, longshore sediment transport rate was estimated using Walton's equation, is given by (Walton and Bruno, 1989).

$$Q = \frac{1290\rho\, g H_b w v C_f}{0.78\,(5\pi/2)\,(v/v_o)} \qquad (1)$$

Where, Q = Longshore sediment transport rate in m^3/ year, ρ = mass density of the sea water = 1025 kg/m^3, g = acceleration due to gravity = 9.81 m/s^2, C_f = the friction coefficient = 0.01, H_b = breaking wave height in m, w = surf zone width in m, v = measured longshore current velocity in m/s, (v/v_o) = theoretical dimentionless longshore current velocity (Longuet-Higgins, 1970).

RESULTS AND DISCUSSION

Surfzone Characteristics

The typical variation on the longshore current velocity and direction, the breaking wave height and period and the breaker angle at Pudhuvalasai beach are presented in Fig.2 and Table 1. The monthly significant breaking wave heights were relatively more about 0.4 - 0.6 m December to March and very low showing less than 0.2 m during the rest of the year. It shows that waves approach the interior part of the Palk Bay only during the Northeast monsoon period is from December to March. The wave period persisted around 3-4 seconds during December to April and 5-8 seconds during the rest of the year. Waves were breaking parallel to the coast during June to September and around 2°-4° with respect to the coast during the rest of the year. Spilling type wave breaking was observed on the beach throughout the year. The width of the surfzone was from 15 to 30 m during December to April and practically no surfzone was found during the rest of the year due to low wave action.

The longshore current direction was towards the south during November to January and towards the north during the rest of the year. The longshore current speed was comparatively high exceeding 0.15 m/s during November to January, March and April, and less tna 0.02 m/s at other months.

BEACH PROCESS

The variation in beach levels in each month up to 600 m seaward from the waterline are shown in Fig.3. The relative change in the volume of sediment in the region was estimated and presented in Fig.4. The beach showed its lowest profile in November and its highest in May. The fluctuation indicates that the beach experiences seaward erosion during the north-east monsoon period from October to January and starts building up from February. The variation of the beach level indicates that the beach is stable and regained more than the original profile over the period of a one year cycle, indicating net annual accretion on this beach.

The nearshore bathymetry surveyed over 1000 x 600 m area off Pudhuvalasai beach in April 1995, August 1995 and February 1996 is presented in Fig.5 to 7. The sea floor variation indicates that compared to April 1995, 0.6 x 10^6 m^3 sand was deposited in August 1995 and 0.14 x 10^6 m^3 deposited by February 1996. The conclusion is that the nearshore region of Pudhuvalasai is in a depositional environment.

SEDIMENT TRANSPORT

Using the measured daily littoral environmental parameters in equation 1, the longshore sediment transport rate on the beach was estimated and is presented monthly in Table 2 and Fig.2. The predominant direction of transport tends to be northerly from February to October and southerly during November to January.

