Monitoring and Mitigating the Impacts of Mumbai Trans-Harbour Link on Flamingos and Other Avifauna and Formulating a Conservation Blueprint for the Sewri–Nhava Seascape.

October 2019 to March 2020
Update

Submitted to

Mangrove and Marine Biodiversity Conservation Foundation of Maharashtra

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Disclaimer

The observations represented in this report are based on study duration mentioned in the report. The observations may change or vary depending upon on further surveys.

Contents

Summary

During October 2019 to March 2020, the abundance and distribution of flamingos and other avifauna were estimated by conducting various population monitoring surveys at different wintering sites. Additionally, the behavioral surveys carried out at different high-tide roosting and low-tide feeding sites shed some light on the behavioral response of shorebirds especially towards disturbances at the construction sites. Simultaneously, bird ringing sessions were also carried out at different roosting sites to understand avifaunal migratory patterns. We also collected and analyzed macrobenthos and plankton samples from the study area.

1. Methodology

1.1 Study site

This study was carried out in four inland wetland sites (high tide roosting sites) that includes Training Ship Chanakya (TSC), Bhandup Pumping Station (BPS), Non-Residential Indian (NRI) complex and Belpada mangrove and three mudflat sites (low tide feeding sites) - Thane Creek, mudflats of Sewri and Nhava-Sheva.

2. Bird sampling

2.1 Bird counts

The total count method was used for sampling birds (Bibby et al*.,* 1998) and adopted different sampling strategies for wetlands, creek and flamingos, viz., wetland count surveys (WCS), transect count surveys (TCS) and flamingo count surveys (FCS).

WETLAND COUNT SURVEYS (WCS): Surveys were conducted simultaneously in all four wetlands during the high tide timings when shorebirds inhabit the inland wetlands for their roosting purpose. The total number of birds observed was counted an hour before and after the high tide. The count was taken for three consecutive days and an average estimation of the total population was calculated.

TRANSECT COUNT SURVEYS (TCS): In TCS, all the species of birds observed in the creek were recorded and their population was estimated. before the commencement of the census, almost the whole of the Thane Creek was divided into 40 transects that differed by a distance of 1 Km. These transects were allotted to a team of researchers, who surveyed it on hand rowed boats. Whereas, ground surveys were carried out at Sewri and Nhava-Sheva jetties. Observer counted and estimated the bird population using Nikon binoculars. Low tide timings were preferred for these counts when the birds feed on the exposed mudflats.

FLAMINGO COUNT SURVEYS (FCS): The census was carried out on three consecutive days in a month to know the abundance of Lesser Flamingo (*Phoeniconaias minor)* and Greater Flamingo (*Phoenicopterus roseus)* by conducting boat surveys at Thane Creek and ground surveys at Sewri and Nhava-

Sheva jetties during low tide. The eastern and western banks of the Creek were divided into 40 transects. Before the census, the Creek was divided into eight stations (each having respective transect IDs): 1. Airoli to Vitava (East), 2. Airoli to Vitava (West), 3. Ghansoli to Airoli (East), 4. Ghansoli to Airoli (West), 5. Ghansoli to Vashi (East), 6. Ghansoli to Vashi (West), 7. Vashi to NRI (East), 8. Vashi to Trombay (West).

The simultaneous counts were taken by direct observations using binoculars by multiple teams of researchers and assistants in hand rowed boats. Observer from each team independently counted and estimated the numbers of birds using blocks of 100, 500, 1000, etc. according to the size of the flock (Bibby, et al. 1998).

2.2 Bird Behavior

To study the behavioral ecology of shorebirds, particularly in response to disturbances, the study sites were divided into 3 categories - Roosting, Feeding, and Construction. Roosting sites include four inland wetlands (high tide dependent) - Training Ship Chanakya (TSC), Bhandup pumping station (BPS), Non-Residential Indian (NRI) complex and Belpada mangrove. Thane Creek is considered a feeding site as it provides a huge area of exposed mudflats that are rich in cyanobacteria and marine benthic fauna during low tide. Sewri and Nhava-Sheva are the construction sites where behavioral surveys were conducted to study bird response to construction activities happening due to Nhava- Sheva sea link construction.

The target species for behavioral observations were decided beforehand based on their abundance within the study sites. These species have been utilizing these sites as their wintering grounds for many years. The species are as follows;

1. Black-tailed Godwit *(Limosa limosa)*
2. Common Greenshank (*Tringa nebularia*)
3. Common Redshank (*Tringa totanus*)
4. Curlew Sandpiper (*Calidris ferruginea)*
5. Lesser Sandplover (*Charadrius mongolus*)
6. Little Stint (*Calidris minuta)*

7. Eurasian Curlew (*Numenius arquata)*
8. Whimbrel (*Numenius phaeopus)*
9. Greater Flamingo (*Phoenicopterus roseus)*
10. Lesser Flamingo (*Phoeniconaias minor)*
11. Pied Avocet (*Recurvirostra avosetta)*

We have classified the behaviour into 11 major categories (Bensaci *et al*., 2015; Eduardo, G., & G. A. Baldassarre, 1997; Felicity, A., & Baldassarre, G. A., 1995; Kumssa, T., & A. Bekele, 2014) viz. Feeding, Movement, Maintenance, Resting, Vigilance, Aggression, Defecation, Flying out, Alert, Courtship, and Standing.

As the behavioral study is aimed to understand the response of target species towards disturbances, the disturbance sources have also been grouped into human disturbances, avian predators, other animals, and vehicle categories. Human disturbances include bird watchers, fishermen, construction activities, etc. Avian predators include Black Kite (*Milvus migrans*), Osprey (*Pandion haliaetus)*, etc. Vehicular disturbances include aircraft, trains, boats, traffic noise, etc. Other animals include dogs, cattle, etc. Noticeably, most of these disturbances are occurring at the roosting, feeding, and construction sites continuously. Hence, it needs to be monitored for further implementation for the conservation of migratory species.

Following covariates were also noted while behavioural video recording:

- Total duration of disturbance
- Distance between the disturbance source and focal bird
- Distance between the focal bird and observer
- Flock size and composition

We adopted Focal Animal Sampling (Altmann, 1973) for understanding the behavioral ecology of shorebirds. Focal individuals were selected arbitrarily and videotaped for 1 minute. As far as possible, different focal birds were selected for subsequent observations. In cases where a few individuals of a species were present, there was a 5 minutes interval between two observations of the same individual. Each observation was treated as independent during transcribing.

The observations were carried out at least one hour before high tide at roosting sites while one hour before low tide at feeding and construction sites. Videos were also recorded if the birds were present even after the high or low tides within the study area.

Videos were transcribed using BORIS v.7.5.3. (Friard & Gamba 2016). An ethogram was created for the behavior of birds in BORIS to assess the time spent by individuals in each activity. We took behaviors or events of short duration, such as defecation and flying out, as point events in the ethogram. Other long-duration behaviors were considered as state events. A state event for no observation was also created in the ethogram which was used when the focal individual was out of the frame. Videos having more than 10 seconds of no observation were discarded during transcribing.

2.3 Bird ringing

Bird ringing was conducted between November 2019 and March 2020 at high tide roosting sites viz., TSC Wetland, NRI wetland, and saltpans around BPS. We used 3-4 wader nets (size 11.5 cm; dimensions 2m × 100m) for capturing birds for ringing. Three to four nets were deployed considering water depth, wind direction, and movement of the waders. Birds were extracted from the nets by experienced trappers and then ringed by experienced ringers to minimise stress and injury to birds. We followed the Indian Bird Banding Manual (Balachandran. S., 2002) for ringing and recording morphology and morphometry of the waders.

In this entire period, from October to March, we could not conduct some of the surveys due to the rain, rough sea condition, and COVID 19 pandemic (Table 1)

Table 1 Summary of surveys conducted in six consecutive months

Surveys	Oct 2019	Nov 2019	Dec 2019	Jan 2020	Feb 2020	Mar 2020
Wetland count Survey	3 (Dates;08, 09, 10)	3 (Dates; 07, 09, 10)	3 (Dates; 07, 08, 09)	3 (Dates; 07, 08, 09)	3 (Dates; 09, 10, 11)	NA
Transect count survey	1 (Dates; 05, 06)	1 (Dates; 02, 03, 04, 05, 06, 09, 10)	1 (Dates; 10, 11, 17, 18, 19, 20, 21)	1 (Dates; 14, 15, 16, 17, 18, 19, 20)	1 (Dates; 12, 13, 14, 15, 16, 17, 18)	1 (Dates; 12, 13, 14, 15, 16)
Flamingo census	1 (Date; 03)	NA	3 (Dates; 02, 03, 04)	3 (Dates; 02, 03, 04)	3 (Dates; 04, 05, 06)	3 (Dates; 03, 04, 05)
Behavioural survey	14 (Dates; 02, 04, 07, 10, 11, 14, 15, 16, 17, 18, 23, 24, 25, 31)	6 (Dates; 01, 07, 09, 10, 12, 26)	8 (Dates; 07, 08, 09, 10, 13, 28, 29, 30)	13 (Dates; 03, 04, 08, 09, 20, 28, 29, 30, 31)	11 (Dates; 02, 03, 17, 18, 19, 20, 25, 26, 27, 28)	6 (Dates; 03, 04, 07, 09)
Ringing sessions	NA	8 (Dates; 03, 06, 07, 08, 09, 10, 11, 12)	9 (Dates; 08, 09,10,11, 12, 13, 26, 27, 28)	10 (Dates; 10,11,12,13, 20,21,22,23 ,24,25)	15 (Dates; 3,4,5,6,7,8,1 0,18,19,20, 21,22,23,24 ,25)	5 (Dates; 6,7,8,11,13)

3. Observations

3.1 Wetland count survey (WCS)

The total number of species recorded from the inland wetlands was 74; 46 migratory (including 27 wader species) and 28 non-migratory species. The observations revealed a gradual increase in avifaunal species richness and abundance throughout the six months. The maximum population was recorded 30188 individuals (of 50 species) in February 2020 and the minimum was recorded 2454 individuals (of 46 species) in November 2019 (Table 2).

Table 2 Species richness and maximum population recorded in all inland wetlands

	Oct, 19	Nov, 19	Dec, 19	Jan, 20	Feb, 20
Total species richness	40	46	49	50	50
Total migratory species richness	26	29	30	31	31
Total resident species richness	14	17	19	19	19
Total no. of individuals	26057	2454	4736	13013	30188
Total no. of migratory individuals	25674	2145	4236	12387	29393

The species richness of migratory birds has increased from October 2019 to February 2020 with the highest of 31 species in February. It was observed that the diversity of migrants has shown a distinct pattern in different inland wetlands. In BPS, the species richness increased and decreased for alternate months with an average of at least 28 species. There was a sharp decline in the population at BPS between October and November 2019. Afterward, it increased gradually till February 2020. A gradual increase in the species richness was observed at NRI from October 2019 to February 2020 with the highest species richness (31) recorded in February 2020. From November 2019 to January 2020 the species richness and the population visiting TSC increased and then the numbers dropped from February 2020. In Belpada, it increased from October-November, 2019, and remained more or less the same till January 2020. Later, a drop in species richness was noticed in February 2020 (Table 3 & 4).

Table 3 Species richness recorded in five consecutive months at different inland wetlands

	BPS	NRI	TSC	Belpada
Oct 2019	26	22	23	21
Nov 2019	25	25	30	25
Dec 2019	31	28	29	25
Jan 2020	29	27	32	26
Feb 2020	31	31	27	21
Average	28	27	28	24

Table 4 Average (maximum-minimum) estimated individuals of migratory birds (excluding flamingos)

Site	Oct, 19	Nov, 19	Dec, 19	Jan, 20	Feb, 20
BPS	19353(25041-15189)	56(64-40)	1883(2860-1293)	1500(1789-1115)	7495(15630-1696)
NRI	128(154-102)	553(681-328)	221(253-201)	3415(4141-2225)	8733(12505-5215)
TSC	157(185-123)	753(1179-511)	623(712-574)	3053(5615-873)	922(1093-712)
Belpada	110(294-16)	159(221-119)	350(411-274)	586(842-329)	152(165-133)

Since last year (October 2018-March, 2019), both diversity and abundance have declined in the wetlands. Several factors may have caused this. For instance, firstly, Panje was one of the larger wetlands, used to support a huge population of migrants. Now, as Panje is disturbed due to inconstant water flow. It can be assumed that the avifauna that was coming to Panje, might have started using the other suitable sites. Secondly, the fluctuations in water level due to rain and human control were making wetlands unsuitable for roosting. Thirdly, BPS, where the highest number of species was recorded, became highly disturbed due to salt extraction during November-February.

During this period, a single individual of one of the rare birds was recorded from BPS; Long-billed Dowitcher (*Limnodromus scolopaceus*) between January and March 2020. This species was also reported by bird photographers in 2017 from mudflats of BPS channel in the Thane Creek.

3.2 Transect count survey (TCS)

In all, a total population of 18650 and 59754 individuals of avifauna (excluding flamingos) were estimated in November and December respectively. These populations comprised 16864 and 57527 individuals of migrants (including waterbirds and raptors) recorded in their respective months. A remarkable increase was observed in the estimated population of January and February i.e., 87984 and 94224 individuals respectively. Among these, 86335 and 93142 were migratory shorebirds and raptors in their respective months. Comparatively, a slight decline was seen in avifaunal abundance in March. Results indicate that a significant addition of numbers was found in the population of waders between November and January. Notably, Little Stint was the most abundant wader species throughout the survey with the highest count (39992) recorded in January. Whereas, Green Sandpiper, Wood Sandpiper, Ruddy Turnstone and Whimbrel were the least counted waders in different months. (Table 5).

Table 5 Species richness and abundance recorded in the Thane Creek

Site	Thane Creek					
Months	**Oct-19**	**Nov-19**	**Dec-19**	**Jan-20**	**Feb-20**	**Mar-20**
Total species number	NA	44	50	51	50	45
Total number of migratory species recorded	NA	29	34	32	35	30
Total number of resident species recorded	NA	15	16	19	15	15
Total population recorded	NA	18650	59754	87984	94224	77240
Total population of migrants	NA	16864	57527	86335	93142	75466
Total population of residents	NA	1786	2227	1649	1082	1774

By contrast, results showed that mudflats of Sewri and Nhava-Sheva supported lower species richness and abundance of migratory as well as resident birds throughout the survey period (Table 6).

