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The Probable Cause for Nesting Pattern of Olive Ridley (*Lepidochelys olivacea*) at Ramnagar Beach, North East Coast of Andaman Island, India

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Abstract

The nesting behaviour of sea turtles remains a subject to study, due to their enigmatic pattern of seasonal breeding activities. Over a period of time, several reports have been made in this context associated with the nesting behaviour of the Olive Ridley turtles. In the present study, characteristics of the breeding beach and nesting pattern of Olive Ridley (*Lepidochelys olivacea*) at Ramnagar along N-E coast of Andaman Islands were investigated, during the nesting periods 2016-2017. The study area hosts Olive Ridley, the dominant sea turtles with more than 300 individuals nesting each year. For this study, the number of sea turtles visited, nested, the sediment characters, salinity, and temperature were taken. The exposed sandy nesting beach characteristics are prone to varying degrees of morphological changes every day. The results depict that even though similar grain size (Coarse Sand to Fine Sand and Very well sorted to Poorly Sorted), with an ambient incubating temperature, pH and salinity with wide nesting area, the selective nesting in the particular location of the beach identified because of comfortable energy conditions in the waters (1.5 m/s) favours the female turtles to reach the beach at the preferable site of Ramnagar and nest.

Keywords

Sea turtle, Olive Ridley, Ramnagar Beach, Nesting Environment, Morphological Changes, Sand Grain, Hatchling, North Andaman

1. Introduction

India has a coastline of 7800 km in length, including the mainland and the offshore Islands of Andaman and Nicobar, and Lakshadweep Islands. Five species of sea turtles namely the Olive Ridley (*Lepidochelys olivacea*), Green Sea (*Chelonia mydas*), Leatherback (*Dermochelys coriacea*), Hawksbill (*Eretmochelys imbricata*) and Loggerhead (*Caretta caretta*) visiting along the Andaman and Nicobar Archipelago beaches for breeding [1] [2], which consists of more than 675 Islands, islets and rock masses, with a coastline of about 1962 km. Among these islands, around 30 Islands are identified as the sea turtle nesting sites in the Andaman and Nicobar Islands [1] [3]. Ramnagar beach in North Andaman is one among the 12 sites of Olive Ridley nesting beach on the East Coast of Andaman [2], and rare visitors of the Leatherback and Green Sea turtles in few numbers.

Recent studies have indicated that the uniqueness of the Indian coastline has an enormous nesting Olive Ridley population in comparison to other global locations [4] [5]. Several thousand Ridleys nest in Andhra Pradesh [6] [7], Tamil Nadu [8] [9] and the Andaman and Nicobar Islands [2] [10]. Research has been carried out on various aspects such as reproductive biology, population biology, migration and evolutionary history of these turtles for their visit to these coasts [11].

Over a period of time, several studies on marine turtles in Andaman and Nicobar Islands were reported. Bhasker [1] has done the pioneer survey work on sea turtle nesting beaches in Andaman during mid 1970s and 1980s in Nicobar Islands. In 1994, from Andaman and Nicobar Environment Team, like Andrews *et al*., [2], and Chandi [12], produced maps of nesting beaches and contributed 2 books on the Islands, namely "The National Biodiversity Strategy and Action Plan A&N Islands". Tripathy [13], Shanker [14], and Chandi [12] contributed significantly to the sea turtle nesting in Andaman and Nicobar Islands. However, no concrete reason is available for the preference of these marine turtles for nesting on these coasts. Gomuttapong *et al*., [15] studied the *Chelonia mydas*, green turtle nesting habitat with temperature and found that the nesting beach not having any influence on beach temperature with nesting activity and egg incubation of the study site Huyong Island and Similan Islands of Andaman Sea. Narayani *et al*., [16] reported that beach profile is important for the turtle nesting in the North Andaman coastal area.

The Olive Ridley (*Lepidochelys olivacea*) is listed by the International Union for the Conservation of Nature (IUCN) Red List as vulnerable and is protected under Schedule I of the Indian Wildlife Protection Act, 1972. The IUCN is constantly improving and updating assessments of the status of the seven sea turtle species including Olive Ridleys [17]. Olive Ridley turtles have a varied diet of algae, lobsters, crabs, tunicates, jellyfish, shrimp, fish, and fish eggs. They can dive to depths of over 150 m to find food. In the open ocean, they just eat about anything they find. Females nest every year, laying eggs in clutches, which is approximately 80 - 160 eggs in number and these eggs takes almost 60 days to hatch. The nesting female leaves track marks that are 70 - 80 cm wide and have asymmetrical forelimb marks. The hatchlings of Olive Ridley turtles are charcoal grey with a greenish hue along their sides. They measure around 38 to 40 mm long and weigh 15 - 17 g at birth. Olive Ridley nest from November to April with a peak from December to February [3]. The Olive Ridley turtle nest during extending from post monsoon (North-East Monsoon) to summer months, *i.e.*, from November to April.

Andaman Islands, North Andaman District, the Ramnagar beach is one of the well-known sites for Olive Ridly nesting. As reported by Peron *et al.*, [18] the nest site selection plays an important role in the survival of marine turtle eggs. To understand the selection site criteria of a location by Olive Ridly turtle, the present study has been initiated at Ramnager beach during the period 2016-17 nesting period.

2. Study Area—Ramnagar Beach

Ramnagar beach is located at (Lat. 13˚09'07"N; Long. 92˚59'04"E) North-East coast of North Andaman, 15 km away from Kalighat village (**Figure 1**). While trekking a kilometer into a forest cover from Ramnagar junction, the sandy beach facing the east, extend to 1.414 km North-South stretch, with a width, ranging from 14 to 35 m from the high tide level (HWL) to low tide level (LWL). On the southern side backwater flows adjacent to the beach area covered with mangroves, allowing fishing boats to venture into the North Andaman Sea (**Figure 2**). The northern side of the beach around 200 m has a rocky shore and thick mountainous vegetation. This whole beach is protected by the Forest Department and entries are restricted for common man use during the nesting season. The fishing activities are totally banned during the nesting period. Maintenance of the beach and hatcheries of the sea turtle and the conservation activities are carried out by the Wildlife Division, Department of Environment and Forest, Andaman and Nicobar Administration.

3. Materials and Methods

3.1. Methods

This study was carried out for eight months starting from November 2016 to June 2017, during the nesting periods of Olive Ridley to understand the beach characters and its importance for nesting.

The sediment samples along with environmental parameters were collected at dawn (5.30 to 7.00am), during the first week of every month. The temperature was observed with the soil thermometer (Gesa Trmomtrus S.L.) at the topsoil and at 30 cm depth at three spots in a traverse towards water column, *i.e.* High Water Level (HWL), Mid Water Level (MWL) and Low Water Level (LWL). The salinity and pH of the sand was measured using the salinity refractometer (ATAGO S/Mill-E), and with three digit pH meter (Labman) in the laboratory. The width of the beach and beach profile for slope angle was carried out with a measuring pole, rope, and tape from the lowest tide level to the crest of the