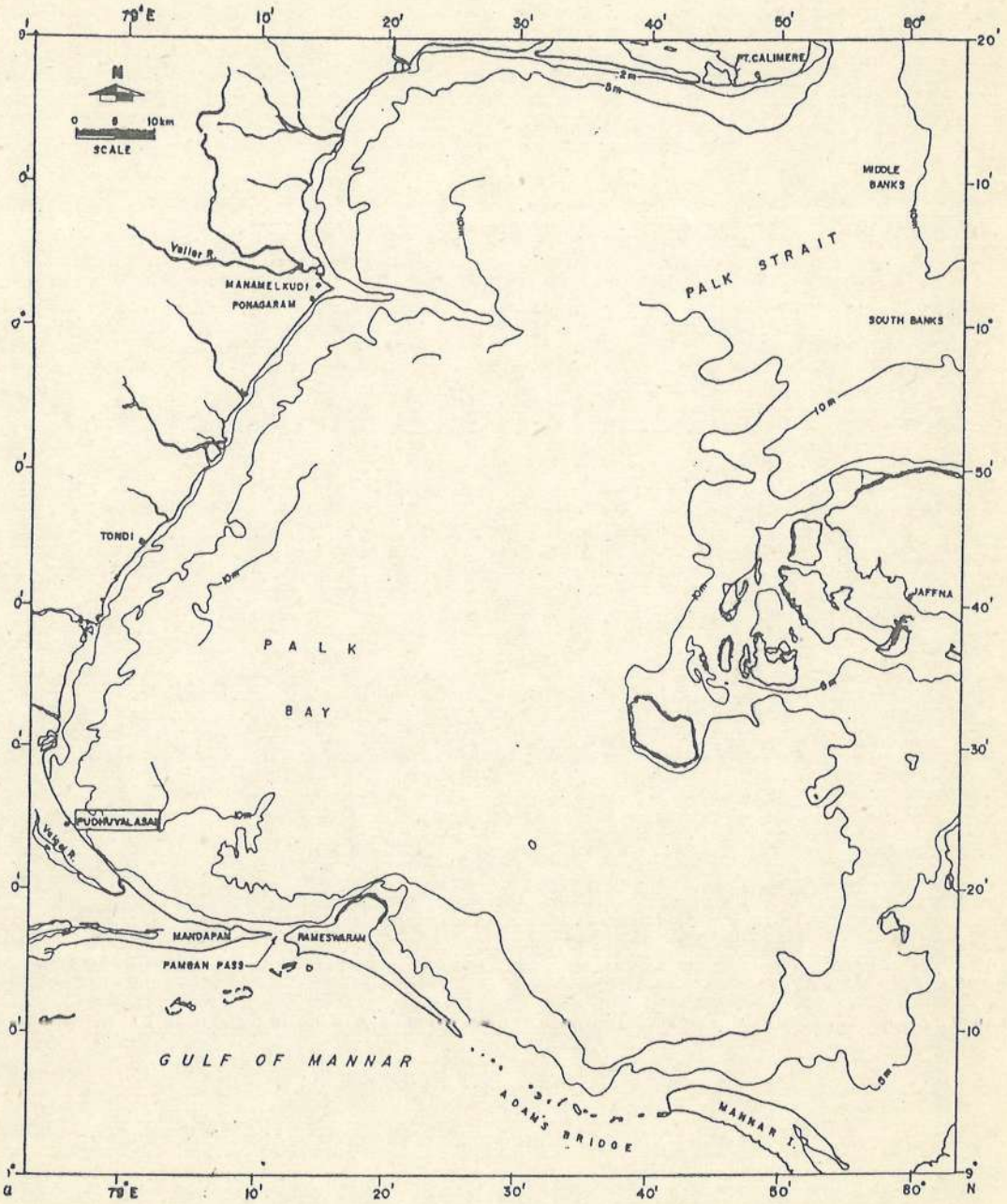

Fig.1 Location Map

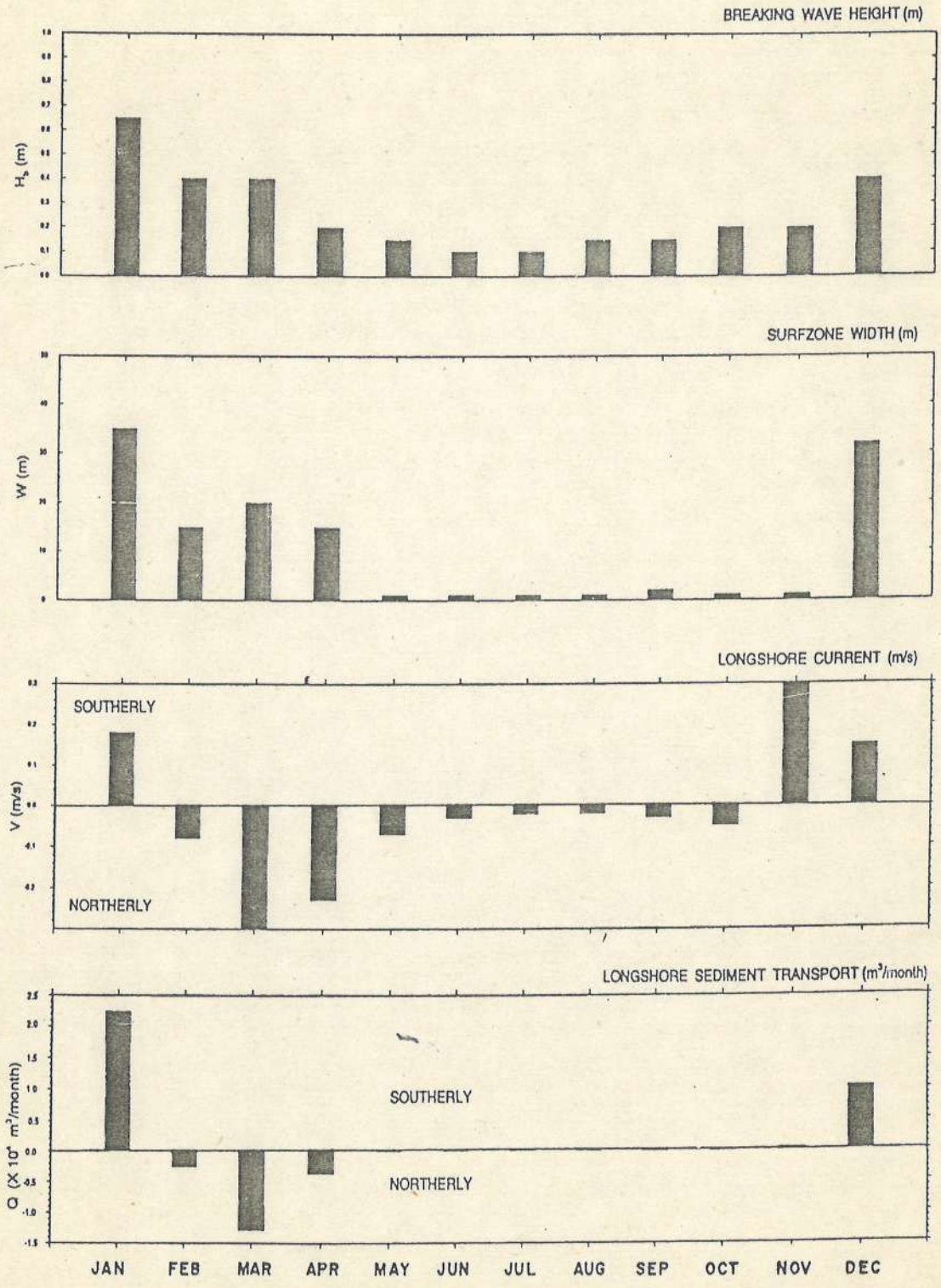

Fig.2 Observed wave characteristics and the sediment transport rate at Pudhuvalasai