Table 6 Species richness and abundance recorded in Sewri and Nhava-Sheva mudflats

Site	Sewri mudflat						Nhava-Sheva mudflat					
	Oct-19	**Nov-19**	**Dec-19**	**Jan-20**	**Feb-20**	**Mar-20**	**Oct-19**	**Nov-19**	**Dec-19**	**Jan-20**	**Feb-20**	**Mar-20**
Total species number	11	14	19	17	15	NA	12	10	12	13	19	NA
Migratory species	8	8	11	10	10	NA	7	5	7	7	8	NA
Resident species	3	6	8	7	5	NA	5	5	5	6	11	NA
Total population	341	1053	227	1410	8305	NA	222	161	322	2642	4500	NA
Migratory population	318	1011	156	1340	8249	NA	136	12	198	2518	4340	NA
Resident population	23	42	71	70	56	NA	86	149	4	124	160	NA

3.3 Flamingo Census (FCS)

In FCS, we estimated the abundance and distribution of Greater flamingos and Lesser flamingos in the Thane Creek, Sewri and Nhava-Sheva mudflats. Due to prolonged monsoon we could survey once in October. Later we sampled for three consecutive days of every month till March 2020. Initially, in Thane Creek, we counted fewer Greater flamingos, 835 individuals in October which increased to 29219 individuals in March 2020. Lesser Flamingo count on the other hand was nil in October which increased to 61,802 in March 2020. Observations showed that the subadult population of both species was comparatively less than adults during the entire survey (Table 7).

Table 7 Population of flamingo species recorded from the Thane Creek

	Age	**Thane creek**					
		Oct-19	**Nov-19**	**Dec-19**	**Jan-20**	**Feb-20**	**Mar-20**
Greater flamingo	**Adult**	26	NA	4287	7020	16710	23671
	Sub-Adult	809	NA	1128	1108	8353	5548
	Total	**835**	**NA**	**5415**	**8128**	**25063**	**29219**
Lesser flamingo	**Adult**	0	NA	9	10357	26770	53462
	Sub-Adult	0	NA	1	4145	7735	8340
	Total	**0**	**NA**	**10**	**14502**	**34505**	**61802**

Results revealed both populations of Greater and Lesser flamingos inhabited the mudflats of the East bank throughout this period of surveys, mainly congregated towards upstream, near Ghansoli channel (Tr IDs; T1-T2 & T37-T40) and downstream regions (Tr IDs; T35-T36 & T29-T34). Later, from January till March, it was observed that the abundance of flamingos was also distributed abundantly over the mudflats of the West bank towards upstream-downstream regions (Tr IDs; T14-T18 & T26).

It was observed that relatively fewer Greater and Lesser flamingos inhabited the mudflats of Sewri and Nhava-Sheva from January to March (Table 8).

Table 8 Population of flamingo species recorded from Sewri and Nhava-Sheva mudflats during FCS

Species	Age	Sewri mudflat						Nhava-Sheva mudflat					
		Oct-19	**Nov-19**	**Dec-19**	**Jan-20**	**Feb-20**	**Mar-20**	**Oct-19**	**Nov-19**	**Dec-19**	**Jan-20**	**Feb-20**	**Mar-20**
GF	**Adult**	NA	NA	NA	0	NA	287	NA	NA	NA	0	NA	1500
	Sub-Adult	NA	NA	NA	0	NA	0	NA	NA	NA	0	NA	0
	Total	**NA**	**NA**	**NA**	**0**	**NA**	**287**	**NA**	**NA**	**NA**	**0**	**NA**	**1500**
LF	**Adult**	NA	NA	NA	2335	NA	2838	NA	NA	NA	0	NA	25
	Sub-Adult	NA	NA	NA	2060	NA	1268	NA	NA	NA	0	NA	0
	Total	**NA**	**NA**	**NA**	**4395**	**NA**	**4106**	**NA**	**NA**	**NA**	**0**	**NA**	**25**

3.4 Bird Behavior

A total of 3017 observations were recorded from October 2019 to March 2020 and 1071 observations have been transcribed in BORIS (Table 9). A monthly and species wise number of observations for each site category is given in Table 10. Pied avocets were not seen at construction sites whereas Whimbrel was not seen at any of the sites during behavioral surveys.

Table 9 Number of observations in each site category

Site category	Oct 19	Nov 19	Dec 19	Jan 20	Feb 20	Mar 20
Roosting	316	148	239	126	219	172
Feeding	386	0	492	157	188	0
Construction	0	80	20	340	114	20

Table 10 Species wise number of observations in each site category

Species	Feeding	Roosting	Construction
Black-tailed Godwit	178	88	5
Common Greenshank	14	173	23
Common Redshank	151	203	142
Curlew Sandpiper	130	83	42
Eurasian Curlew	22	218	50
Greater Flamingo	140	119	26
Lesser Sandplover	145	16	70
Little Stint	183	115	25
Whimbrel	0	0	0
Lesser Flamingo	120	184	191
Pied Avocet	140	21	0

The behavior surveys were started from September 2019 and September to November was considered as the post-monsoon season, December to February as winter and March to May as summer season. Here we have plotted the activity budget of species that had a minimum of 30 observations during post-monsoon season. These species include Common Redshank, Little Stint, Eurasian Curlew, Black-tailed Godwit, Common Greenshank, Curlew Sandpiper, Greater Flamingo, and Lesser Sand Plover. Out of these species, only Common Redshank has a minimum of 30 observations at each site category i.e. feeding, roosting, and construction sites. Little Stint and Curlew Sandpiper have it on feeding and roosting sites. The rest of the species have their activity budgets plotted only at one of the site categories.

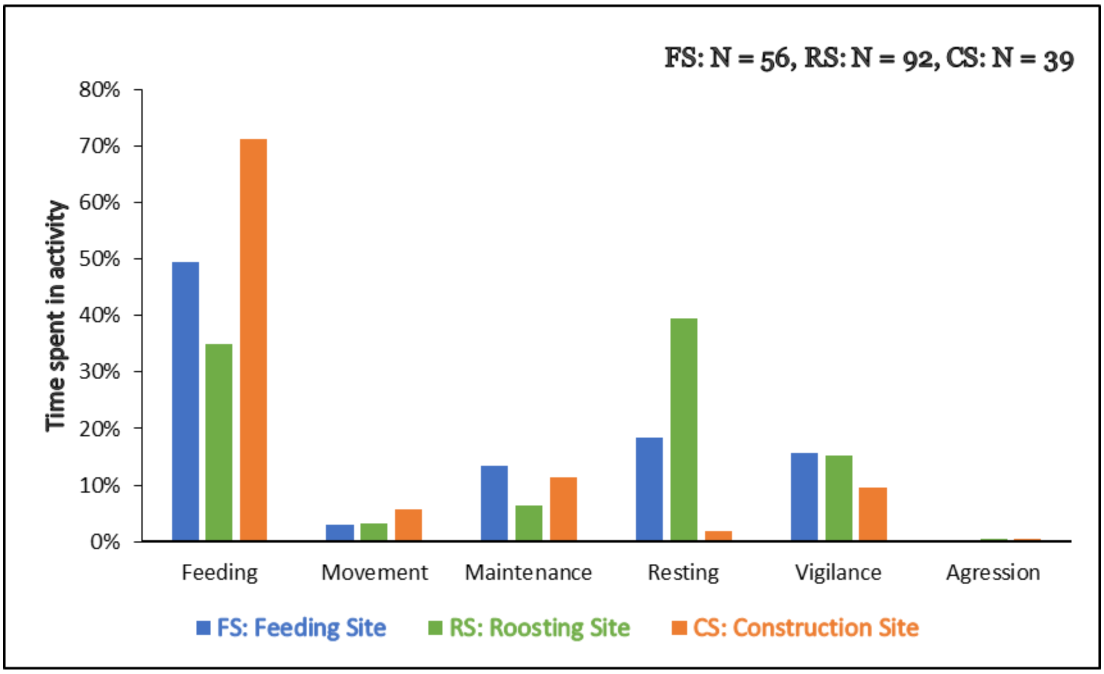


Figure 1 Activity budget of Common Redshankat feeding, roosting, and construction sites

Fig 1: shows the activity budget of Common Redshankat all of the sites and we can see that it spends most of its time feeding at construction (Sewri and Nhava-Sheva). The mudflats of Sewri and Nhava-Sheva provide one of the major foraging grounds for these birds. The proportion of time spent in feeding by Common Redshank is higher at construction sites as compared to feeding and roosting sites. Whereas, time spent in vigilance is lower at construction sites than that of feeding and roosting sites. This suggests that this species is not affected by the construction activities and may have habituated to such anthropogenic activities. Birds can become habituated to disturbances (Fitzpatrick & Bouchez, 1998) because birds can learn and identify the predictable patterns of human activities that do not pose any threat to them (Burger, 1989; Burger & Gochfeld, 1991). Similar results were observed for Common Redshank by Rosli & Nor Atiqah, 2017 where the birds ignored sound produced by vehicles and continued feeding until the vehicles came very close. It has also been observed during the behavior surveys that other waders also come as close as up to 5 meters to the under-construction bridge. However, we have seen a decline in the wader population at the construction sites. So even though the birds are getting accustomed to the construction, the construction activities could still be impacting the overall population of waders. If this impact is temporary or permanent can be inferred only after 5 years of post-construction monitoring. The impact of disturbance on the populations of birds also depends upon the availability of an alternative habitat (Burton, 2003). The decision for moving to a new site depends on the availability and quality of the new site (Ydenberg and Dill, 1986). However, in some cases, birds might continue to feed in areas where the food is sufficient even in the presence of human disturbances (Rosli & Nor Atiqah, 2017), as seen in the case of Common Redshank at construction sites. This is done to optimize the energy expenditure as flying to a new foraging site will require more energy (Lafferty, 2001).

Waders such as Little Stint, Black-tailed Godwit, Curlew Sandpiper, Lesser Sand Plover and Common Greenshank were almost equally engaged in resting and vigilance at the roosting sites indicating a high degree of predation and disturbance at these sites (Fig 2, 3, 4, 5, 6 & 7). Spending much time in vigilance at roosting sites can negatively impact the fitness of these birds as it reduces the time available for fitness-enhancing activities such as resting, maintenance, and foraging (Fritz, 2002). This can also increase their energy expenditure which can affect their ability to build fat reserves to fulfill their annual cycle of moult, migration, and breeding (Spencer, 2010). In the case of Greater Flamingo at roosting sites, it spent most of its time on maintenance followed by feeding and vigilance indicating that it is not affected by the disturbances, unlike the smaller waders. The flamingos may have habituated to the human disturbances and avian predators such as Black Kites and Marsh Harriers pose no threat to these large birds (Fig 8). All these species also devote much of their time in feeding at the feeding sites followed by maintenance and vigilance as seen in the graphs.