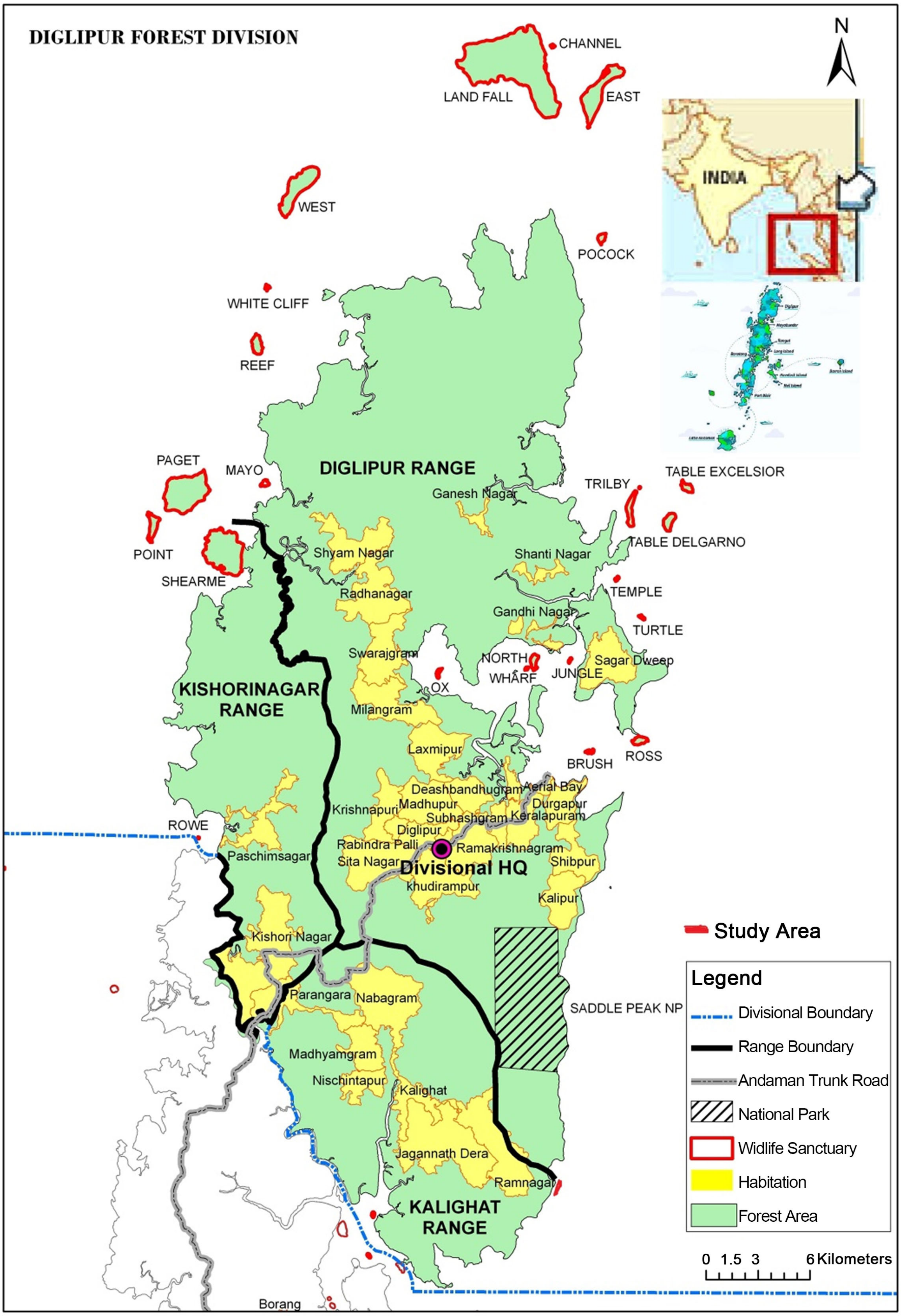


Figure 1. Location of the study area—Ramnagar.

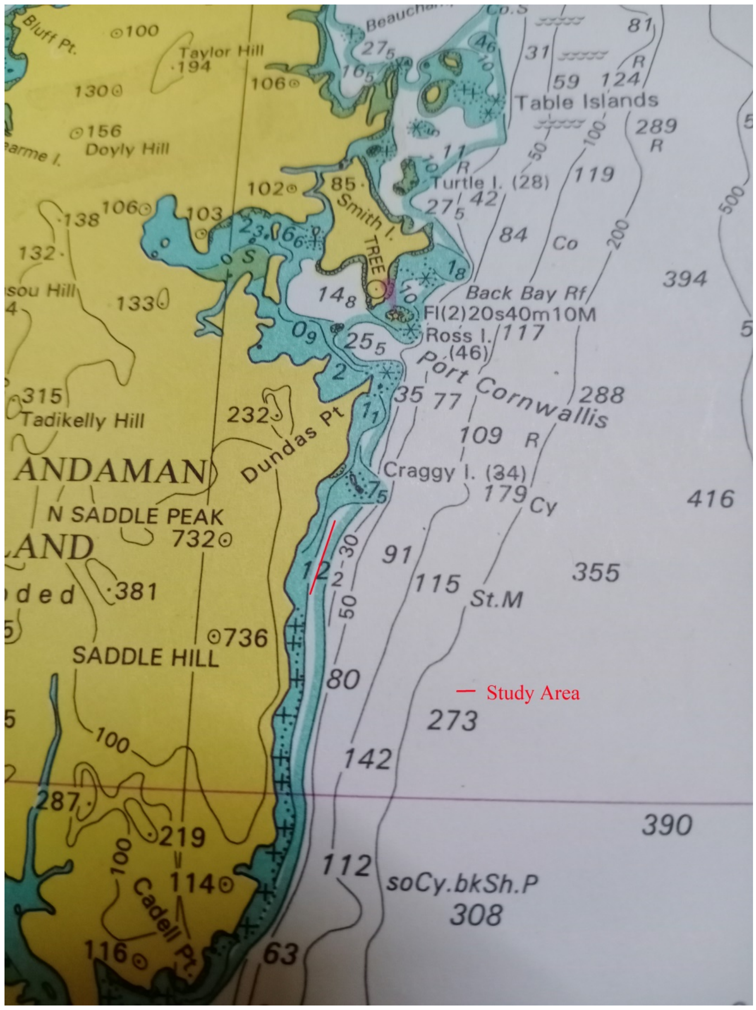


Figure 2. Hydrography map of the study area—Ramnagar.

berm. The total length of the sandy beach is equally divided into five blocks and numbered as Station 1 for 0 to 280 m, Station 2 for 280 to 560 m, Station 3 for 560 to 840 m, Station 4 for 840 to 1120 m, and Station 5 for 1120 to, 1400 m from south to north with an average length of 280 m each. The sediment size distributions of the collected samples were determined by dry sieve method as mentioned by Lindholm [19]. The grain size data was analysed using moment method [20]. Along with the physical parameters and sediment texture characters, number of sea turtles visited, number of turtles nested, number of eggs lay in each nest and the number of hatchlings hatched, was also recorded during the period of study on daily basis. Over and above, daily record maintained by the Andaman and Nicobar, Department of Environment and Forest on nesting was also verified along with the information collected such as time, nest numbers, egg counts, etc. Passega [21] [22] and Paseega and Byramjee [23], CM Diagram had been applied to understand the energy condition for grain size movement. Further, the exact energy needed for those grain size evolved through sediment transport measurements manual [24].

3.2. Materials

The sediment samples along with the soil temperature, salinity, pH and the flora existed in the vicinity, were collected for this study. In the centre point of the station (*i.e.*, around 140 m from the starting point the station), sediment samples were collected with a PVC pipe of length 30 cm and a width of 5 cm inserted at three locations from berm to Low Water Level (LWL) at a traverse of each station. The positions at sediment samples collected are designed at High Water Level (HWL), Mid Water Level (MWL) and Low Water Level (LWL). At each position, the samples were collected as three layers such as 0 - 10 cm as T—top layer, 11 - 20 cm as M—middle layer, and 21 - 30 cm as B—bottom layer.

The sediment samples were dried at 60˚C in a hot air oven and then sieved by the standard ASTM sieves in the order of 1 phi (500 μ), 2 phi (250 μ), 3 phi (125 μ), 4 phi (63 μ) and 5 phi (31 μ) ranges in Ro-Tap sieve shaker. Measured the weight of the sand retained in each individual sieve and the cumulative weight percentage was calculated. Based on the cumulative weight percentage, the necessary plot was evolved and the moment measures information were used to calculate the different textural statistical parameters such as Mean, Median, Standard Deviation, Skweness, and Kurtosis.

4. Results and Discussion

When choosing the beach for nesting, a sea turtle has to consider several factors that can affect the nesting and hatching success of its offspring, like sandy beach with wide nesting area, without disturbance and a safe place for its offspring [25]. The bay beach structure is like a curve shaped or necklace shaped with a slope angle of 15.5˚. The southern end covers with sandy sediments and northern end exposed for rocky outcrop (**Figure 2**). The width of the beach varies between 14 to 35 m. The slope angle also maintained throughout the study period is 15.8˚ to 15.3˚. The temperature ranges from 31.00˚C to 28.00˚C on the surface area and in 30 cm depth of sediment the temperature varied between 27.00˚C to 26.00˚C. The salinity is between 31 to 29 PSU and pH ranged from 08.22 to 08.01, that is in the good alkaline region.

The high tide regions are covered with vegetation such as *Thespetia populenea*, *Pandanaus odorifer*, *Pandamus tectorius*, Sea bird weed, Sea Mauva, Pakkota grass and *Ipomea sp*., as the major vegetation on the coast, *Palium*, *Acetabularia*, *Pedina*, *Tricleocarpa and Sargasum* are commonly seen marine algae in the intertidal region along with the fauna such as jelly fish, other marine fishes and crabs, seen in abundance. These fauna and flora are the favourable diet of Olive Ridley.