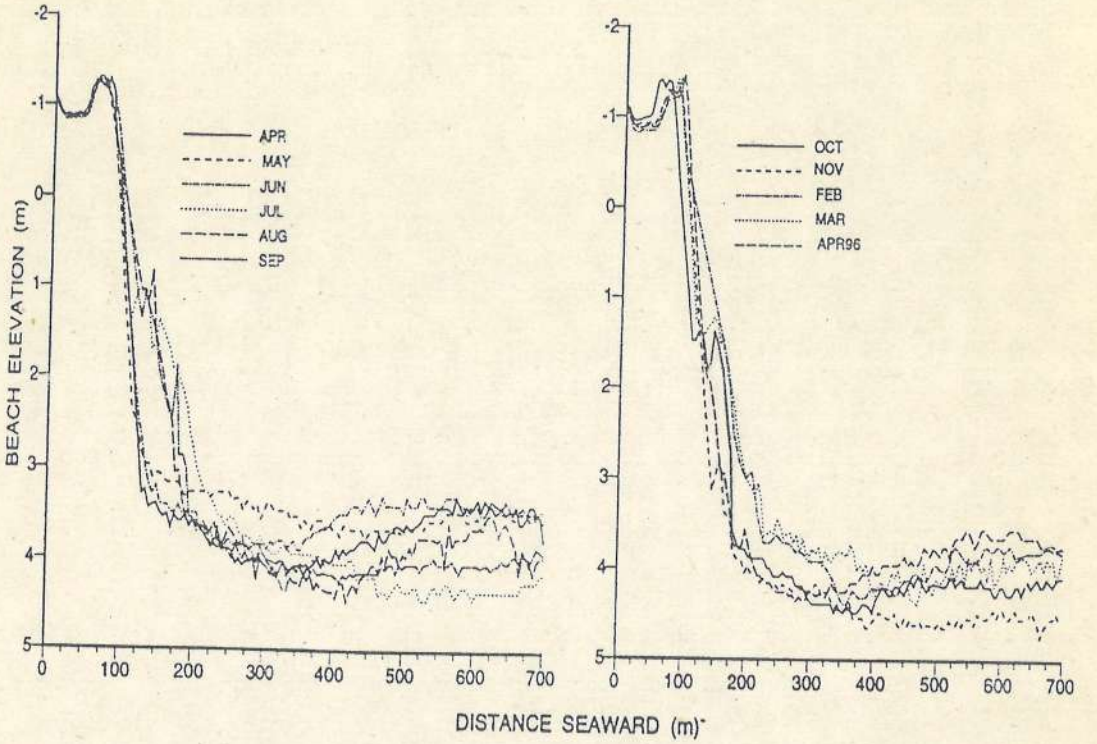

Fig.3 Nearshore profile at Pudhuvalasai

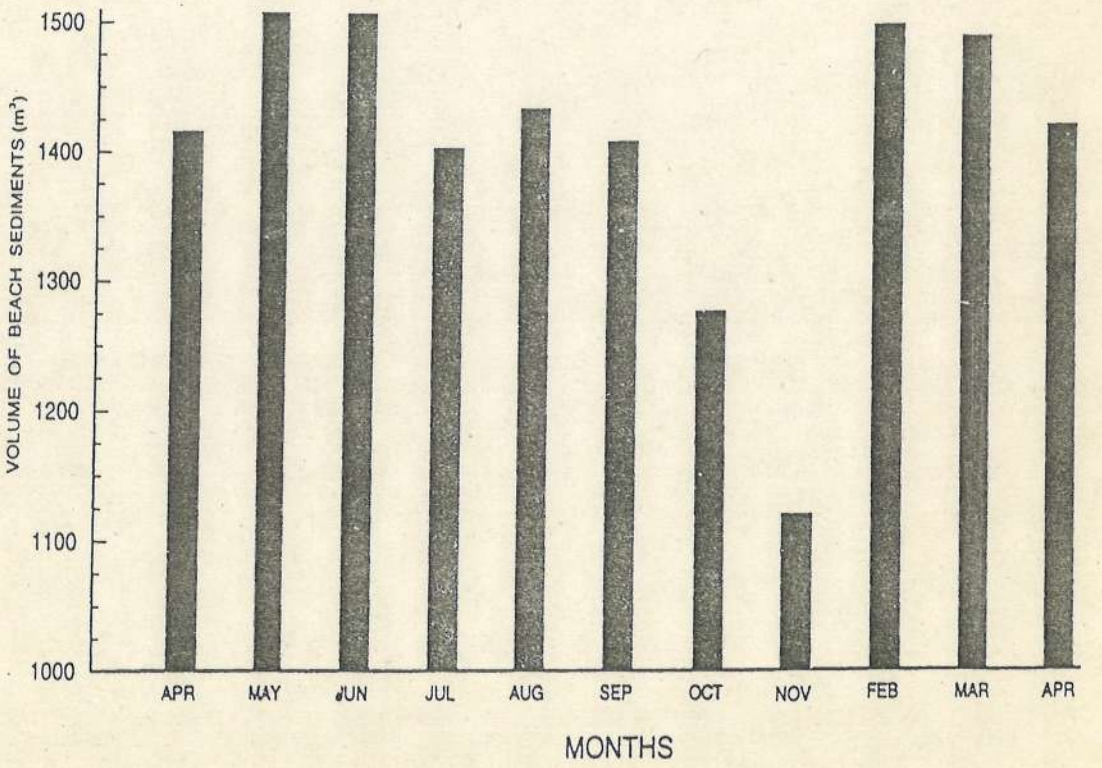

Fig.4 Monthly variation of beach sediment volume per meter length at Pudhuvalasai