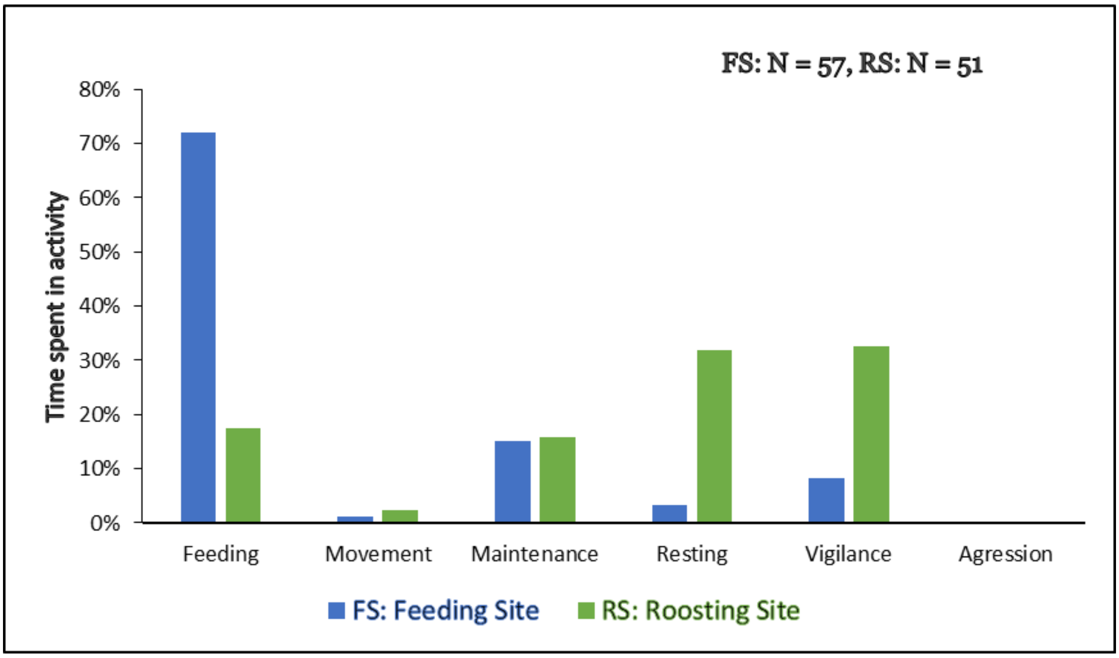


Figure 2 Activity budget of Little Stint at feeding and roosting site

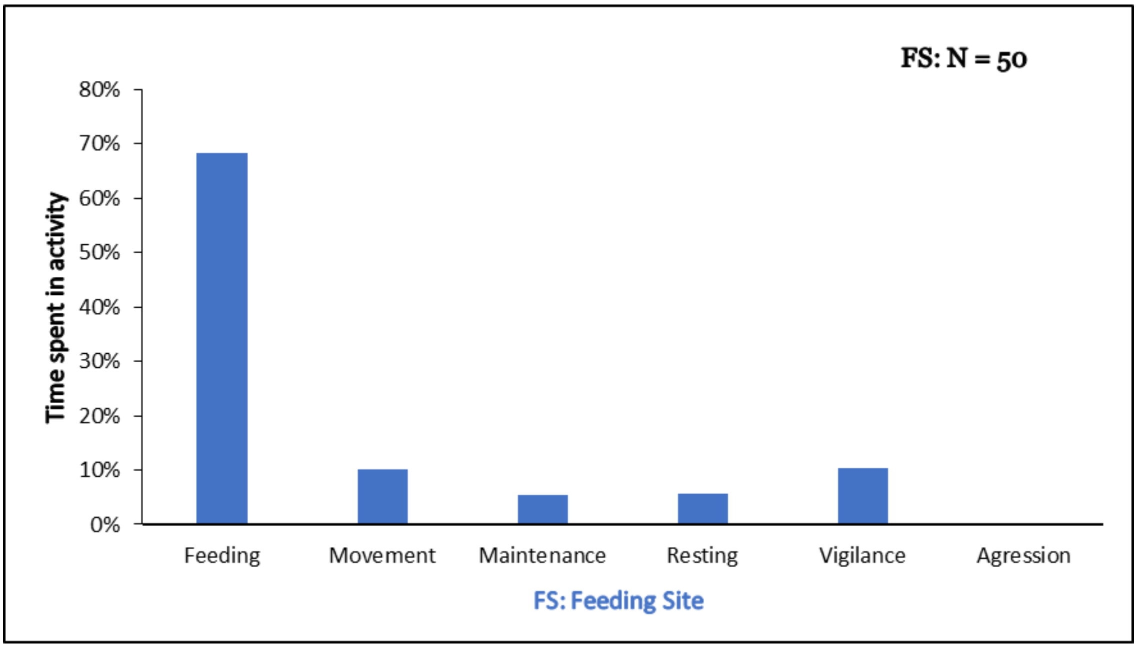


Figure 3 Activity budget of Black-tailed Godwit at feeding site

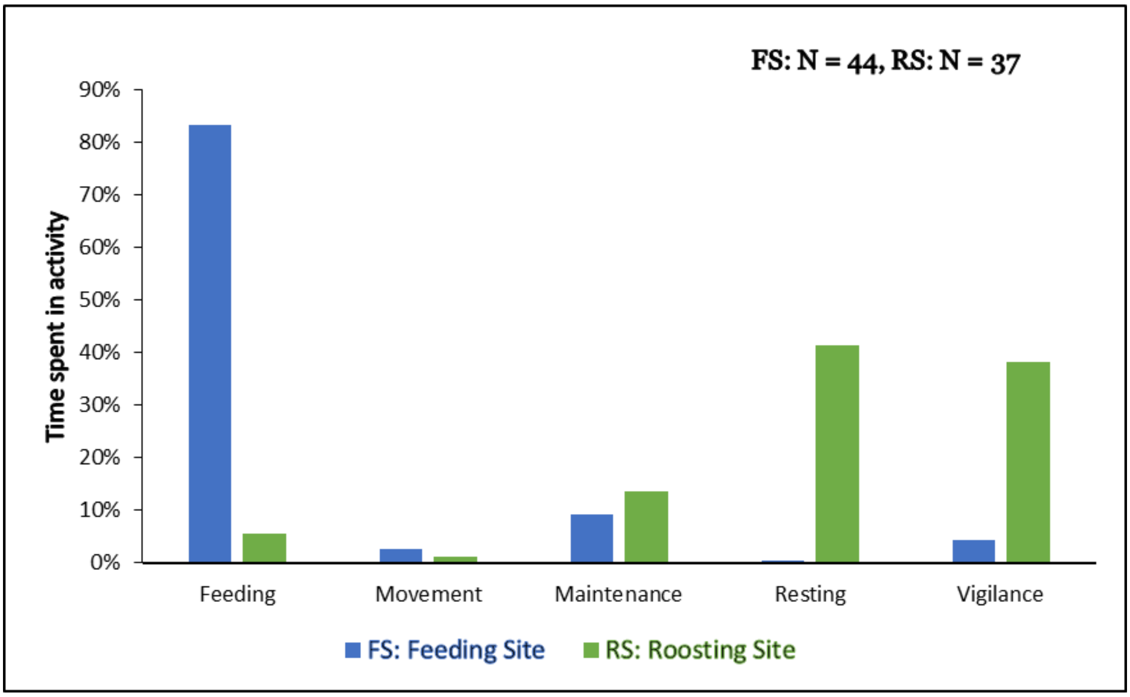


Figure 4 Activity budget of Curlew Sandpiper at feeding and roosting sites

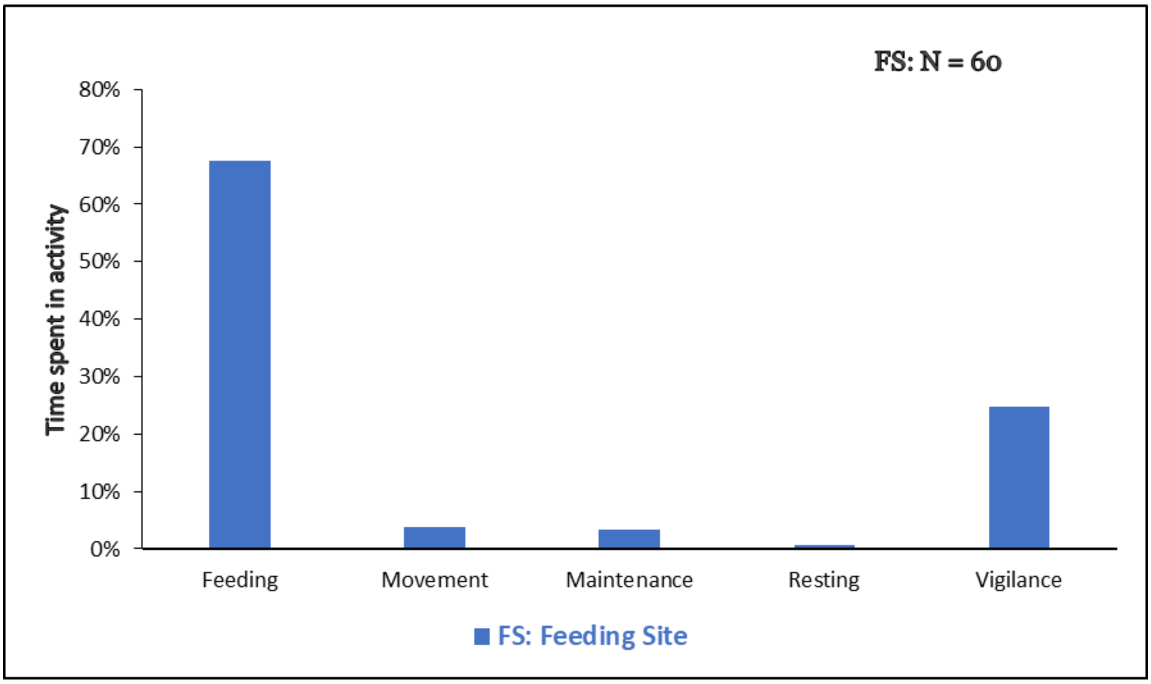


Figure 5 Activity budget of Lesser Sand Plover at feeding site

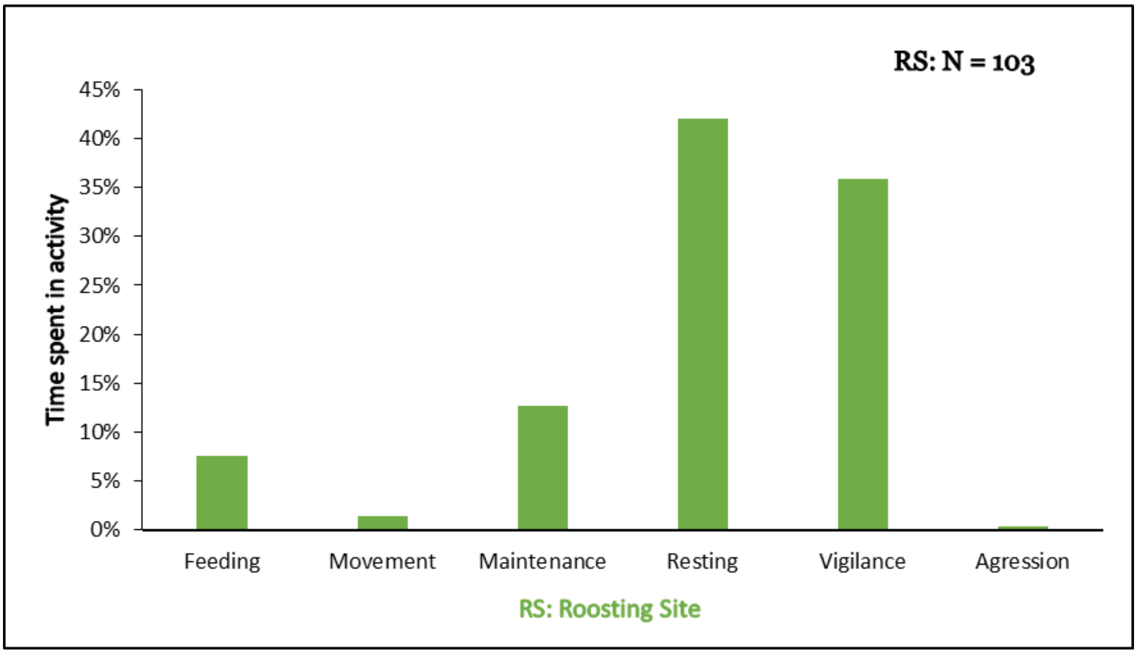


Figure 6 Activity budget of Common Greenshank at roosting site

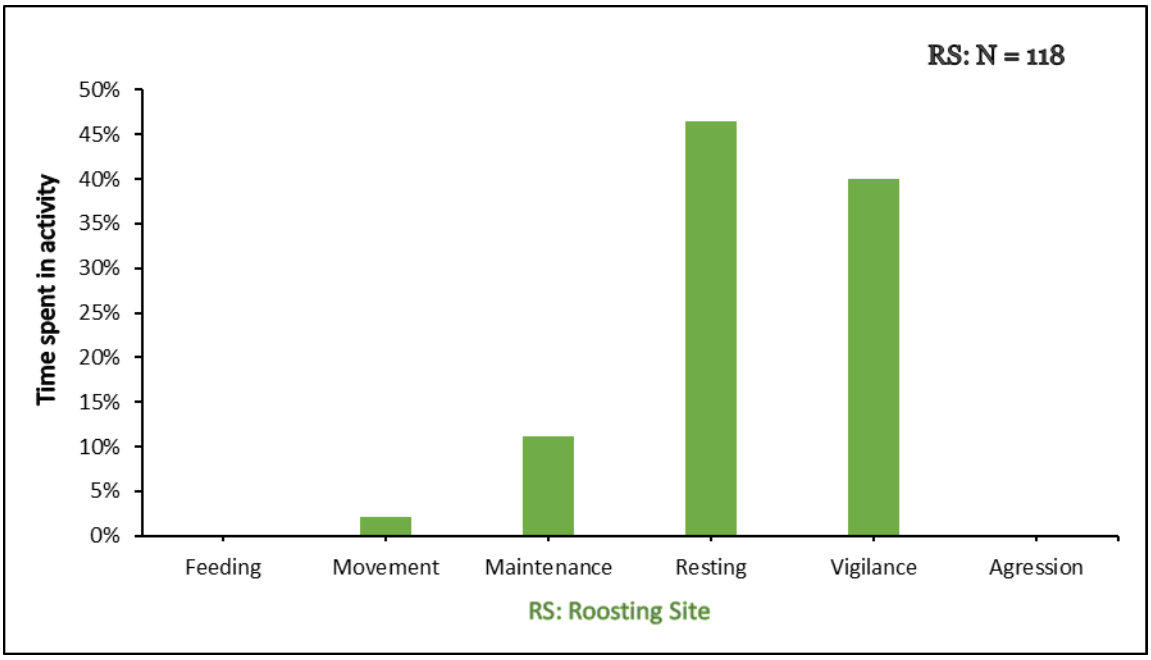


Figure 7 Activity budget of Eurasian curlew at roosting site

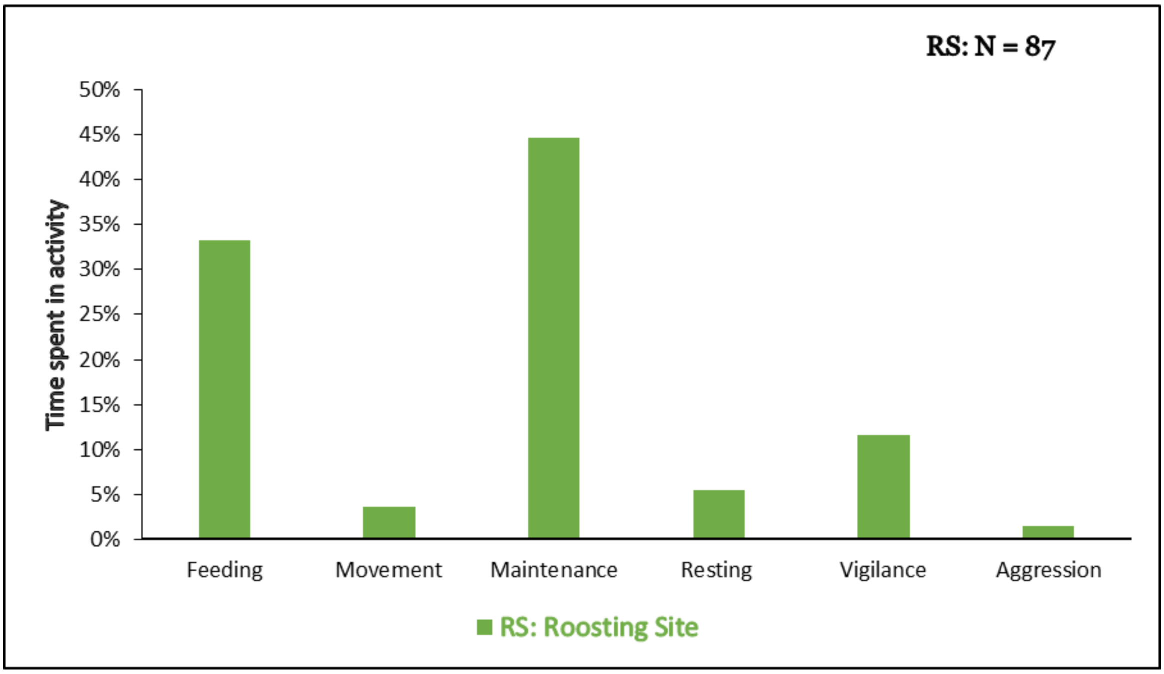


Figure 8 Activity budget of Greater Flamingo at the roosting site

3.5 Bird ringing

We conducted 49 trapping sessions from September 2019 to March 2020. All these trapping sessions were done mainly at two sites BPS and TSC. We were successful in trapping 5356 birds during these sessions of which 5318 were small waders and 38 Flamingos. We also got 385 recaptures during these trapping sessions. Details are as below.