Sediment Texture

Even though, the sediment samples were collected and analysed for textural parameters and it has been found out that most of the stations beach characters are uniform with a slight modification due to local condition prevailed (**Table 1**). The sediment nature is as follows (**Table 2**): the mean size varied between 0.12 ø

Table 1. Sediment Textural Analysis data of each station with reference to tidal conditions for the study period 2016-2017 (Average of surface (A), 10 cm (B) and 20 cm (C) data). Mz-Moment Mean; Sd—Moment Standard Deviation; Sk—Moment Skewenes. Ku—Moment Kurtosis; LWL—Low Water Level; MWL—Mid Water Level; HWL—High Water Level.

	LWL—Station 1							
	16-Nov	16-Dec	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17
Mz	0.17	0.62	0.53	1.79	0.80	0.62	0.90	0.66
Sd	0.16	0.61	0.73	0.76	0.86	0.60	0.51	0.85
Sk	0.50	0.33	0.9	−0.50	0.62	0.32	−0.38	1.00
Ku	0.00	0.73	0.39	0.87	0.60	0.64	1.02	0.54
	LWL—Station 2							
Mz	0.45	0.77	0.7	1.15	0.56	0.29	1.13	0.54
Sd	0.54	0.66	0.7	0.93	0.77	0.54	0.90	0.75
Sk	0.57	0.38	0.3	0.39	1.00	0.83	−0.11	1.00
Ku	0.17	0.99	0.4	0.56	0.60	0.94	0.52	1.14
	LWL—Station 3							
Mz	0.82	0.52	0.58	0.98	0.47	0.28	0.92	0.39
Sd	0.73	0.58	0.66	1.05	0.67	0.63	0.92	0.63
Sk	0.37	0.72	0.44	0.32	1.00	0.83	0.54	1.00
Ku	0.74	0.57	0.39	0.54	0.33	0.22	0.50	1.13
	LWL—Station 4							
Mz	0.59	0.58	0.56	0.84	0.69	1.56	0.44	0.66
Sd	0.50	0.79	0.66	1.02	0.87	0.70	0.62	0.85
Sk	1.00	1.00	0.58	0.63	1.00	−0.13	1.00	1.00
Ku	0.65	0.75	0.39	0.64	0.69	1.09	0.93	0.67
	LWL—Station 5							
Mz	0.44	0.23	0.63	0.84	0.82	1.09	0.93	0.78
Sd	0.47	0.42	0.84	0.96	0.81	0.80	0.89	0.57
Sk	0.60	0.83	1.00	0.55	0.35	0.51	0.26	0.84
Ku	0.40	0.21	0.70	1.47	0.79	0.73	0.54	0.70
	MWL—Station 1							
Mz	0.12	0.42	0.71	1.27	0.44	0.23	0.31	0.43
Sd	0.32	0.62	0.83	0.91	0.62	0.32	0.62	0.67
Sk	0.83	1.00	0.77	−0.05	0.83	0.67	0.59	0.67
Ku	0.00	0.85	0.75	0.82	0.41	0.24	−0.12	0.41
	MWL—Station 2							
Mz	0.49	0.75	0.43	0.96	0.71	0.80	0.86	0.50
Sd	0.51	0.60	0.65	0.88	0.61	0.75	0.83	0.59
Sk	1.00	0.18	0.83	0.31	0.49	0.31	0.26	0.60
Ku	1.34	0.76	0.17	0.95	1.10	0.76	0.71	0.54

Continued

				MWL—Station 3				
Mz	2.27	0.73	0.49	0.88	0.91	0.42	0.56	0.91
Sd	1.45	0.62	0.69	1.06	0.86	0.65	0.85	0.85
Sk	2.16	−0.03	0.67	0.71	0.29	1.00	0.73	0.28
Ku	1.00	0.57	0.13	0.71	0.60	0.39	0.59	0.61
				MWL—Station 4				
Mz	0.71	0.56	0.43	0.89	0.73	0.96	0.45	0.76
Sd	0.64	0.59	0.67	0.90	0.81	0.76	0.47	0.80
Sk	0.27	0.49	1.00	0.46	0.62	0.55	1.00	0.47
Ku	0.55	1.04	0.24	0.55	0.78	0.71	0.19	0.64
				MWL—Station 5				
Mz	0.48	0.72	0.71	1.44	0.94	0.40	0.91	0.69
Sd	0.37	0.75	0.90	0.98	0.85	0.45	0.84	0.80
Sk	0.38	0.37	1.00	−0.59	0.26	0.83	0.01	0.44
Ku	0.47	0.63	0.54	0.88	0.39	0.00	0.58	0.68
				HWL—Station 1				
Mz	0.51	0.48	0.66	1.03	0.82	0.74	1.39	1.01
Sd	0.72	0.63	0.85	0.70	0.82	0.76	0.85	0.81
Sk	1.00	1.00	1.00	0.08	0.50	0.30	−0.31	0.66
Ku	0.63	0.38	0.63	0.77	0.14	0.58	0.68	0.49
				HWL—Station 2				
Mz	0.33	0.87	0.73	0.42	0.78	1.23	1.62	0.75
Sd	0.46	0.51	0.87	0.63	0.82	0.77	0.77	0.80
Sk	0.49	−0.52	0.86	1.00	0.62	1.00	−0.60	0.66
Ku	0.71	1.49	0.59	0.45	0.62	1.62	1.23	0.63
				HWL—Station 3				
Mz	0.31	0.99	0.45	0.86	0.96	0.50	0.74	0.54
Sd	0.44	0.69	0.66	1.14	0.56	0.58	0.81	0.75
Sk	1.00	−0.01	1.00	0.79	0.43	0.82	0.64	1.01
Ku	0.80	0.90	0.64	0.66	1.02	0.68	1.06	0.89
				HWL—Station 4				
Mz	0.28	0.55	0.89	1.13	0.68	0.33	0.67	0.83
Sd	0.48	0.56	0.89	0.71	0.87	0.55	0.73	0.88
Sk	1.00	0.43	0.51	−0.47	0.77	0.83	0.40	0.62
Ku	0.30	0.65	0.54	1.24	0.35	0.19	0.59	0.65
				HWL—Station 5				
Mz	0.53	0.13	0.23	0.82	0.55	0.70	0.00	0.33
Sd	0.74	0.25	0.49	0.71	0.65	0.81	0.10	0.64
Sk	1.00	0.67	0.67	−0.01	0.47	0.74	0.33	0.45
Ku	1.17	0.27	0.18	0.58	0.19	0.43	0.00	0.21

Table 2. Overall Sediment textural data range for the study period (month of November 2016 to June 2017) and its expressions.

Textural Parameters	High Water Level (HWL)	Medium Water Level (MWL)	Low Water Level (LWL)
Mean (Mz)	1.39 ø to 0.13 ø Coarse Sand to Medium Sand	2.27 ø to 0.12 ø Coarse Sand to Fine Sand	1.79 ø to 0.17 ø Coarse Sand to Medium Sand
Standard Deviation (Sd)	0.44 to 1.14 Well Sorted to Poorly Sorted	0.32 to 1.45 Very Well Sorted to Poorly Sorted	0.16 to 1.05 Very Well Sorted to Poorly Sorted
Skweness (Sk)	−0.60 to 1.01 Very Coarse Skewed to Very Fine Skewed	−0.59 to 2.16 Very Coarse Skewed to Very Fine Skewed	−0.50 to 1.00 Very Coarse Skewed to Very Fine Skewed
Kurtosis (Ku)	0.00 to 1.62 Very Platy kurtic to Very Leptokurtic	0.0 to 1.34 Very Platy kurtic to Leptokurtic	0.0 to 1.47 Very Platy kurtic to Leptokurtic

to 2.27 ø, *i.e.*, Coarse Sand to Fine Sand nature. The standard deviation showed that 0.16 to1.45, *i.e.*, Very Well sorted to Poorly sorted. The data on skweness suggested that it ranged between −0.60 to 2.16, *i.e.*, Very Coarse Skewed to Very Fine Skewed. The kurtosis values ranged between 0.00 to 1.62, *i.e.*, Very Platy Kurtic to Very Lepto Kurtic. Based on these data it has been concluded that the overall beach area has coarse sand to fine sand nature and poorly sorted to well sorted characters. After cursory analysis of the physical parameters and sediment texture along with the beach character shows (**Table 1**) all the parameters are almost similar during the study period.