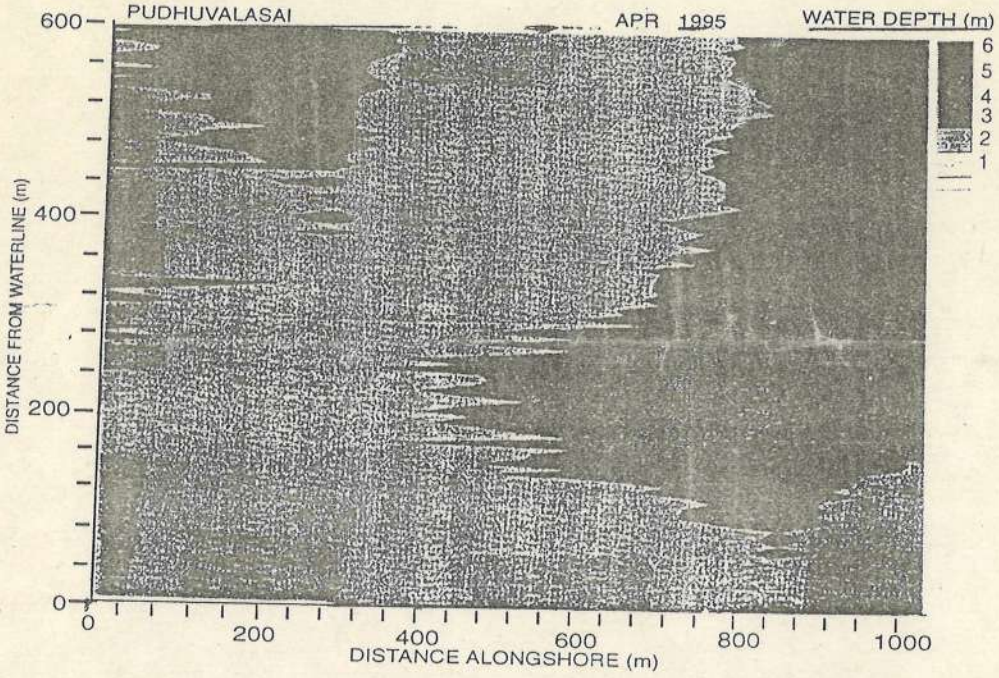

Fig.5 Nearshore planform at Pudhuvalasai in April 1995

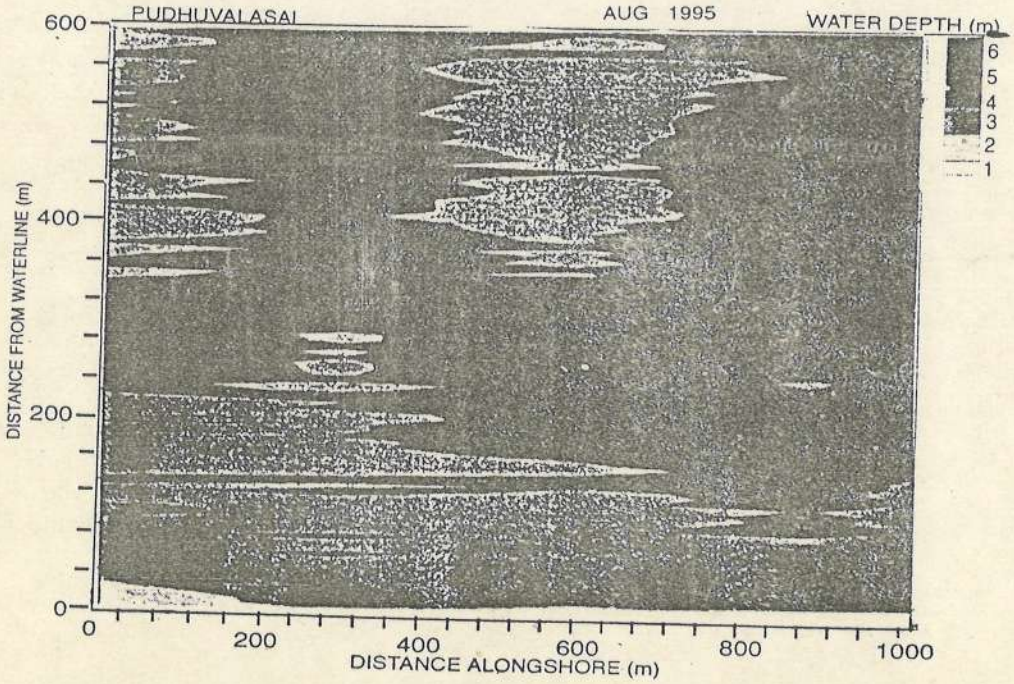

Fig.6 Nearshore planform at Pudhuvalasai in August 1995

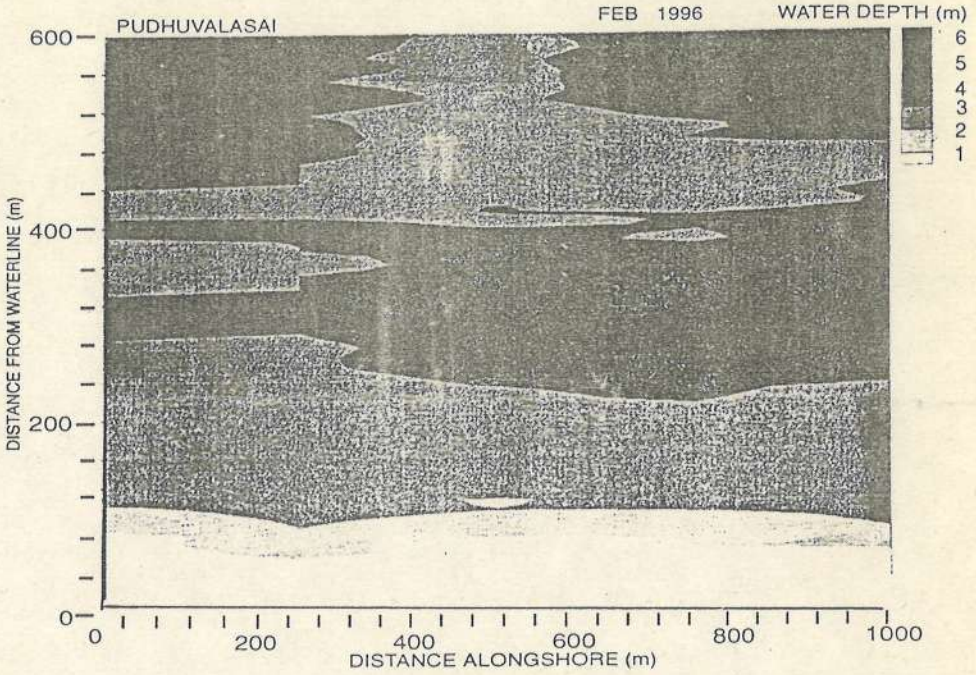

Fig.7 Nearshore planform at Pudhuvalasai in February 1996

Table 1 Monthly variation of littoral environmental parameters of Pudhuvalasai

Month	Year	H_b (m)	T (s)	α_b (deg)	w (m)	Longshore current (m/s) North of BM	Bench Mark (BM)	South of BM
Jan	1996	0.65	4.0	2	35	0.15	0.18	-0.10
Feb	1996	0.40	3.0	-2	15	-0.23	-0.08	-0.20
Mar	1996	0.40	5.0	-4	20	-0.20	-0.30	-0.28
Apr	1995	0.20	3.0	-1	15	-0.30	-0.23	-0.20
May	1995	0.15	8.0	-2	1	-0.10	-0.07	-0.03
June	1995	0.10	6.0	-1	1	0.00	-0.03	-0.02
July	1995	0.10	6.0	0	1	-0.01	-0.02	-0.02
Aug	1995	0.15	5.0	0	1	-0.02	-0.02	-0.05
Sep	1995	0.15	4.0	0	2	-0.03	-0.03	0.00
Oct	1995	0.20	5.0	-3	1	-0.02	-0.05	0.00
Nov	1995	0.20	5.5	3	1	0.27	0.30	0.33
Dec	1995	0.40	4.0	1	32	0.08	0.15	0.00

Table 2 Longshore transport at Pudhuvalasai

Month	Monthly Gross (m^3)	*Monthly Net (m^3)
Jan	22393	22393
Feb	2684	2684
Mar	12885	12885
Apr	3758	3758
May	54	-54
June	18	-18
July	9	-9
Aug	13	-13
Sep	54	-54
Oct	54	-54
Nov	322	322
Dec	10308	10308

Auual Gross = 52552 m^3/year Annual Net = 13494 m^3/year
* (-) shows that transport is northerly
(+) shows that transport is sourtherly

However, due to less wave action, negligible sediment transport takes place during May to October. The transport during November to January is significant, the quality being up to 0.03 x 10^6 m^3 in three months. The annual gross transport is 0.05 x 10^6 m^3/year, the annual net transport is 0.01 x 10^6 m^3/year towards south.