Table 11 Ringing and colour flagging details

Date of ringing session	No. of Individuals ringed	Recaptures	Recaptured Species
3-11-2019	51	8	7 Common Redshank, 1 Curlew Sandpiper
6-11-2019	94	21	17 Common Redshank, 1 Green Shank, 2 Lesser Sand Plover, 1 Curlew Sandpiper
7-11-2019	101	13	8 Common Redshank, 1 Little Stint, 4 Curlew Sandpiper
8-11-2019	23	3	3 Common Redshank
9-11-2019	170	1	1 Common Redshank

10-11-2019	147	1	1 Terek Sandpiper
11-11-2019	111	0	
12-11-2019	136	11	2 Curlew Sandpiper, 1 Little Stint, 8 Common Redshank
8-12-2019	287	7	4 Terek Sandpiper, 2 Lesser Sand Plover, 1 Curlew Sandpiper
9-12-2019	269	5	3 Terek Sandpiper, 1 Little Stint, 1 Lesser Sand Plover
10-12-2019	197	9	7 Common Redshank, 1 Curlew Sandpiper, 1 Terek Sandpiper
11-12-2019	121	7	3 Curlew Sandpiper, 3 Common Redshank 1 Lesser Sand Plover
12-12-2019	152	5	3 Lesser Sand Plover, 1 Common Sandpiper, 1 Little Stint
13-12-2019	156	11	2 Terek Sandpiper, 1 Common Redshank, 2 Lesser Sand Plover, 6 Little Stint
26-12-2019	94	0	
27-12-2019	45	0	
28-12-2019	180	2	1 Common Redshank, 1 Lesser Sand plover
10-1-2020	151	5	4 Common Sandpiper, 1 Terek Sandpiper
11-1-2020	14	0	
12-1-2020	36	6	5 Common Redshank, 1 Lesser Sand Plover
13-1-2020	170	6	3 Common Redshank, 2 Terek Sandpiper, 1 Curlew Sandpiper
20-1-2020	149	14	1 Common Redshank, 1 Common Sandpiper, 4 Lesser Sand Plover, 2 Little Stint, 6 Terek Sandpiper
21-1-2020	144	7	4 Common Sandpiper, 2 Lesser Sand Plover, 1 Little Stint
22-1-2020	139	9	5 Common Redshank, 3 Curlew Sandpiper, 1 Terek Sandpiper
23-1-2020	91	5	2 Terek Sandpiper, 1 Common Redshank, 2 Curlew Sandpiper
24-1-2020	88	0	
25-1-2020	136	11	3 Common Sandpiper, 3 Curlew Sandpiper, 2 Lesser Sand Plover, 3 Little Stint
3-2-2020	139	06	2 Little Stint, 1 Kentish Plover, 1 Lesser Sand Plover, 1 Curlew Sandpiper, 1 Terek Sandpiper

4-02-2020	117	2	1 Lesser Sand Plover, 1 Curlew Sandpiper
5-02-2020	76	11	7 Curlew Sandpiper, 4 Common Redshank
6-02-2020	76	28	19 Common Redshank, 3 Lesser Sand Plover, 1 Little Stint, 5 Curlew Sandpiper
7-02-2020	13	0	
8-02-2020	67	0	
10-02-2020	103	8	3 Terek Sandpiper, 1 Little Stint, 1 Common Redshank, 1 Lesser Sand Plover, 1 Common Sandpiper, 1 Curlew Sandpiper
18-02-2020	25		
19-02-2020	7		
20-02-2020	80	6	4 Common Sandpiper, 2 Lesser Sand Plover
21-02-2020	91	7	7 Common Redshank
22-02-2020	103	11	11 Common Redshank
23-02-2020	122	16	12 Common Redshank, 2 Little Stint, 1 Common Green Shank, 1 Terek Sandpiper
24-02-2020	81	12	4 Common Redshank, 7 Terek Sandpiper, 1 Lesser Sand Plover
25-02-2020	200	28	26 Common Redshank, 1 Marsh Sandpiper, 1 Grey Plover
06-03-2020	159	28	1 Terek Sandpiper, 27 Common Redshank
07-03-2020	69	7	6 Curlew Sandpiper, 1 Little Stint
8-03-2020	129	25	2 Curlew Sandpiper, 20 Common Redshank, 2 Lesser Sand Plover, 1 Terek Sandpiper,
11-03-2020	161	23	15 Common Redshank, 1 Curlew Sandpiper, 6 Terek Sandpiper, 1 Lesser Sand plover
13-03-2020	102	7	3 Common Redshank, 2 Curlew Sandpiper, 1 Lesser Sand Plover, 1 Terek Sandpiper

4. Benthic Fauna

The diversity and dynamics of a population and their interaction with the environment play a vital role in understanding community ecology. The shoreline also known as the intertidal zone is subjected to rhythmic rise and fall of water level which eventually causes gradient display of organisms having elastic ability to survive through changing temperature and salinity. In this system, primary and secondary consumers are benthic fauna, which in turn are consumed by top predators such as epibenthic crustaceans, fishes, and shorebirds (Raffaelli and Hawkins, 1999). Many studies have revealed a positive correlative between shorebird abundance and their invertebrate prey availability (Boettcher et al., 1995) at muddy intertidal mudflats. This aide the study of diversity and distribution of macrobenthic fauna to very essential in the present study. Additionally, the benthos is regularly monitored as a pointer of conceivable changes within the system. Being closely associated with the sediment and relatively long-lived, benthic fauna indicates the effects of environmental changes at a particular place over a long period.

Wetlands in coastal areas are crucial natural resources and are gaining importance in recent years. The coastal wetlands comprise of critical transition zones between continental landmasses, freshwater habitats, and marine habitats and are ecologically sensitive systems (Ghosh, 2017, Turner et al. 2000). These transition zones facilitate ecosystem services like shoreline protection, organic decomposition, carbon sequestration, flood control, nutrient cycling, water quality improvement, habitat for migratory and resident animals, and regulation of fluxes of nutrients, water, particles, and organisms between land, rivers, and the ocean (Costanza et al. 1997; Levin et al. 2001).

5. Methodology

Macrobenthos samples were collected from intertidal mudflats of the Thane Creek, Sewri, Nhava, Wetlands from October 2019 to March 2020. Due to prolonged rains, Thane Creek was not sampled during October. Along with this, macrobenthos samples were also collected from the sub-tidal area of the Thane Creek from December 2019 to March 2020. The sampling period has been divided into four phases namely Phase I (October), winter (November, December, and January), Phase II (February), and summer (March) to represent seasons. Thane Creek was divided into forty transects at an interval of 1 km along both banks of the Creek for the estimation of macrobenthic density, biomass, and diversity of Polychaete families. Two transects from Sewri and Nhava-Sheva were sampled monthly along with the creek sampling during the study period. In January and February 2020, three transects were sampled from Sewri whereas in Nhava-Sheva, one additional transect was laid during February 2020. Intertidal mudflats were divided into 3 zones i.e. Mangrove line (Zone A), mid-water line (Zone B), and low-water line (Zone C), to study the changes in the macrobenthic distribution at different tide levels. To explore the distribution and composition of macrobenthic groups within the upper 15 cm of the substratum, the core has been sectioned into five strata (2cm, 4cm, 8cm, 11cm, and 15cm). These sections were also created based on the beak size of the shorebirds inhabiting the mudflats for feeding. This later component also aids in correlating the vertical stratification of macrobenthic groups and food preference of the bird species.

Van Veen grab (0.02 m^2) was used to collect macrobenthos samples from the middle channel of the Thane Creek as subtidal samples. The samples were collected from the channel from 10 locations each 2km apart and which also coincides with the transects laid over the mudflats.

The present study was carried in five wetlands- BPS, TSC, NRI complex, and Belpada. In the case of wetlands, quadrate (20*20cm) was used to collect sediment samples from four different directions of the wetland.

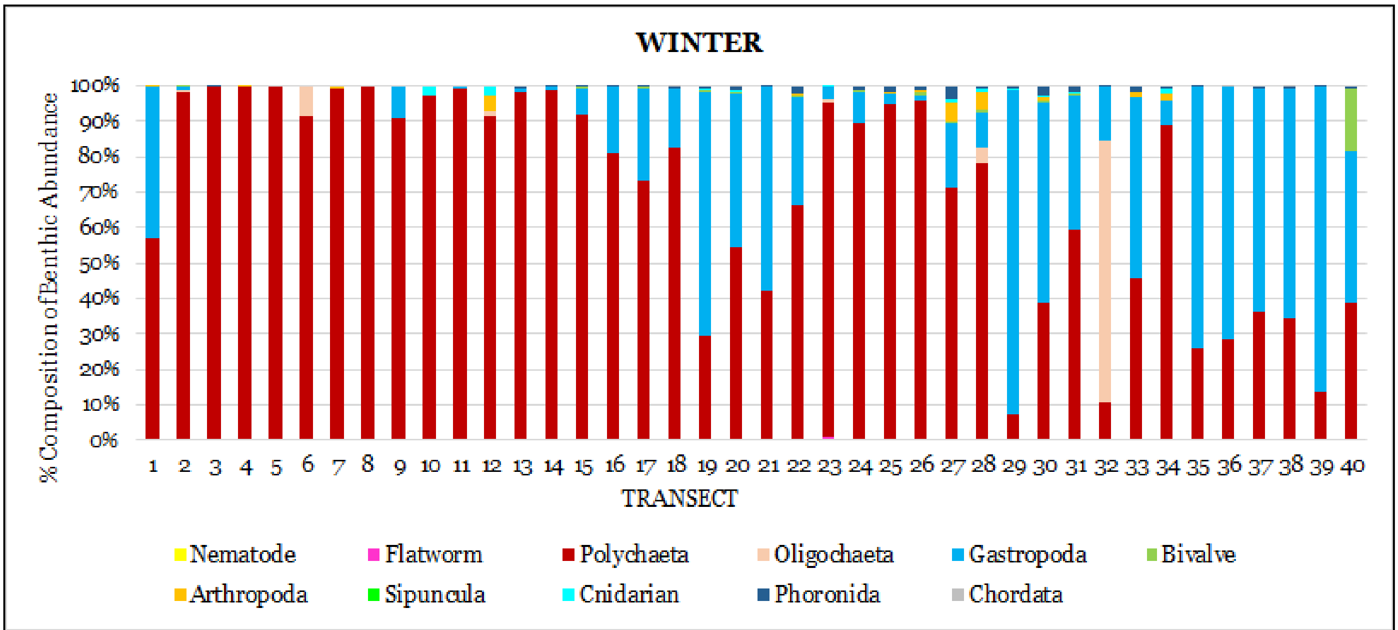
A total of five sites (P1 to P5 and Z1 to Z5) were sampled in the Thane Creek every month from October 2019 to March 2020 for the collection of phytoplankton and zooplankton with the help of plankton nets. Due to bad weather conditions, only three sites were sampled in November 2019. Analysis for January, February, and March is under process and will be included in future reports.

6 Results

6.1 Thane Creek

An overall seasonal trend in the macrobenthic density and biomass has been observed during the study period. Macrobenthic density has shown a considerable decrease from winter (15343/m3) to Phase II (4108/m3). A similar trend was observed in the case of macrobenthic biomass with average values 14.96g/m3 during winter which declines to 4.18 g/ m3 during Phase II. Overall a decline in the average density of Polychaetes and Gastropods has been observed from winter (2966/m3; 15343/m3) to Phase II (1800/m3; 4108/m3). A similar trend was observed in terms of macrobenthic biomass for Polychaetes (winter-0.97 g/m3; Phase II-0.53 g/m3) and Gastropods (winter-1.77 g/m3; Phase II-0.29g/m3) during the study period. In winter, Gastropods (1287/m3) dominated the macrobenthic composition followed by Polychaetes (975/m3), Phoronida (29/m3) and Bivalve (11/m3). Whereas during Phase II (Fig. 9), Polychaete (401/m3) dominated the macrobenthic composition followed by Gastropod (239/m3), Phoronida (3/m3) and Bivalve (2/m3). In the case of macrobenthic biomass (Fig. 10), Gastropods (1.77g/m3) displayed maximum biomass followed by Polychaetes (0.9g/m3), Chordates (0.1g/m3) during winter. In Phase II, Polychaetes (0.53g/m3) exhibited the highest biomass followed by Arthropods (0.04g/m3) and Flatworms (0.4g/ m3). East bank has shown highest density and biomass (avg. 15343/m3; 14.96g/ m3) in Tr 39 during winter whereas in Phase II West bank displayed the highest density and biomass (4108/m3 ; 4.18 g/

m3) in Tr 20. Overall, during the study period, 10 Phylum and 20 groups of invertebrates were observed in the Thane Creek. Winter exhibited higher macrobenthic diversity with the presence of 18 faunal groups whereas, Phase II exhibited 16 faunal groups. Arthropoda was the most diversified phylum comprising of 9 groups namely Brachyura, Barnacle, Shrimp, Anomuran, Amphipod, Taniads, Cumacean, Pycnogonid, Insect larvae.