The nesting of turtle in the study area was analysed based on the location and it numbers. It has been suggested that the station 5 has least number, *i.e.*, only one nesting in each month of the nesting period (**Table 3**). However, it shows a gradational increment towards southern side stations. The station 4 shows around 7 - 8 nesting and station 3 shows 3 to 26 nesting. The station 2 shows 7 to 69 nesting and the station 1 shows that 10 to 38 nesting, in the whole nesting period of the year 2016-2017.

It is very interesting to note that the sandy beach environment, almost all the physical and sediment texture parameters are same, in the stations of the study. Further, the sediment texture and number of nest available in the beach of each month has been analysed for ANOVA test and found that the low tide zone, mid tide zone, and high tide zone sediment mean size and nesting of the station state almost similar in nature and not having any impact on nesting of turtle (**Table 4**).

In this circumstance, why the turtle prefer to make their nest along the station 2, 1 and 3, instead of 4 and 5? This question leads to explore the real phenomenon happening in this sector, which favours the turtle nesting.

So, the hypothesis proposed that the stations where more number of nesting taken place will be comfortable zone for the turtle? in what way? How this comfort zone has been achieved by the turtle?

Table 3. Nesting status for the year 2016-2017 periods along with the first percentile and median size of sediment texture.

	STATION-1		
MONTH	GRAIN SIZE-1 μ	GRAIN SIZE-50 μ	NO. OF NESTING
Nov-16	0.1	0.5	0
Dec-16	0.1	0.4	14
Jan-17	0.1	0.5	38
Feb-17	0.1	1.5	30
Mar-17	0.1	0.9	10
Apr-17	0.1	0.7	0
May-17	0.1	1.4	0
Jun-17	0.1	0.5	0
	STATION-2		
Nov-16	0.1	0.5	0
Dec-16	0.1	0.7	28
Jan-17	0.1	0.6	69
Feb-17	0.1	0.4	29
Mar-17	0.1	0.6	7
Apr-17	0.1	0.4	0
May-17	0.1	1.3	0
Jun-17	0.1	0.7	0
	STATION-3		
Nov-16	0.1	0.4	0
Dec-16	0.1	1.1	19
Jan-17	0.1	0.5	26
Feb-17	0.1	0.8	15
Mar-17	0.1	1.1	3
Apr-17	0.1	0.5	0
May-17	0.1	0.6	0
Jun-17	0.1	0.5	0
	STATION-4		
Nov-16	0.1	0.4	0
Dec-16	0.1	0.6	7
Jan-17	0.1	0.7	7
Feb-17	0.1	1.3	6
Mar-17	0.1	0.6	8
Apr-17	0.1	0.4	0

Continued

May-17	0.1	0.8	0
Jun-17	0.1	0.9	0
	STATION-5		
Nov-16	0.1	0.4	0
Dec-16	0.1	0.4	1
Jan-17	0.1	0.4	1
Feb-17	0.1	0.9	1
Mar-17	0.8	0.8	0
Apr-17	0.1	0.6	0
May-17	0.1	0.4	0
Jun-17	0.1	0.8	0

Table 4. The result of high tide, mid tide and low tide environment mean sediment texture and number of nest in that environment compared and analysed for variance (ANOVA). (a) High tide line-mean vs. number of nest; (b) Mid tide line-mean vs. number of nest; (c) Low tide line-mean vs. number of nest.

(a)

Group	N	Missing	Median	25%	75%
16-Nov	12	2	0.140	0.000	0.510
16-Dec	12	2	0.995	0.480	15.250
Jan-17	12	2	0.945	0.608	29.000
Feb-17	12	2	1.080	0.965	18.500
Mar-17	12	2	0.890	0.648	7.250
Apr-17	12	2	0.165	0.000	0.710
May-17	12	2	0.000	0.000	0.902
Jun-17	12	2	0.165	0.000	0.875

H = 35.265 with 7 degrees of freedom. ($P \le 0.001$).

(b)

Group	N	Missing	Median	25%	75%
16-Nov	12	2	0.0600	0.000	0.545
16-Dec	12	2	0.875	0.680	15.250
Jan-17	12	2	0.855	0.475	29.000
Feb-17	12	2	1.355	0.943	18.500
Mar-17	12	2	0.925	0.642	7.250
Apr-17	12	2	0.115	0.000	0.515
May-17	12	2	0.155	0.000	0.635
Jun-17	12	2	0.215	0.000	0.707

H = 38.101 with 7 degrees of freedom. ($P \le 0.001$).

(c)

Group	N	Missing	Median	25%	75%
16-Nov	12	2	0.0850	0.000	0.485
16-Dec	12	2	0.885	0.565	15.250
Jan-17	12	2	0.850	0.575	29.000
Feb-17	12	2	1.470	0.945	18.500
Mar-17	12	2	0.810	0.538	7.250
Apr-17	12	2	0.140	0.000	0.737
May-17	12	2	0.220	0.000	0.922
Jun-17	12	2	0.195	0.000	0.660

H = 34.770 with 7 degrees of freedom. ($P \leq 0.001$).

The probe was initiated to analyse the grain size at three layers at each zone. During the process, it has been found that the nesting taken place only in the above the High Tide Zone, so the data developed for the Mid Tide Zone and Low Tide Zone was eliminated and considered for the High Tide Zone samples alone. Further, during the selection of nesting, only surface characters are more important than the subsurface, so further narrowing down our probe along with the surface textural parameters only. The sediment texture was studied by Passega [21] [22] and applied first percentile (C) and median (M), in probability scale, as a plot and translated the grain size to depositional sub environments with the help of C-M Diagram. The same method was tried here and CM plot was drawn for each station for all the nesting months. The **Figures 3-7** exhibited the studied samples falls in the dynamic conditions of Cr-rolling, Cu-Uniform suspension and Cs-graded suspension. Based on these inferences, the sedimentary data was plotted on the C-M diagram are falling in Cu region and inferred that uniform suspension and rolling level.

As reported by Passega [22] and Paseega and Byramjee [23], the studied grain size parameters for "C" falls 0.1 μ and "M" falls in the range of 0.4 to 1.5 μ size. These size ranges suggested that it falls in the "PQ" range of environment. This environment energy condition suggested that the energy fall in the range of suspension and rolling movement of grain size. Similarly, Ludwikowska-Kedzia [26] studied the fluvial environment and suggested that the energy fall in the range of saltation coupled with suspension and rolling conditions.

The inferred energy condition to be matched with the real water environmental condition, the plot was constructed using the data of nesting took place in the area from LWL (normal line graph drawn in Excel). Along with this data another plot (Excel) was developed the high tide level on the day using the tide chart. These two graphs were fused together and found that (**Figures 8-15**), the variation surprisingly similar to the high tide alignment with space. This information clearly suggested that, the probable energy condition existed in the stations 2, 1 and 3 were maximum comfortable for the female turtle with eggs to reach the shore and attain its destination for nesting. This energy was high or low, in the stations 4 and 5, was least selected during this nesting operations by the turtles.

So, wherever, the turtle landed in the beach, they make their nest and lay their eggs.

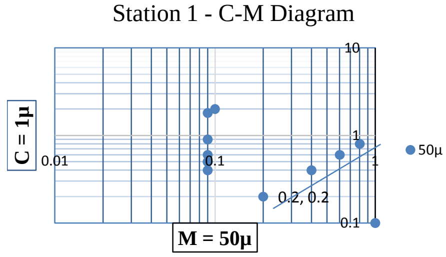


Figure 3. CM diagram for the nesting period surface samples of Station 1.

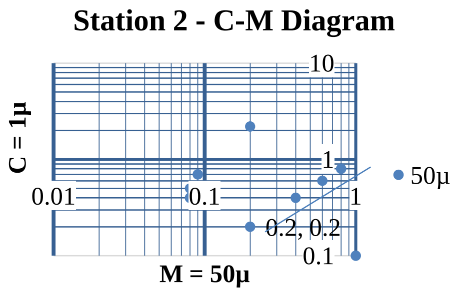


Figure 4. CM diagram for the nesting period surface samples of Station 2.

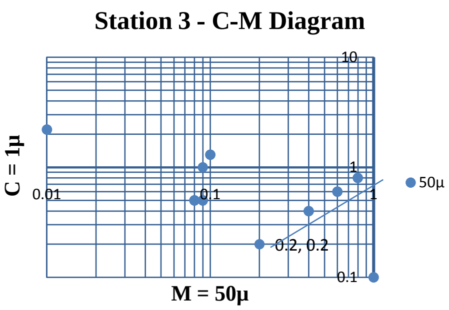


Figure 5. CM diagram for the nesting period surface samples of Station 3.