Wave refraction study shows that in Palk Bay, that is, between Vedaraniyam and Rameswaram, wave activity was found to be low during the northeast monsoon and practically absent during southwest monsoon (Jena, 1997). Jena, Chandramohan and Sanil Kumar, 1997 stated that on the Poompuhar - Nagapattinam coastline the littoral drift towards south due to the occurrence of cyclonic storm during north

east monsoon which is common in this region, increases the volume of southerly drift and deposit a part of littoral material permanently in the Palk Bay. Usha and Subramanian (1993) stated that the accretion pattern was obserced in Palk Bay at Ammapattinam, Mandapam and Rameswaram. This region is a relatively sheltered area with respect to waves and currents, and it's favours deposition. Chandramohan (1988) and Chandramohan et al, (1990) stated that the coast between Point Calimere and Athirampatnam in Palk Bay is sheltered by Sri Lankan island from south, southeast and easterly waves. Loveson, et al, 1990 have argued that large amount of sediments from those pediments are removed constantly by rainfall and minor rivers and the erosion is found to be intensive along the coastal islands of this region. The eroded sediments have been brought to the littoral zone and dumped in the Palk Bay.

CONCLUSIONS

The present study shows that due to the less wave action and weak currents littoral drift is very low along the Pudhuvalasai region. The littoral materials brought by different sources are being deposited within Palk Bay which are evidenced from the results of the nearshore bathymetry survey.

The sea floor variation indicates that compared to April 1995, 0.06 x 10^6 m^3 sand was deposited by August 1995 and 0.14 x 10^6 m^3 deposited by February 1996. The conclusion is that the nearshore region of Pudhuvalasai is in a depositional environment. More studies on directional waves, formation of shoals and exchange of sediments between Palk Bay and Gulf of Mannar would yield a better understanding on the pattern of sediment movement in this region.

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REFERENCES

Ahmad, E. (1972) Coastal geomorphology of India, pp.402.

Balachandran, S. (1995) Shore birds of the Marine National Park in the Gulf of Mannar, Tamil Nadu. Journal of Bombay National History society, 92(3), pp.303-313.

Basco, D.R. (1982) Surfzone currents. Misc. Report No.82-7, CERC, Coast. Engrg., 7, pp.331-355.

Chandramohan, P. (1988) Longshore sediment transport model with particular reference to Indian coast. Ph.D. thesis, Indian Institute of Technology, Madras.

Chandramohan, P., Nayak, B.U. and Raju, V.S. (1990) Longshore transport model for south Indian and Sri Lankan coast. J.Wtrwy., Port, coast and Engrg., ASCE, USA.

Jena, B.K. (1997) Littoral drift sources and sinks along Indian coast. Manuscript of Ph.D. Thesis.

Jena, B.K., Chandramohan, P. and Sanil Kumar, V. (1997) Littoral drift based on directional waves along north Tamilnadu coast, India. Communicated to J.Wtrwy., Port, coast and Engrg., ASCE, USA.

Longuet-Higgins, M.S. (1970) Longshore currents generated by obliquely incident waves, 1 & 2, J.Geophy.Res., 75, pp.6778-6801.

Loveson, V.J., Rajamanickam, G.V., and Chandrasekar, N. (1990) Environmental impact of micro-deltas and swamps along the coast of Palk Bay, Tamilnadu. In : Sealevel variation and its impact on coastal environment (Ed. Rajamanickam, G.V.), pp.159-178.

Usha, N. and Subramanian, S.P. (1993) Seasonal shoreline oscillation of Tamilnadu coast. Current Science, 65(9), pp.667-668.

Vasudevan. V. and Seetaramaswamy, (1983) Distribution of clay minerals in modern sediments of Palk Bay. Indian Journal of Marine Sciences, 12, pp.218-219.

Walton, T.L. (Jr.) and Bruno, R.O. (1989) Longshore transport a detached break water, phase II. J.Coast.Res., pp.667-668.