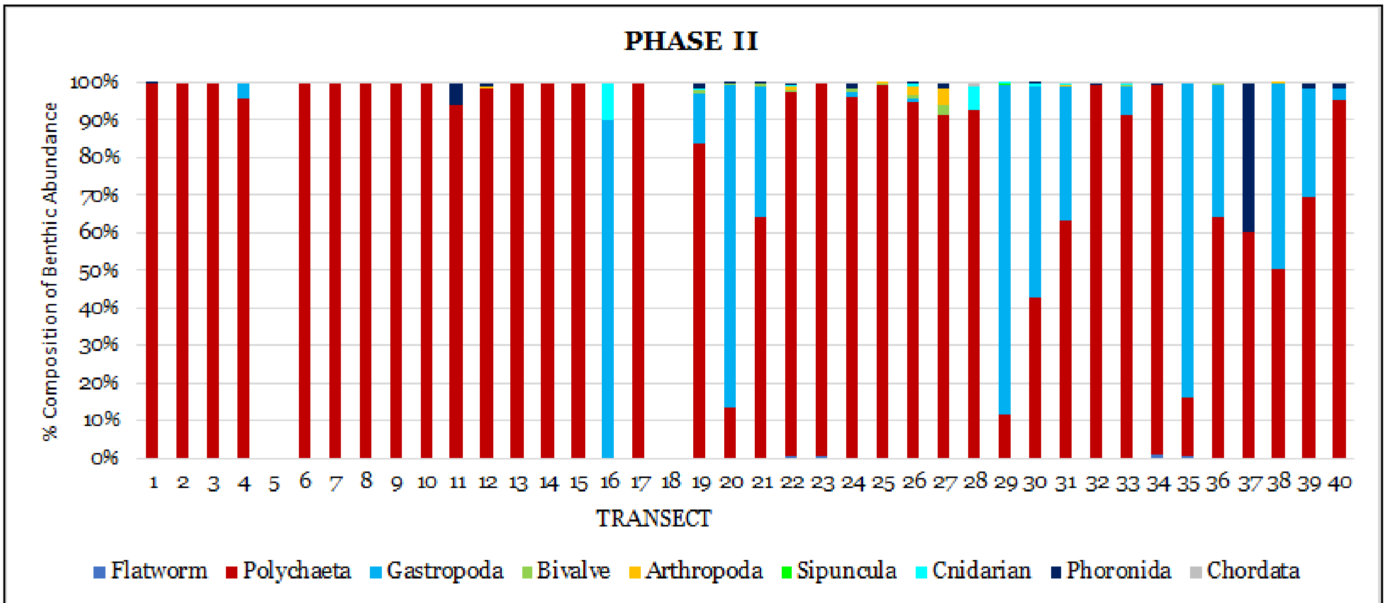
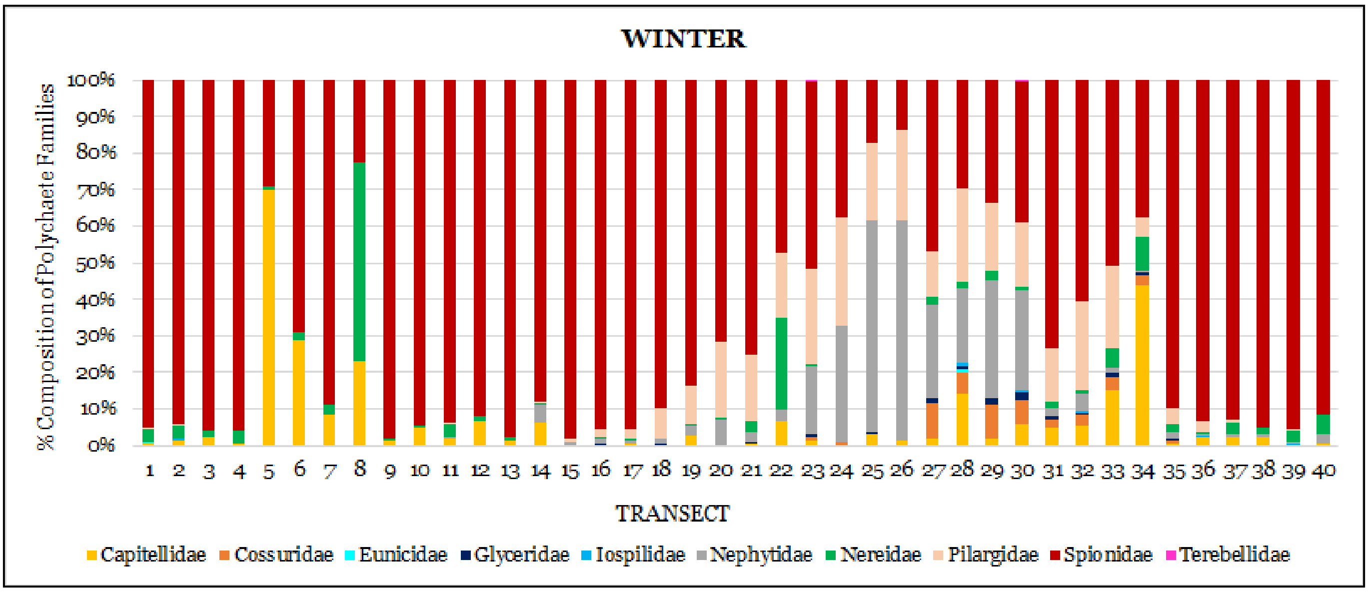


Figure 9 Seasonal variation in the percentage composition of macrobenthic density in different transects of the Thane Creek



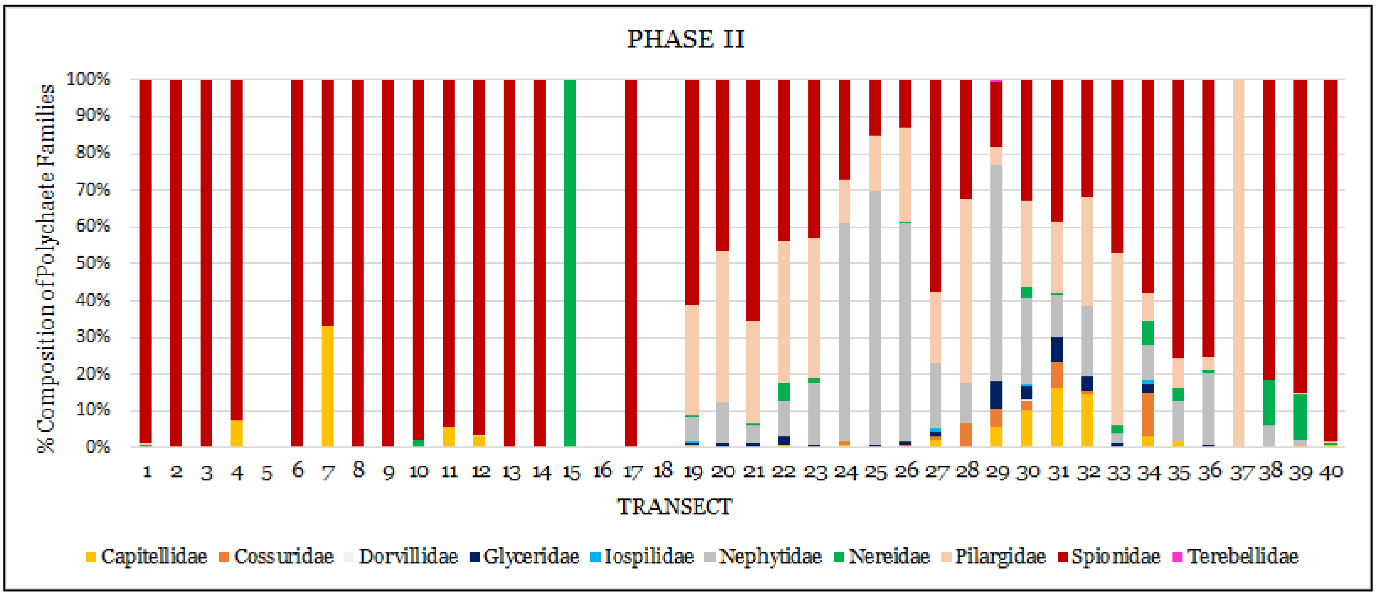
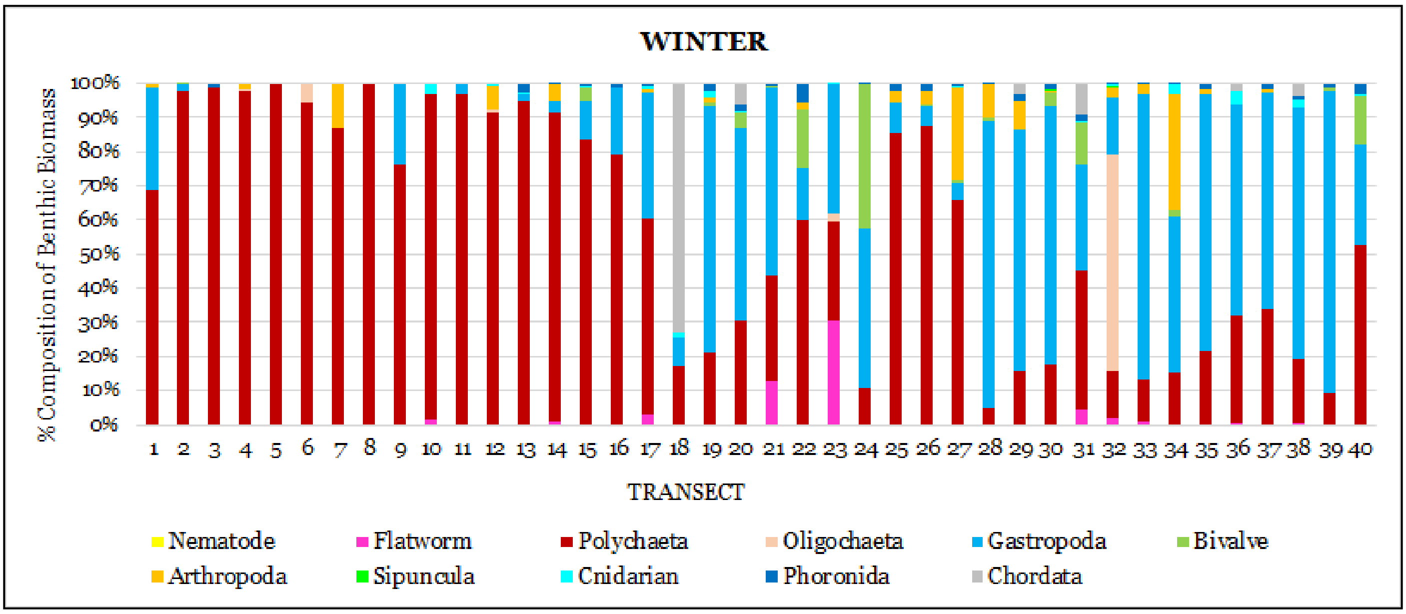


Figure 10 Seasonal variation in the percentage composition of macrobenthic biomass in different transects of the Thane Creek



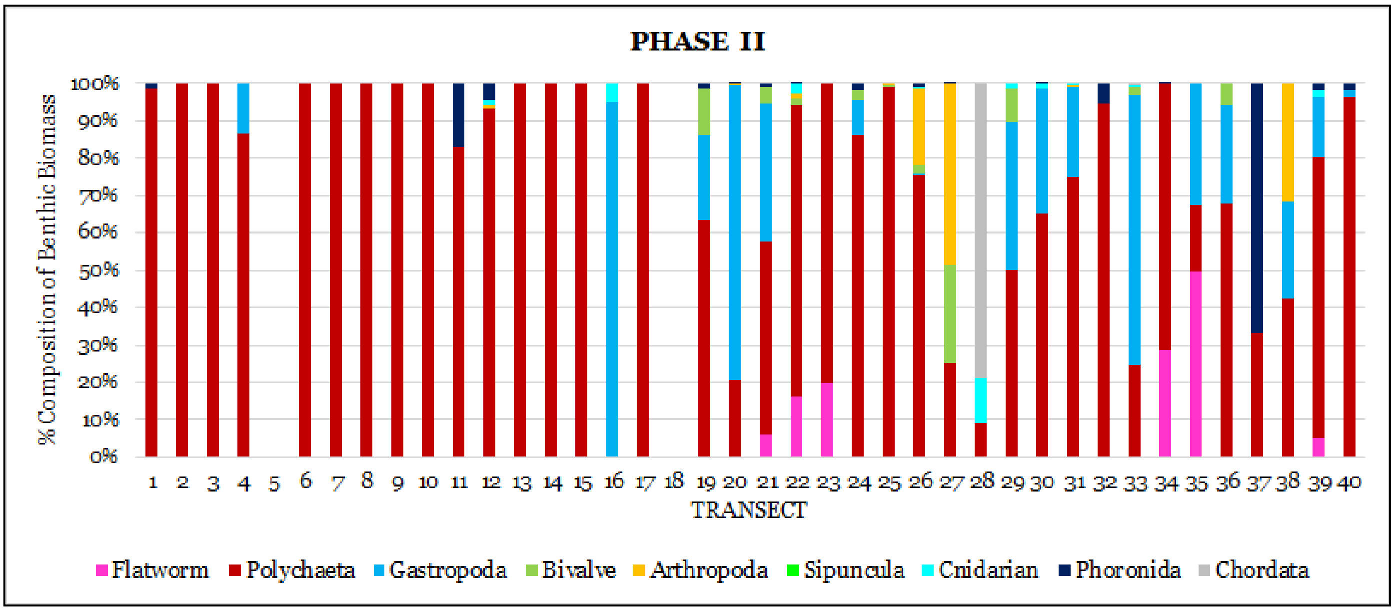


Figure 11 Seasonal variation in the percentage composition of Polychaete families in different transects of the Thane Creek

During the present study total, 15 Polychaete families (Fig. 11) were recorded from intertidal mudflats of the Thane Creek. The maximum number of Polychaete families was observed during December (11 families) followed by January (10 families) and February (10 families) and November (9 families). Based on their density Spionidae found to be the dominating family followed by Pilargidae, Nephytidae, Nereidae, and Capitellidae. The Percentage composition of Spionidae has declined from 86% in winter to 73 % during Phase II whereas an increasing trend was observed in the case of Pilargidae (winter- 5% to Phase II- 13%) and Nephytidae (winter- 3% to Phase II- 9%).