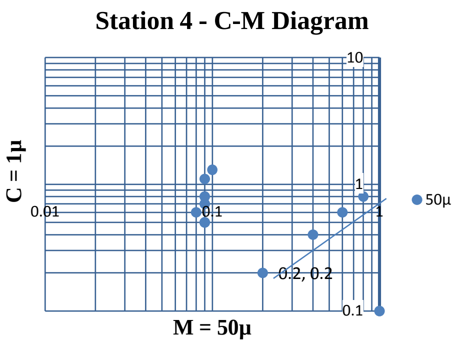


Figure 6. CM diagram for the nesting period surface samples of Station 4.

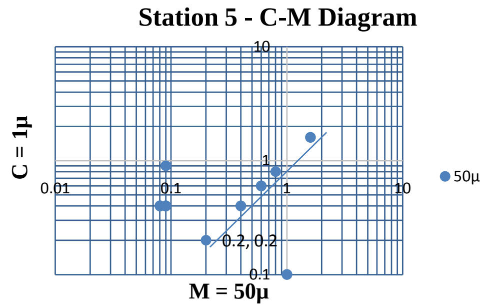


Figure 7. CM diagram for the nesting period surface samples of Station 5.

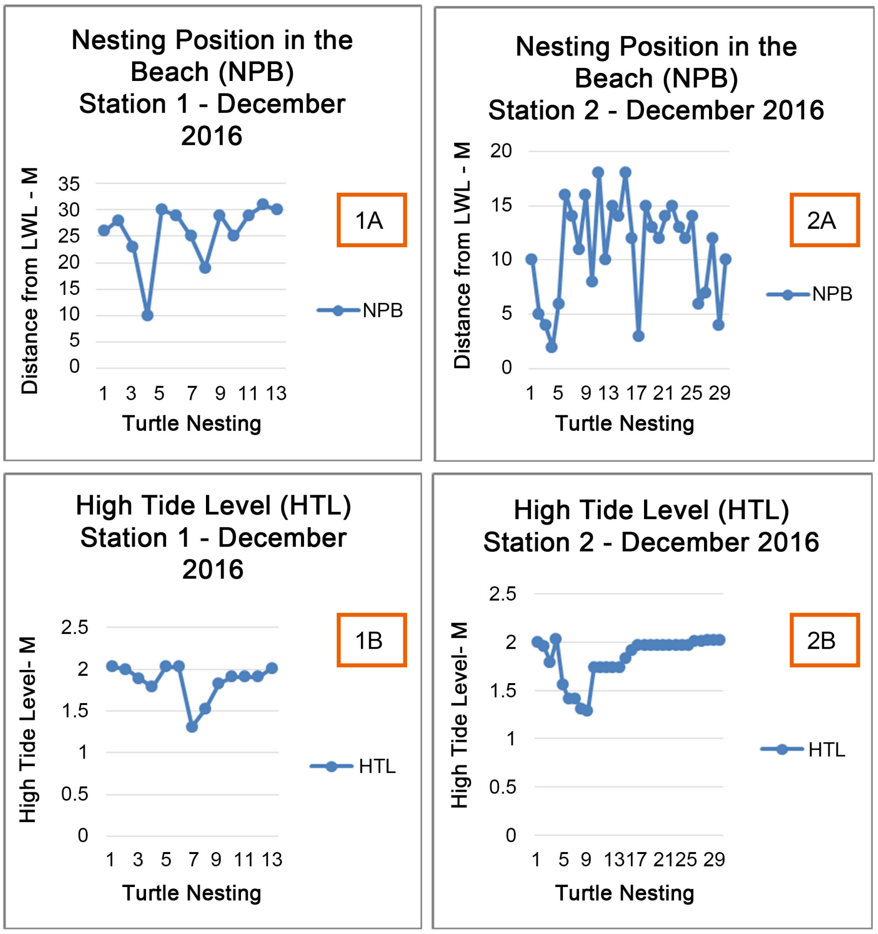


Figure 8. Relationship between high tide level (1B, 2B) and distance from LWL to nesting place (1A, 2A) for the stations 1 and 2 during the month of December 2016.

The energy level for these grains goes rolling and suspension stage of the environment identified by the sediment transport measurements manual [24] up to a depth of 4.5 m the energy level may be around 1.5 m/s. This energy level may help comfortably to carry the turtle to the shore. According to Cheng *et al.*, [27] reported that the velocity of wave breaker observed in their study area has been around 1 to 1.5 m/s also support the present finding of high tide energy level inferred in this study region.

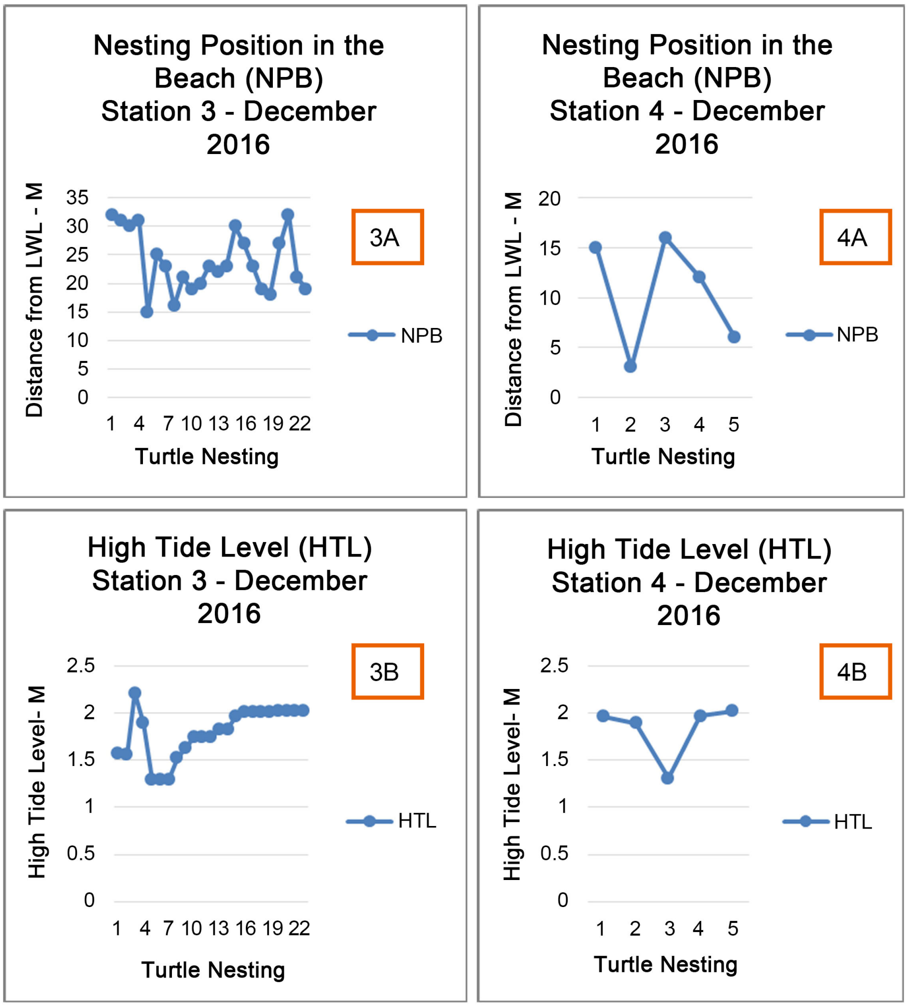
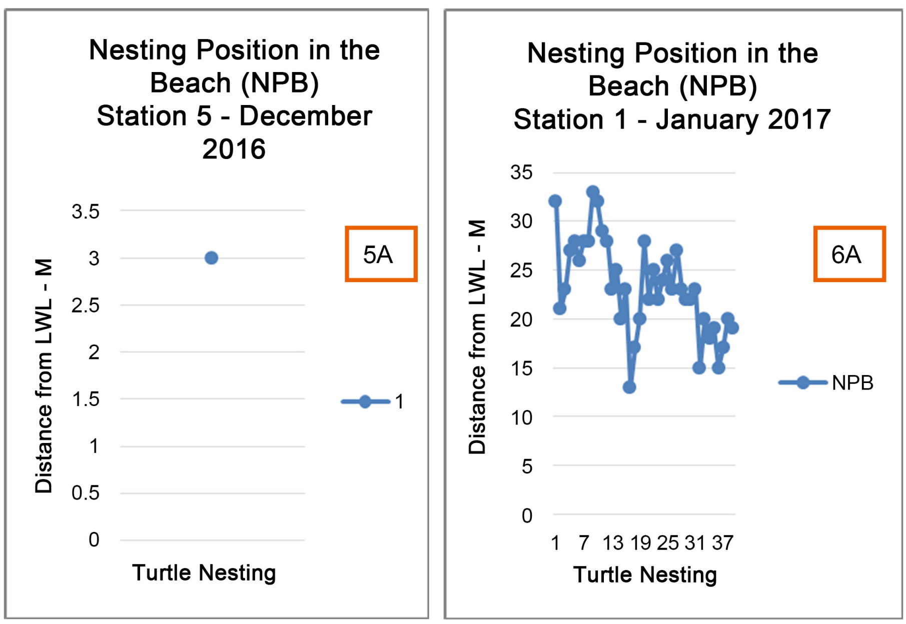


Figure 9. Relationship between high tide level (3B, 4B) and distance from LWL to nesting place (3A, 4A) for the stations 3 and 4 during the month of December 2016.