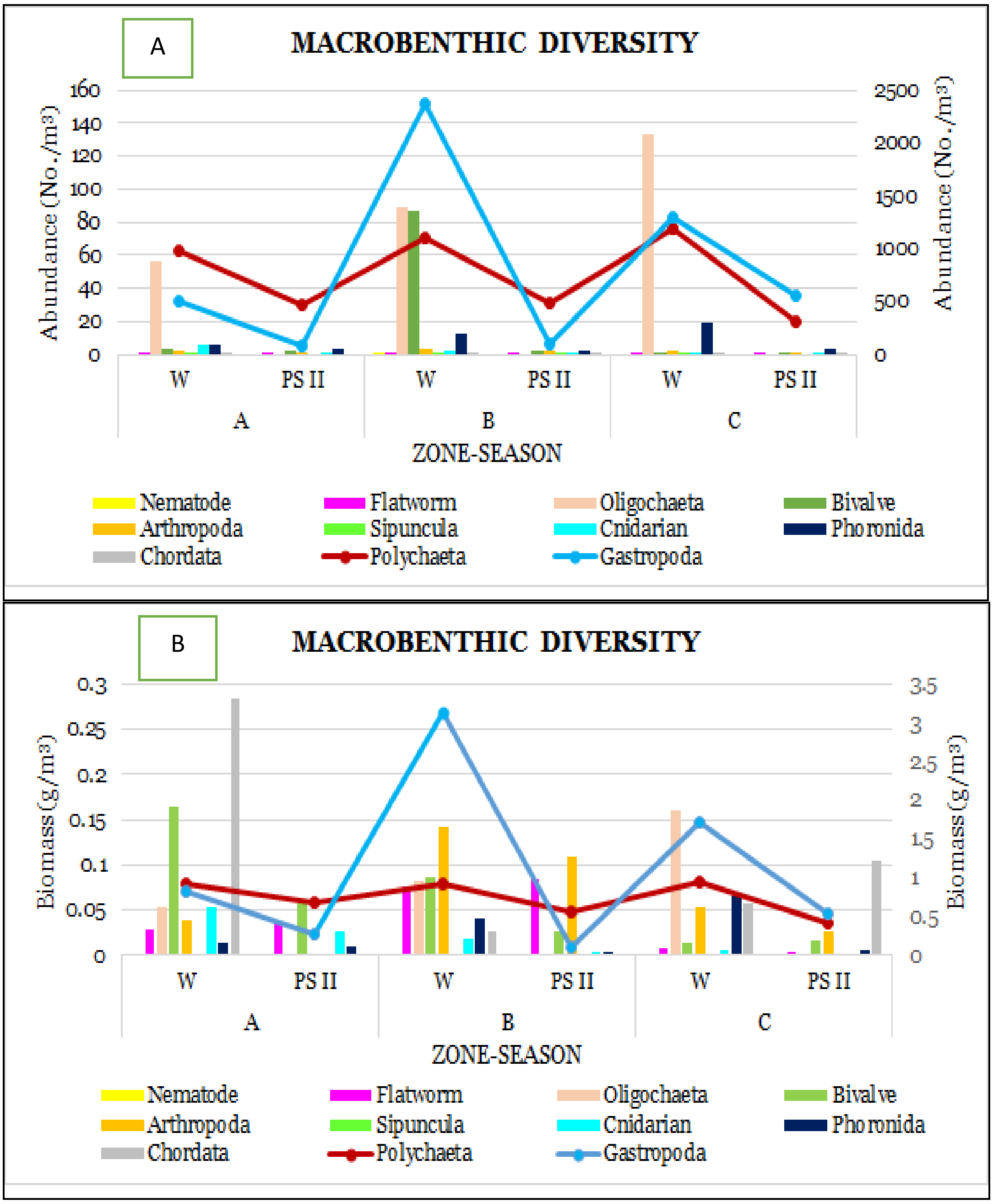
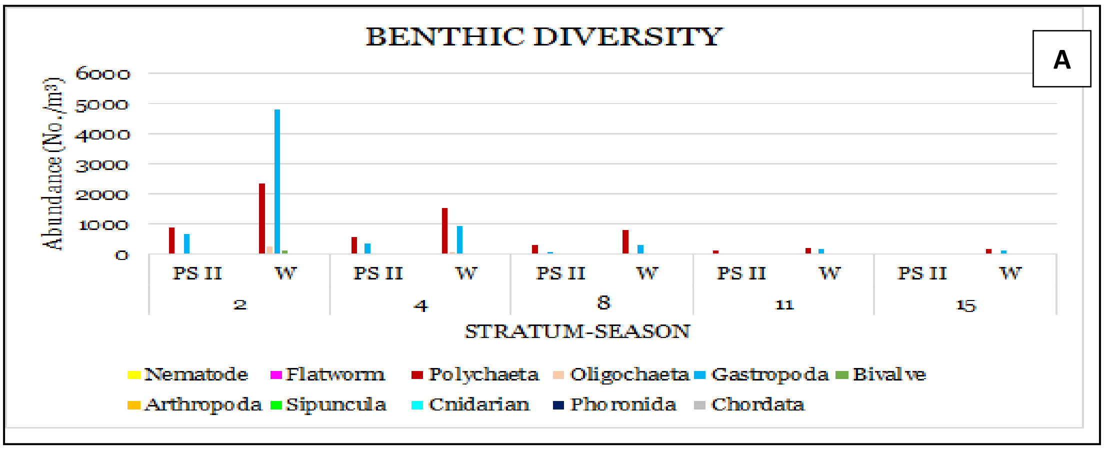


Figure 12 Zonal variation in macrobenthic density (A) and biomass (B) in different seasons along the Thane Creek

Macrobenthic diversity shows variation along with zones and different stratum. Presently no specific observations were obtained in terms of zonal distribution and biomass of the macrobenthic groups. Zone A (Fig. 12) exhibited dominance of Polychaetes both in terms of abundance (winter-980/m^3; Phase II- 505/m^3) and biomass (winter-0.9g/m^3; Phase II-0.8/m^3) followed by Gastropods during both seasons. Whereas Zone C contradicts the observations obtained at the Zone A as instead of Polychaetes, Gastropod dominates the macrobenthic composition in terms of density and biomass.

Zone B exhibits dominance of Gastropods in terms of both abundance and biomass during winter whereas Polychaete dominates in Phase II. Overall Zone B (10 No.) exhibits more faunal diversity followed by Zone A (8 No.) and Zone C (7 No.).

Maximum macrobenthic diversity was observed in stratum 4 and all other strata showed consistent diversity (Fig. 13). Macrobenthic density and biomass declined vertically downwards from the stratum 2cm to stratum 15cm. Polychaete dominates the benthic abundance followed by Gastropods in all stratum during both seasons except for stratum 2cm in the winter season, which exhibits an opposite trend. Polychaetes dominate in terms of macrobenthic biomass in all stratum except for stratum 2cm for both seasons.



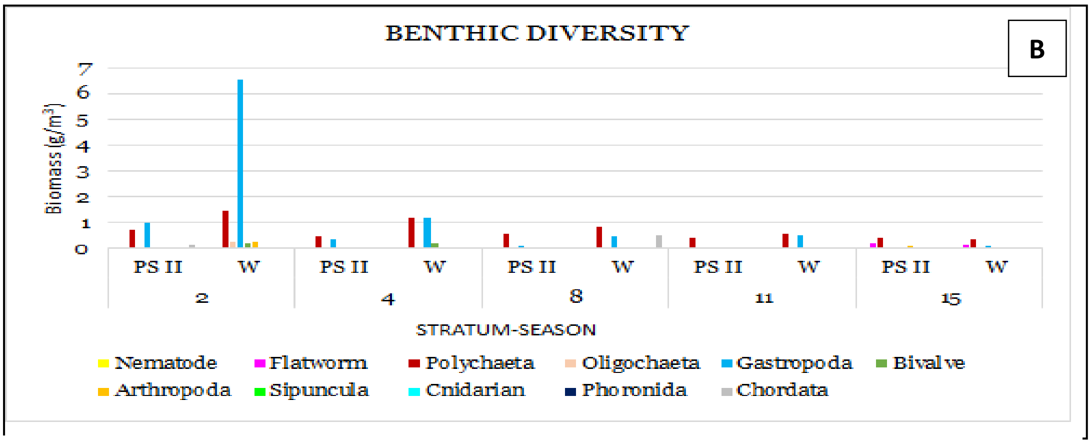


Figure 13 Vertical variation in macrobenthic density (A) and biomass (B) in different seasons along the Thane Creek

6.2 Subtidal

Polychaetes, Gastropods, and Phoronids found dominating the macrobenthic composition within the subtidal zone. Polychaetes dominate in terms of density at all the sampling points and in both the seasons followed by Gastropods and Phoronids. The density of macrobenthos (Fig. 14 A) was found to be highest in the winter season (avg. 233/unit volume) which declined during Phase II (avg. 135 per unit volume). The summer season (represented by the month of March) depicted a slight rise again in the macrobenthic density (avg. 204 per unit volume). The overall abundance of Polychaetes was highest in winter (avg. 233/unit volume) followed by summer (avg. 126/unit volume) and least during Phase II (avg. 126/unit volume). Whereas an opposite trend has been observed in case of Gastropods (winter- avg. 81/unit volume; summer- avg. 50/unit volume; Phase II- avg. 135/unit volume) and

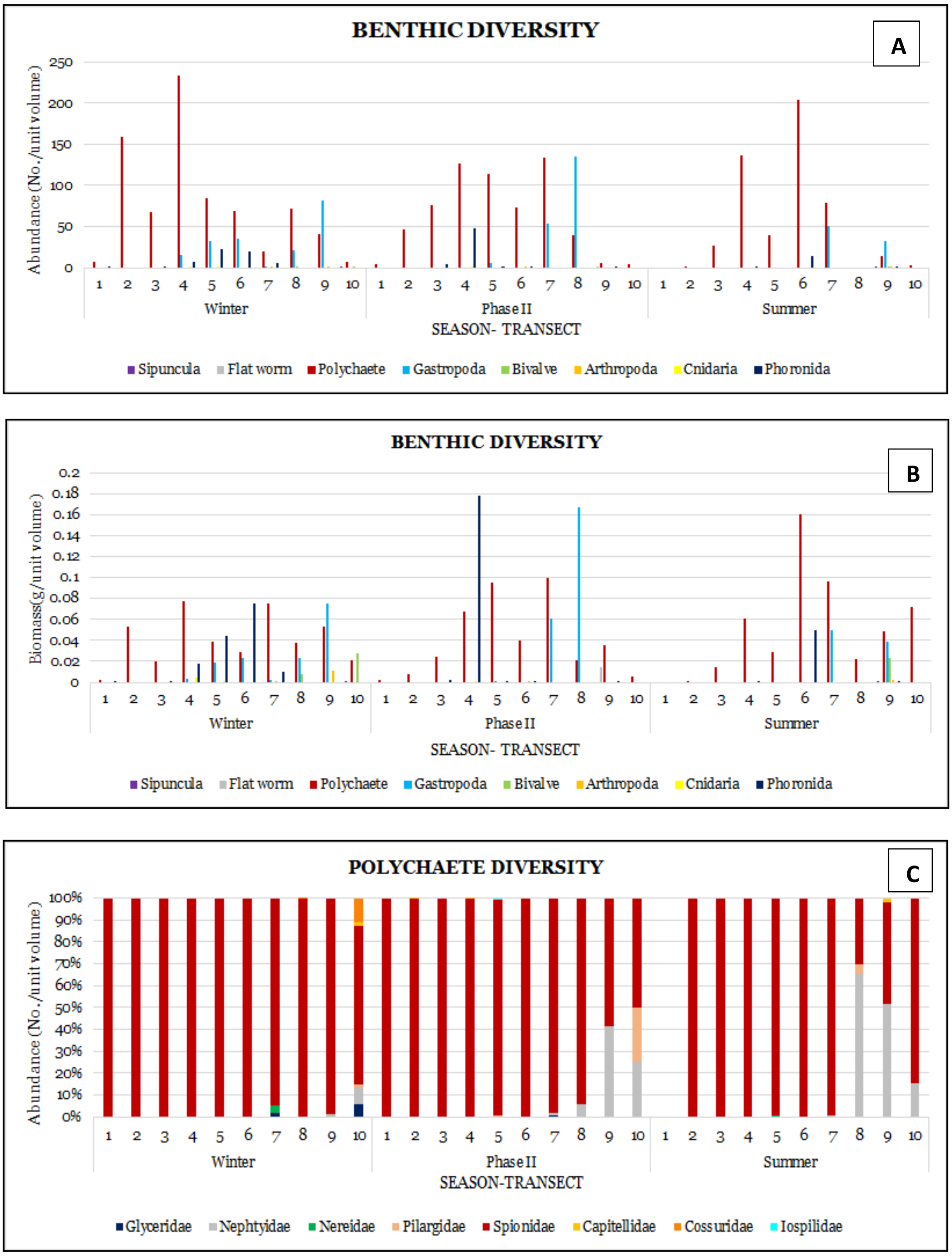


Figure 14 Seasonal variation in Macrobenthic abundance (A), biomass (B) and Polychaete families (C) along the subtidal area of the Thane Creek

Phoronids (winter- avg. 22/unit volume; summer- avg. 14/unit volume; Phase II- avg. 49/unit volume). Phase II exhibited maximum biomass (Fig. 14 B) as compared to the other two seasons. Polychaetes dominate in terms of biomass during winter (0.07g/unit volume) and summer (0.16g/unit volume) followed by Phoronids and Gastropods. Whereas in Phase II, Phoronids (0.15g/unit volume) exhibits the highest biomass followed by Gastropods and Phoronids.

During this study period total of 7 invertebrate phyla and 9 groups were recorded from the sub-tidal area. Winter displayed maximum faunal diversity (9 groups) followed by Phase II (8 groups) and summer (8 groups).

Pertaining to Polychaete diversity (Fig. 14 C) about, 8 families were observed, of which 6 families showed their presence consistently in all three seasons. The family Spionidae was predominant throughout the seasons followed by the family Nephtyidae when compare to the other families which were in less numbers.

6.3 Sewri and Nhava-Sheva mudflats

At these two mudflats, among all seasons, winter exhibits maximum macrobenthic abundance (Fig. 15 A) (Sewri-1236/m^3; Nhava-Sheva-278/m^3) and diversity (Sewri-7 No.; Nhava-Sheva- 8No.) followed by Phase II and Phase I. Phase II has depicted maximum biomass (Fig. 15 B) (Sewri-1.91g/m^3; Nhava-Sheva-3.16g/m^3) in both sampling places followed by winter and phase I. Overall 8 invertebrate phylum and 12 groups and 8 invertebrate phylum and 10 groups were observed during the study period from Nhava-Sheva and Sewri respectively. Polychaetes dominate in terms of abundance in both Sewri (1236/m^3) and Nhava-Sheva (278/m^3) during all sampling seasons followed by Gastropods and Arthropods. Gastropods depicted maximum biomass during Phase I (0.1 g/m^3) and winter (1.914 g/m^3) whereas Bivalve showed (1.9 g/m^3). In the case of Nhava-Sheva, Bivalve exhibits maximum biomass during Phase I (0.01 g/m^3) and Chordata count maximum during winter (1.57 g/m^3) and Phase II (3.17g/m^3). Overall, Sewri exhibits more abundance of benthic fauna whereas Nhava-Sheva shows more diversity.