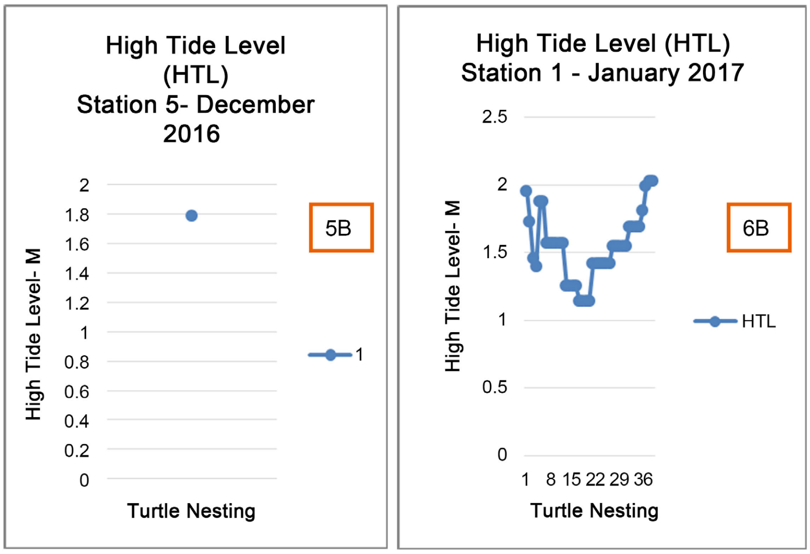


Figure 10. Relationship between high tide level (5B, 6B) and distance from LWL to nesting place (5A, 6A) for the stations 5 for the month of December 2016 and station 1 for the month of January 2017.

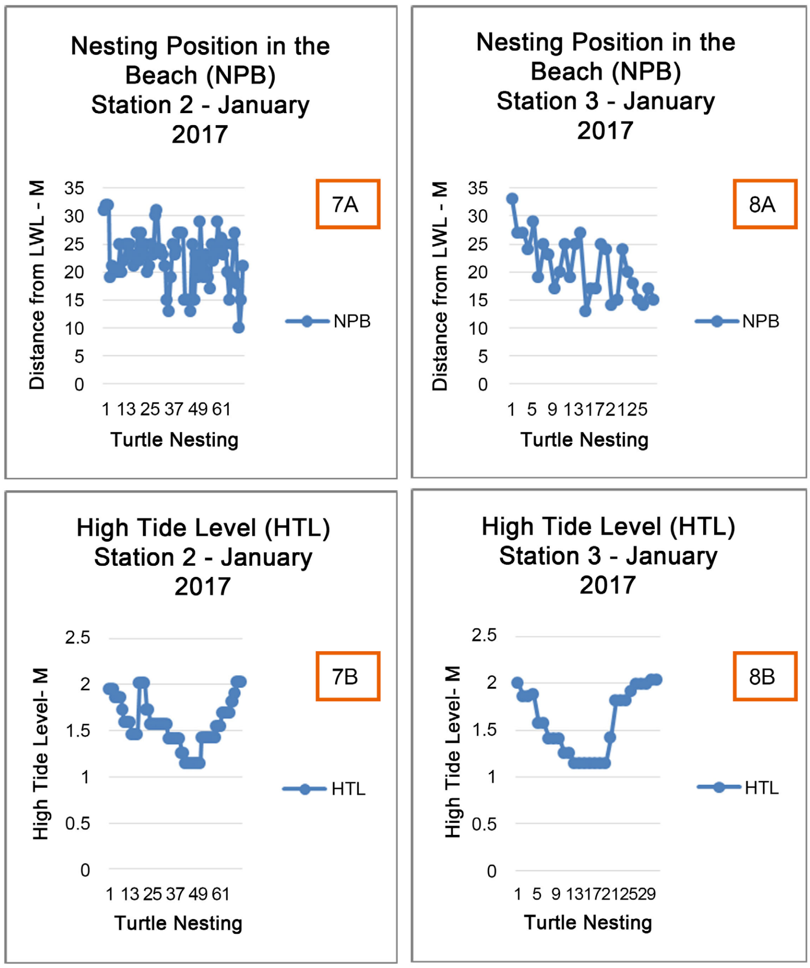


Figure 11. Relationship between high tide level (7B, 8B) and distance from LWL to nesting place (7A, 7B) for the stations 2 and 3 during the month of January 2017.

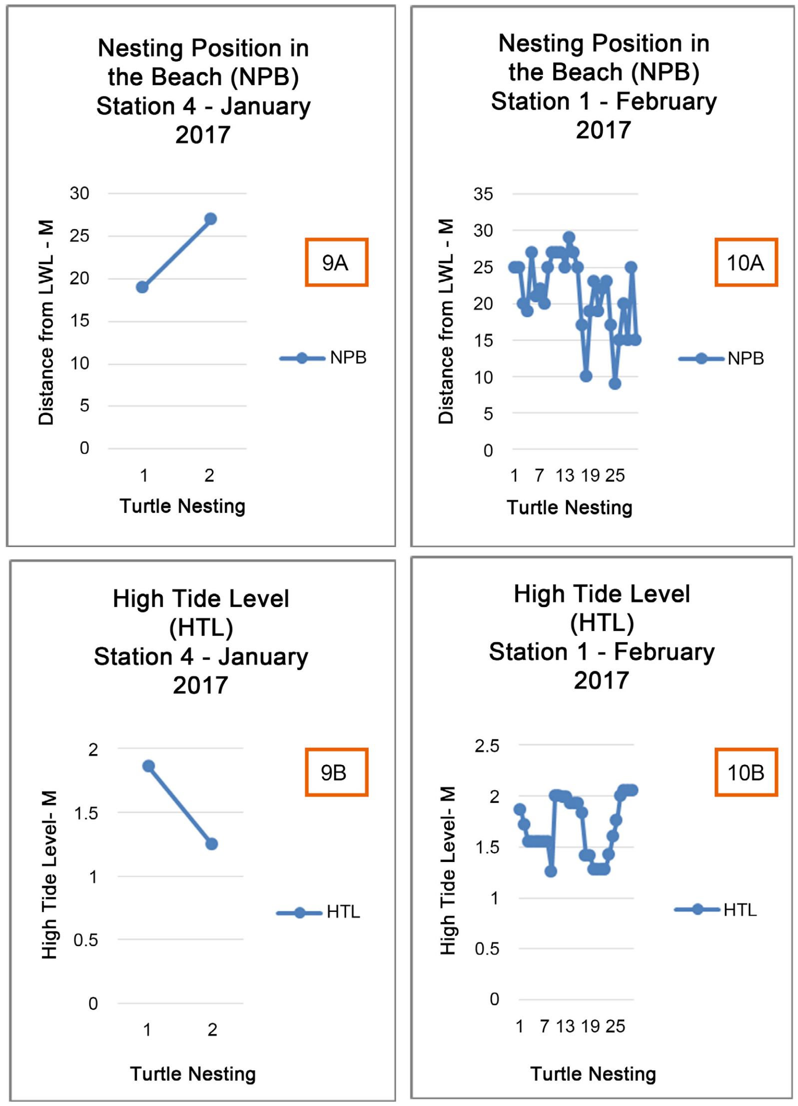
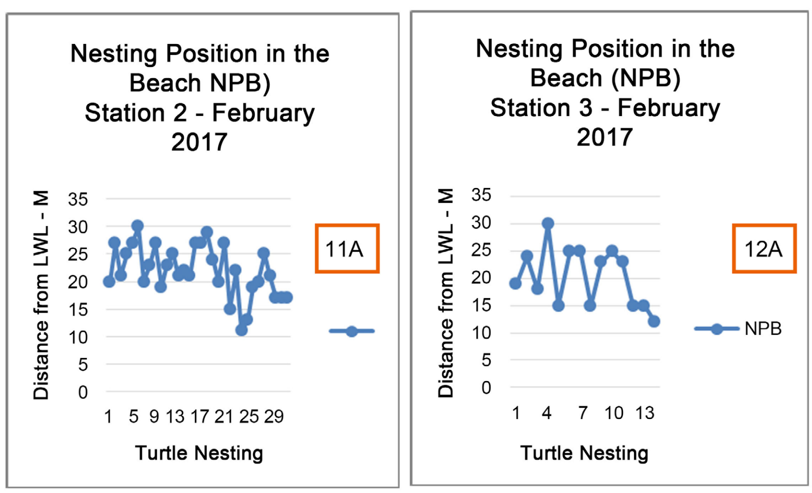


Figure 12. Relationship between high tide level (9B, 10B) and distance from LWL to nesting place (9A, 10A) for the stations 4 for the month of January 2017 and station 1 for the month of February 2017.



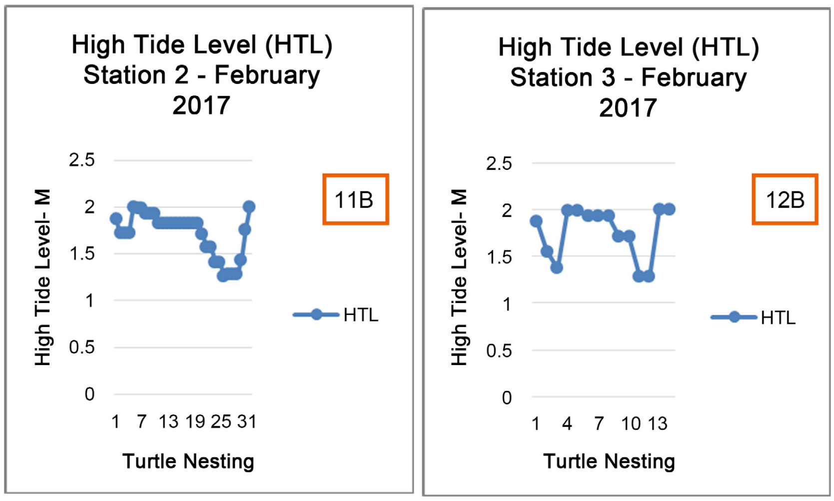


Figure 13. Relationship between high tide level (11B, 12B) and distance from LWL to nesting place (11A, 12A) for the stations 2 and 3 during the month of February 2017.

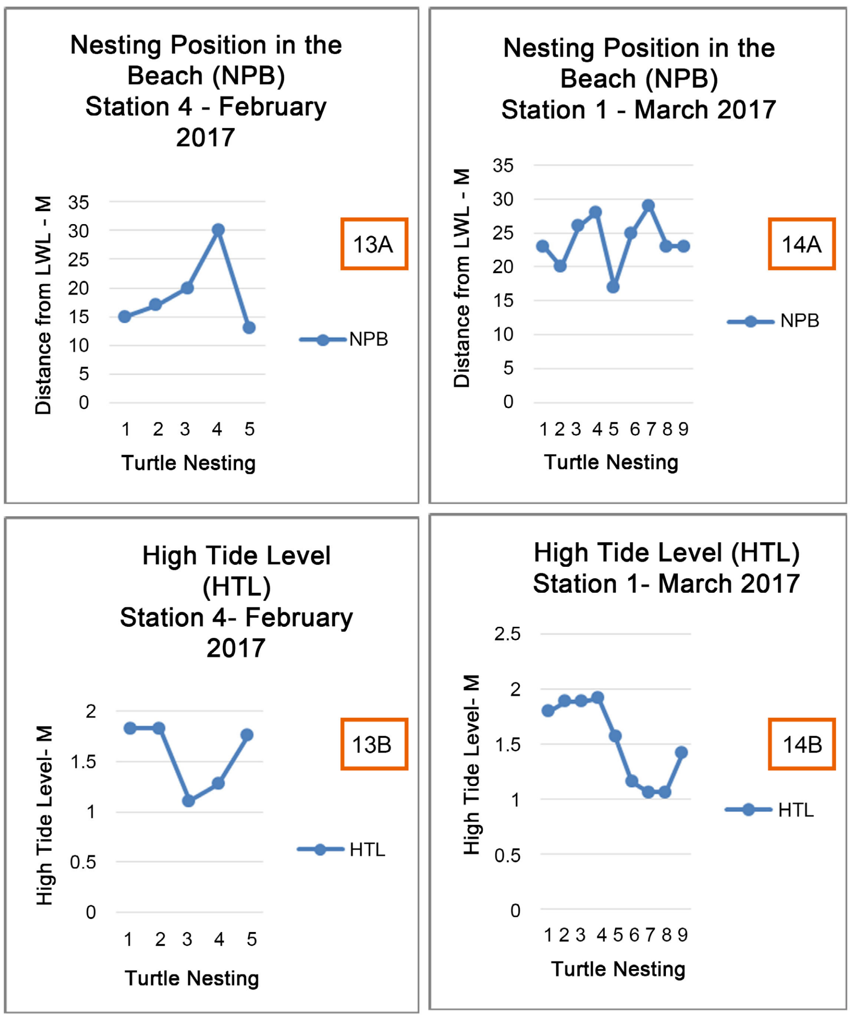


Figure 14. Relationship between high tide level (13B, 14B) and distance from LWL to nesting place (13A, 14A) for the stations 4 for the month of February 2017 and station 1 for the month of March 2017.

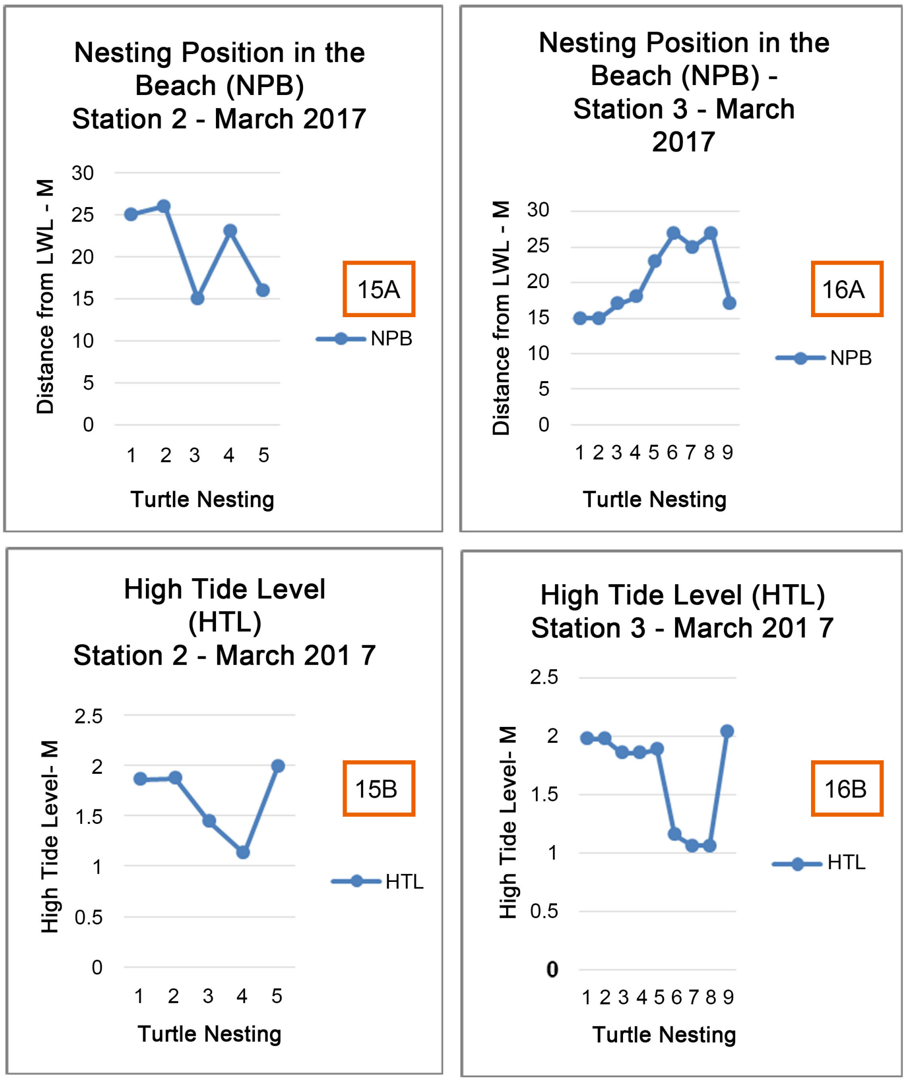


Figure 15. Relationship between high tide level (15B, 16B) and distance from LWL to nesting place (15A, 16A) for the stations 2 and 3 during the month of March 2017.