Zone C exhibits maximum benthic density (Sewri-1495/m^3; Nhava-Sheva- 293/m^3) followed by Zone B irrespective of seasons. In terms of biomass, Zone C shows the highest value (13.1g/m^3) in Sewri followed by Zone B (5.7g/m^3) whereas Zone B (9.5g/m^3) dominates in case of Nhava-Sheva followed by Zone C. Zone A exhibits less density (Sewri-902/m^3; Nhava-Sheva- 330/m^3) and biomass (Sewri-0.8/m^3; Nhava-Sheva- 0.6/m^3) during both seasons at both places. In terms of diversity, Zone A (8 No.) depicts maximum diversity in Nhava-Sheva whereas in Sewri Zone C (7 No.) exhibits more diversity as compared to other Zones. In Nhava-Sheva, Zone C was not sampled during Phase I due to less exposure of mudflat. Overall, winter exhibits maximum abundance in all zones at both sites except for Zone A of Sewri mudflats.

During the study, it was observed that Polychaetes dominates in all stratum followed by Gastropods. Overall, the maximum density of macrobenthos was observed within the upper 2 cm stratum-which further declines and found the lowest value of density at the 15cm stratum. In Sewri, maximum biomass was observed in stratum 2 (21.824g/m^3) followed by stratum 15 (5.5g/m^3), stratum 11 (1.4g/m^3) whereas in Nhava-Sheva stratum 8 showed maximum value (15.84g/ m^3) followed by stratum 2 (10.13g/ m^3), stratum 15 (1.1g/ m^3). Biomass does not show any such trend. Stratum 8 exhibits maximum diversity (9 No.) whereas all other stratum shows consistent faunal diversity.

In

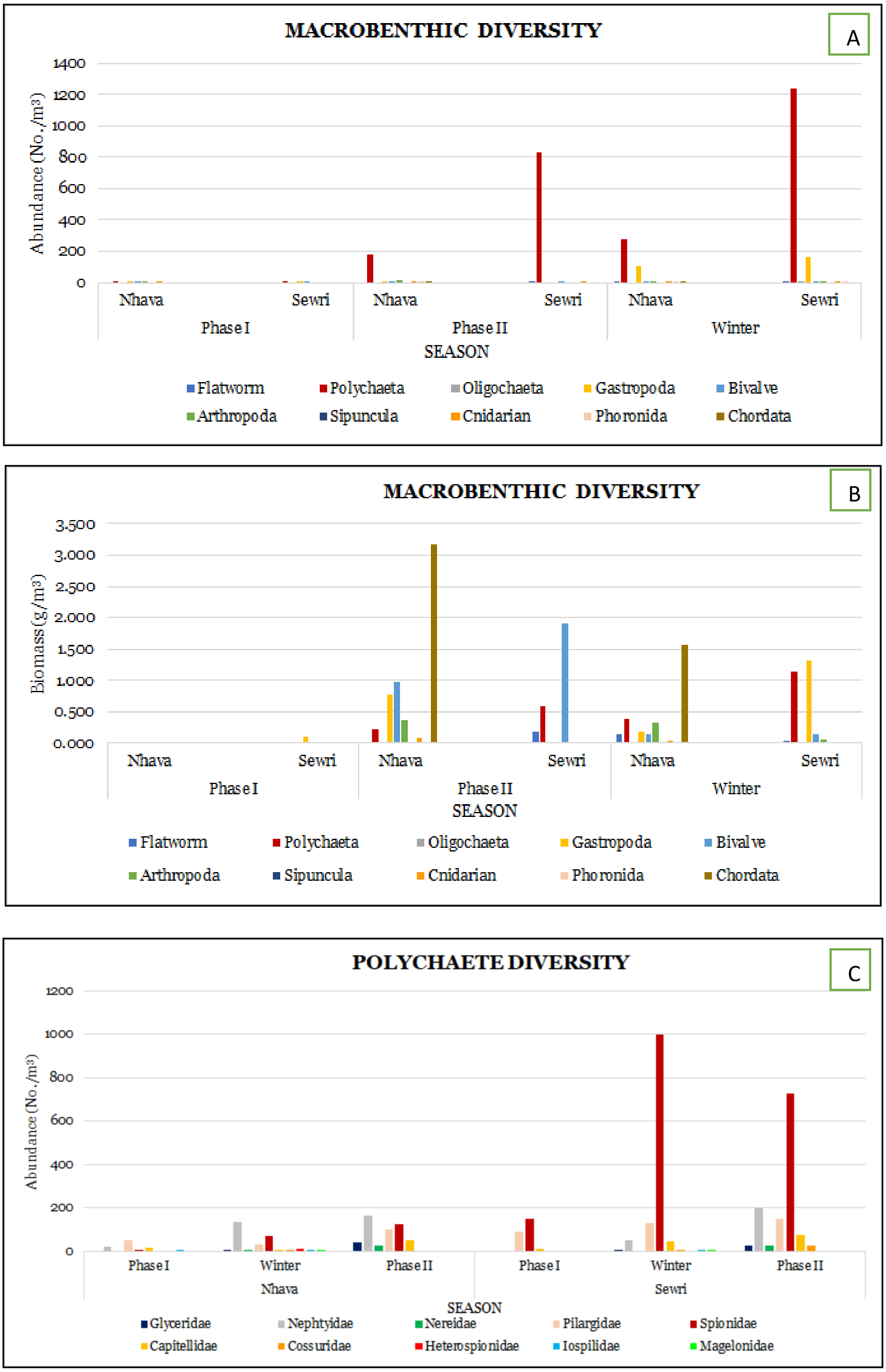


Figure 15 Seasonal Variation of macrobenthic abundance (A), biomass (B) and Polychaete diversity (C) along Sewri and Nhava

terms of the composition of Polychaete (Fig. 15 C), Nhava-Sheva exhibits more diversity as compared to Sewri. Overall, 10 families were recorded during three seasons and four families were prevalent Spionidae, Pilargidae, Nephytidae, and Capitellidae. Although Phase I showed the least diversity in terms of Polychaete composition however winter season exhibits maximum Polychaete diversity in both sampling areas followed by Phase II.

At Sewri, Spionidae was the most dominating Polychete family during all seasons followed by Pilargidae and Capitellidae during Phase I and winter. Whereas during Phase II second dominating family was Glyceridae and Pilargidae.

At Nhava-Sheva, during Phase I, Pilargidae was the dominating family followed by Nephytidae and Capitellidae. Nephytidae dominated Polychete composition followed by Spionidae, Pilargidae, and Capitellidae during winter and Phase II.

6.4 Wetlands

Belpada: This wetland exhibits maximum macrobenthic density (1753/m^3) and faunal diversity (4 No.) during winter followed by Phase II and Phase I. Whereas maximum biomass (2.9g/m^3) was observed during Phase I followed by winter and Phase II.

BPS: In the case of BPS, Phase II recounts maximum density (1931/m^3) followed by Phase I (1683/m^3) and winter (334/ m^3). Benthic density was higher during Phase I (3.7g/m^3) and declines with seasons from winter (2g/m^3) to Phase II (0.5g/m^3). Winter exhibit more diversity of benthic fauna in BPS during winter while the other two seasons have equal diversity.

NRI: Phase I showed a maximum density (451/m^3) with a continuous decline from winter (286/m^3) to Phase II (50/m^3). Benthic biomass and diversity displayed similar trends in NRI, being maximum during winter (3.6g/m^3; 5 No.) followed by Phase I (1.6g/m^3; 3 No.) and Phase II (0.5g/m^3; 1 No.).

TSC: Phase I showed the least benthic density (440/m^3) in TSC and a seasonal increase in density was observed from Winter (647/ m^3) to Phase II (731/m^3). Whereas maximum benthic biomass was observed in Phase I (14g/ m^3) followed by Phase II (10.8g/m^3) and winter (3.3g/ m^3). Winter (5No.) supported maximum diversity in TSC followed by Phase I (4 No.) and Phase II (2 No.).

Overall, 5 Phylum and 9 benthic groups (Fig. 16) were observed in all wetlands. Arthropoda is the most diversified phylum comprising the presence of 4 groups- Amphipods, Shrimp, Chironomus larvae, and Tanaids. Arthropods contribute to maximum benthic density in NRI and BPS during Phase I and in TSC during Phase II whereas Gastropods exhibits maximum contribution during winter. Overall, Polychaetes were present in all sites and during all seasons. In total, 5 Polychaete families (Fig. 16 C) were observed in wetlands during all seasons. Belpada being the most diversified wetland supports 5 families in winter and 3 families during the other two seasons. There was no diversity and seasonal variation observed in NRI as only Nereidae was found during all seasons. In BPS, Phase I exhibited the presence of Nereidae, whereas both Spionidae and Nereidae were observed during winter and Phase II. Similarly, TSC also showed the presence of only Nereidae during Phase I and Phase II whereas Spionidae and Nereidae being present in winter. Nereidae was found at all sites during all seasons and dominates other families at all sites during Phase I. During winter and Phase II, Capitellidae dominated Belpada and Spionidae in BPS.

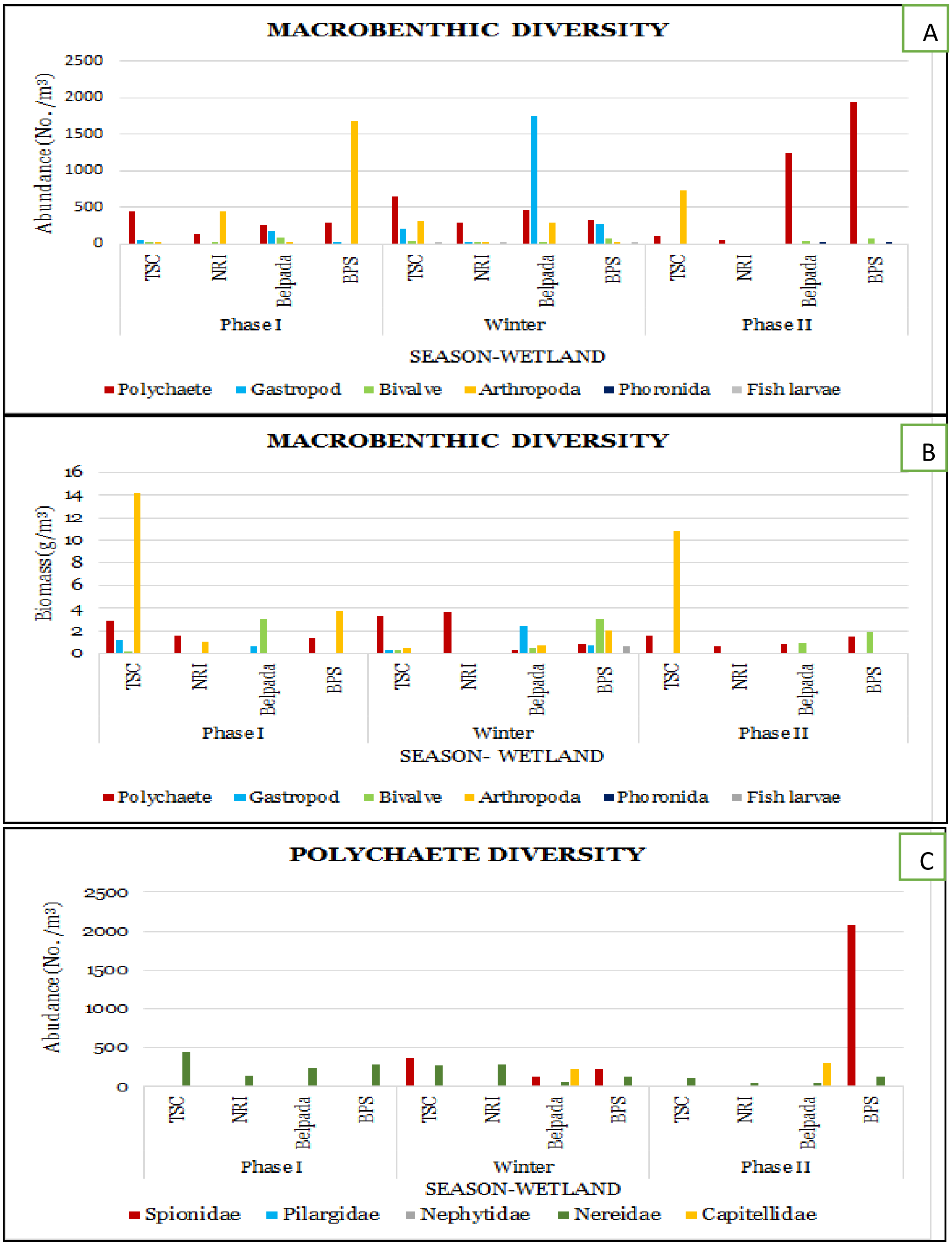


Figure 16 Seasonal Variation of macrobenthic abundance (A), biomass (B) and Polychaete (C) diversity in different wetlands

6.5 Planktons

A total of 23 species of phytoplanktons were found during both seasons (Fig. 17). In Phase I, *Skeletonema costatum* (39%) dominates followed by *Coscinodiscus granii*

(17%) and *Navicula* sp., all other species contribute less than 10% to phytoplankton composition. During winter, *Skeletonema costatum* (21%) dominates the composition followed by *Odontella* sp. (20%) and *Thalassiosira* sp. (11%) and rest all species account less than 10% to plankton composition. *Dinophysis miles*, *Ornithocerus* sp., *Thalassionema* sp. were found only during Phase I whereas *Cyclotella* sp., *Cylindrotheca Closterium* and *Thalassiothrix* sp. were observed in only during winter season. Overall, 20 phytoplankton species were found in Phase I and 19 during winter. Except for *Leptocylendricus* sp., *Odentella* sp., *Surirella* sp., and *Thalassiosira subtilis*, all other phytoplankton species exhibited a seasonal decline in percentage composition from Phase I to winter.