5. Conclusion

The study of marine turtle nesting of Olive Ridley was carried out in Ramnagar beach, located at North Andaman, Andaman and Nicobar Islands, India for the nesting period 2016 to 2017. The sediment character, number of nesting, date and time of nesting suggested that the turtle has reached the shore during the favourable energy condition of marine water attained. This energy level may be around of 1.5 m/s water movement. This condition favoured the turtle with egg can easy to reach the shore with less effort and without any harm to the animal. So, this condition was attained by shore structure, and sediment characters along with high tide water energy levels exerted on beach. A further study needs to be probed and establish a similar kind of concept to all the nesting environments to understand the mechanism of marine turtle nesting habitat.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Bhaskar, S. (1993) The Status and Ecology of Sea Turtles in the Andaman and Nicobar Islands. Center for Herpetology, Chennai, Publication No. ST 1/93, 1-37.

[2] Andrews, H.V., Tripathy, A., Aghue, S., Gles, S., Saw, J. and Naveen, K. (2006) The Status of Sea Turtle Populations in the Andaman and Nicobar Islands of India. A UNEP/CMS-IOSEA Project of Priority Research Areas, Center for Herpetology, Chennai, 92-93.

[3] Murugan, A. (2016) Sea Turtles and Their Conservation in Andaman and Nicobar Islands. Kyoto University Research Information Repository, Kyoto.

[4] Shanker, K., Ramadevi, J., Choudhury, B.C., Singh, L. and Aggarwal, R.K. (2004) Phylogeography of Olive Ridley Turtles (*Lepidochelys olivacea*) on the East Coast of India: Implications for Conservation Theory. *Molecular Ecology*, **13**, 1899-1909. https://doi.org/10.1111/j.1365-294X.2004.02195.x

[5] Shanker, K., Pandav, B. and Choudhury, B.C. (2004) An Assessment of Olive Ridley (*Lepidochelys olivacea*) Nesting Population in Orissa on the East Coast of India. *Biological Conservation*, **115**, 149-160. https://doi.org/10.1016/S0006-3207(03)00104-6

[6] Tripathy, B., Shanker, K. and Choudhury, B.C. (2003) A Survey of Olive Ridley Turtles and Their Nesting Habitats in Andhra Pradesh on the East Coast of India. *Oryx*, **37**, 454-463. https://doi.org/10.1017/S0030605303000826

[7] Tripathy, B., Shanker, K. and Choudhury, B.C. (2006) Sea Turtles and Their Nesting Habitats at the Andhra Pradesh Coast. In: Shanker, K. and Choudhury, B.C., Eds., *Marine Turtles of the Indian subcontinent*, Universities Press, Hyderabad, 68-87.

[8] Bhupathy, S. and Saravanan, S. (2002) Status Survey of Sea Turtles along the Tamil Nadu Coast. A GOI-UNDP Sea Turtle Project Report. Salim Ali Centre for Ornithology and Natural History, Coimbatore.

[9] Bhupathy, S. and Saravanan, S. (2006) Marine Turtles of Tamil Nadu Coast. A GOI-UNDP Sea Turtle Project Report. Salim Ali Centre for Ornithology and Natural History, Coimbatore.

[10] Andrews, H.V., Krishnan, S. and Biswas, P. (2001) The Status and Distribution of Marine Turtles around the Andaman and Nicobar Archipelago. GOI UNDP Sea Turtle Project Report. Madras Crocodile Bank Trust, Tamil Nadu.

[11] Shanker, K., Namboothri, N. and Choudhury, B.C. (2015) Marine Turtles in India: Research and Conservation. Centre for Ecological Sciences, Indian Institute of

Science, CV Raman Avenue, Bangalore.

[12] Chandi, M. (2015) A Story of Field Assistants and Sea Turtle Research in the Andaman and Nicobar Islands. Andaman and Nicobar Islands Environmental Team (ANET), Wandoor and Nature Conservation Foundation, Mysore.

[13] Tripathy, B. (2004) A Study of the Offshore Distribution of Olive Ridley Turtles (*Lepidochelys olivacea*) in the Coastal Waters of Rushikulya Rookery along the Orissa Coast, India. Wildlife Conservation Society India Programme, CWS, Bangalore, 34 p.

[14] Shanker, K. (2007) Deconstructing Sea Turtle Conservation in India. In: Shahabuddin, G. and Rangarajan, M., Eds., *Making Conservation Work*, Permanent Black, New Delhi, 89-110.

[15] Gomuttapong, S., Klom-in W., Kitana, J., Pariyanonth, P., Thirakhupt, K. and Kitana, N. (2013) Green Turtle, *Chelonia mydas* Nesting and Temperature Profile of the Nesting Beach at Huyong Island, The Similan Islands in Andaman Sea. *Natural Resources*, **4**, 357-361. https://doi.org/10.4236/nr.2013.44043

[16] Narayani, S., Venu, S. and D'Silva, A.J. (2018) Comparison of Beach Profiles Conducive for Turtle Nesting in Andaman. *Journal of Threatened Taxa*, **26**, 12337-12343. https://doi.org/10.11609/jott.3373.10.10.12337-12343

[17] Mazaris, A.D., Schofield, G., Gkazinou, C., Almpanidou, V. and Hays, G.C. (2017) Global Sea Turtle Conservation Successes. Global Sea Turtle Conservation Successes. *Science Advances*, **3**, e1600730. https://doi.org/10.1126/sciadv.1600730

[18] Peron, C., Chevallier, D., Martin, G., Chatelet, A., Anthony, E.J., Le Maho, Y. and Gardel, A. (2013) Beach Morphological Changes in Response to Marine Turtles Nesting: A Preliminary Study of Awala-Yalimapo Beach, French Guiana (South America). *Journal of Coastal Research*, **65**, 99-104. https://doi.org/10.2112/SI65-018.1

[19] Lindholm, R.C. (1991) A Practical Approach to Sedimentology. CBS Publishers and Distributors, Delhi, 276 p.

[20] Friedman, G.M. (1962) Comparison of Moment Measures for Sieving and Thin-Section Data in Sedimentary Petrological Studies. *Journal of Sedimentary Petrology*, **32**, 15-35. https://doi.org/10.1306/74D70C36-2B21-11D7-8648000102C1865D

[21] Passega, R. (1957) Texture as Characteristic of Clastic Deposition. *American Association of Petroleum Geologists Bulletin*, **41**, 1952-1984. https://doi.org/10.1306/0BDA594E-16BD-11D7-8645000102C1865D

[22] Passega, R. (1964) Grain Size Representation by CM Patterns as a Geological Tool. *Journal of Sedimentary Petrology*, **34**, 830-847. https://doi.org/10.1306/74D711A4-2B21-11D7-8648000102C1865D

[23] Passega, R. and Byramjee, R. (1969) Grain-Size Image of Clastic Deposits. *Sedimentology*, **13**, 233-252. https://doi.org/10.1111/j.1365-3091.1969.tb00171.x

[24] Sediment Transport Measurement (2003) Design Manual-Sediment (SW) Volume 5, DHV Consultants & Delft Hydraulics with Halcrow, Tahal, CES, ORG & JPS.

[25] Clark, M. (2004) Sea Turtles: Final Paper. Topical Field Courses-Papers. Marine Ecology.

[26] Ludwikowska-Kędzia, M. (2000) Evolution of the Middle Segment of the Belnianka River Valley in the Late Glacial and Holocene. Dialog Press, Warsaw, 180.

[27] Cheng, J., Wang, P. and Smith, E.R. (2015) Hydrodynamic Conditions Associated with an Onshore Migrating and Stable Sandbar. *Journal of Coastal Research*, **32**, 153-163.