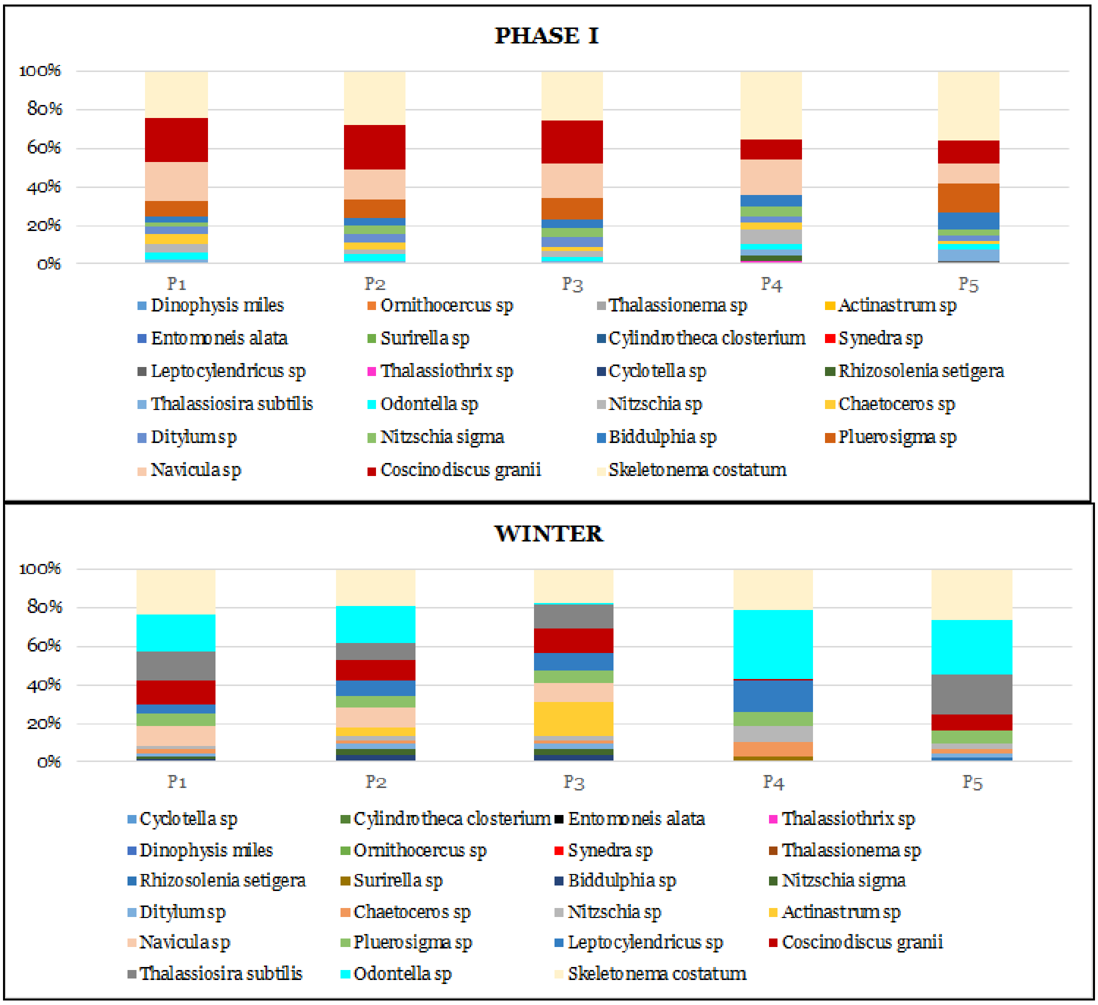


Figure 17 Seasonal variation in percentage composition of Phytoplankton along the Thane Creek

A total of 18 Zooplankton (Fig. 18) groups were found during both seasons. Medusa (Phase I-61% and winter-28%) was the most dominating group during both seasons followed by Copepod (Phase I-20%, winter-26%) Decapod larvae (14%) was third dominating group during Phase I whereas in winter *Acetes* sp. (14%) was the third dominating group followed by Decapod larvae (12%). All other groups during both seasons contribute less than 10% to the composition. With seasonal change rise in zooplankton diversity was observed from Phase I (12 No.) to winter (18 No.)

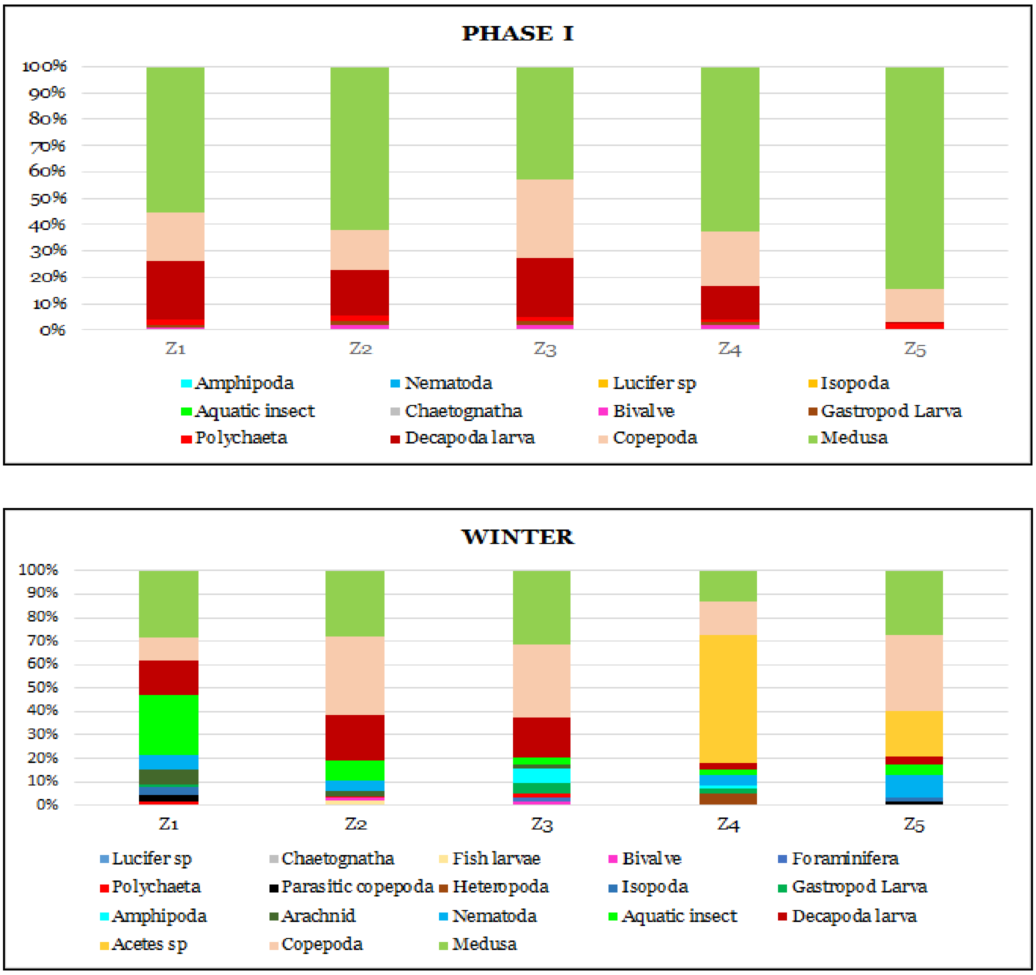


Figure 18 Seasonal variation in percentage composition of Zooplankton along the Thane Creek

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Appendix 1. Photo Plates

Plate 1: Congregation of migratory birds at study sites

Image 1.1: Flock of Black-tailed godwit at BPS pond adjacent to saltpans.

Image 1.2: Flock of Grey plover at TSC wetland.

Image 1.3: Flock of Eurasian curlew at TSC wetland.

Image 1.4: Flock of Marsh sandpiper at BPS pond adjacent to saltpans.

Image 1.5: Adults of Lesser flamingo at Thane Creek mudflats.

Image 1.6: Subadults of Lesser flamingo at Thane Creek mudflats.

Plate 2: Migratory and resident birds at study sites

Image 2.1: Flock of Eurasian spoonbill at BPS wetland.

Image 2.2: Flamingos feeding at Sewri mudflats.

Image 2.3: Disturbed flock of Black-tailed godwit at BPS wetland.

Image2.4: Disturbed flock of Slender-billed gull at BPS wetland.

Image 2.5: Female Common teal at NRI.

Image 2.6: Painted stork at NRI.

Image 2.7: Black coloured Lesser flamingo at NRI wetland

Image 2.8: Long-billed dowitcher at BPS wetland.

Image 2.9: Common redshank and Wood sandpiper at BPS pond adjacent to saltpans.

Image 2.10: Common greenshank and Marsh sandpiper at BPS pond adjacent to saltpans.

Image 2.11: Little Ringed plover at Nhava-Sheva mudflat.

Image 2.12: Ruff and Marsh sandpiper at Belpada wetland.

Plate 3. Habitats

Image 3.1: NRI wetland, one of the sites possess a large congregation of flamingos.

Image 3.2: Sewri mudflat.

Image 3.3: Belpada wetland.

Image 3.4: BPS wetland.

Plate 4. Bird ringing and recoveries

Image 4.1: Installing the wader net before ringing at BPS saltpans.

Image 4.2: Resighting of ringed individual of subadult Lesser flamingo at NRI wetland.

Image 4.3: Ringed individual of Marsh sandpiper at NRI wetland.

Image 4.4: Resighting of ringed individual of Lesser sandplover at Thane

Image 4.5: Ringed individual of Little Ringed plover at TSC wetland.

4.6: Ringed individual of Grey plover.

Plate 5. Some of the existing disturbances at study sites

Image 5.1: Photographers at NRI wetland during the survey.

Image 5.2: Saltpan extraction workers at BPS saltpans.

Image 5.3: A dog on mudflats of Thane creek.

Annexure 1. Checklist of birds recorded from Oct 2019-Mar 2020.

COMMON NAME	SCIENTIFIC NAME	STATUS	BPS	BEL	NRI	TSC	TC	SE W	NS
Anatidae									
Lesser Whistling Duck	*Dendrocygna javanica*	M					+		
Indian Spot-billed Duck	*Anas poecilorhyncha*	R	+	+	+	+	+		
Northern Shoveler	*Spatula clypeata*	M	+		+		+		
Northern Pintail	*Anas acuta*	M	+		+		+		
Garganey	*Anas querquedula*	M			+	+	+		
Common Teal	*Anas crecca*	M	+		+	+	+		
Ruddy Shelduck	*Tadorna ferruginea*	M	+	+		+	+		
Podicipedidae									
Little Grebe	*Tachybaptus ruficollis*	R	+		+				
Ciconiidae									
Painted Stork	*Mycteria leucocephala*	R	+	+	+	+	+	+	+
Phoenicopterid ae									
Greater Flamingo	*Phoenicopterus roseus*	M	+	+	+	+	+	+	+
Lesser Flamingo	*Phoeniconaias minor*	M	+		+	+	+	+	+
Threskiornithi dae									
Black-headed Ibis	*Threskiornis melanocephalus*	R	+	+	+	+	+	+	+
Glossy Ibis	*Plegadis falcinellus*	M	+		+	+	+		
Eurasian Spoonbill	*Platalea leucorodia*	M	+	+	+	+	+		
Ardeidae									
Indian Pond Heron	*Ardeola grayii*	R	+	+	+	+	+	+	+

Grey Heron	*Ardea cinerea*	R	+	+	+	+	+	+	+
Purple Heron	*Ardea purpurea*	R		+	+	+	+	+	
Striated Heron	*Butorides striata*	R					+		
Cattle Egret	*Bubulcus ibis*	R					+		
Great Egret	*Casmerodius albus*	R	+	+		+	+	+	+
Intermediate Egret	*Mesophoyx intermedia*	R	+	+	+	+	+	+	+
Little Egret	*Egretta garzetta*	R	+	+	+	+	+	+	+
Western Reef Egret	*Egretta gularis*	R	+	+	+	+	+	+	+
Phalacrocoracidae									
Little Cormorant	*Phalacrocorax niger*	R	+	+	+	+	+		+
Accipitridae									
Shikra	*Accipiter badius*	R		+					
Black Kite	*Milvus migrans*	R	+	+	+	+	+	+	
Western Marsh Harrier	*Circus aeruginosus*	M	+	+	+	+	+		
Greater Spotted Eagle	*Aquila clanga*	M					+		
Brahminy Kite	*Heliastur indus*	R	+		+	+	+		+
Pandionidae									
Osprey	*Pandion haliaetus*	M				+	+		
Rallidae									
White-breasted Waterhen	*Amaurornis phoenicurus*	R				+	+		
Eurasian Coot	*Fulica atra*	R	+		+	+	+		
Recurvirostridae									
Black-winged Stilt	*Himantopus himantopus*	R	+	+	+	+	+		
Pied Avocet	*Recurvirostra avosetta*	M	+		+	+	+		
Charadriidae									
Red-wattled Lapwing	*Vanellus indicus*	R	+	+	+	+	+		

Pacific Golden Plover	*Plover Pluvialis fulva*	M	+	+		+	+		
Grey Plover	*Pluvialis squatarola*	M	+	+	+	+	+	+	
Little Ringed Plover	*Charadrius dubius*	M	+	+					+
Kentish Plover	*Charadrius alexandrinus*	M	+	+			+		
Greater Sand Plover	*Charadrius leschenaultii*	M	+						
Lesser Sand Plover	*Charadrius mongolus*	M	+	+		+	+	+	+
Scolopacidae									
Ruff	*Philomachus pugnax*	M	+	+					
Common Snipe	*Gallinago gallinago*	M	+	+	+	+			
Black-tailed Godwit	*Limosa limosa*	M	+	+		+	+	+	
Bar-tailed Godwit	*Limosa lapponica*	M	+			+	+		
Long-billed Dowitcher	*Limnodromus scolopaceus*	M	+				+		
Whimbrel	*Numenius phaeopus*	M		+					
Eurasian Curlew	*Numenius arquata*	M	+	+	+	+	+	+	+
Common Redshank	*Tringa totanus*	M	+	+	+	+	+	+	+
Marsh Sandpiper	*Tringa stagnatilis*	M	+	+	+	+	+	+	
Common Greenshank	*Tringa nebularia*	M	+	+	+	+	+	+	+
Green sandpiper	*Tringa ochropus*	M				+	+	+	+
Wood Sandpiper	*Tringa glareola*	M	+	+	+	+	+		
Terek sandpiper	*Xenus cinereus*	M	+				+		
Common Sandpiper	*Actitis hypoleucos*	M	+	+	+	+	+	+	+
Ruddy Turnstone	*Arenaria interpres*	M				+	+	+	
Great Knot	*Calidris tenuirostris*	M	+		+	+			
Little Stint	*Calidris minuta*	M	+	+	+	+	+	+	+
Temminck's Stint	*Calidris temminckii*	M	+						
Curlew Sandpiper	*Calidris ferruginea*	M	+	+		+	+	+	+

Dunlin	*Calidris alpina*	M	+				+		
Broad-billed Sandpiper	*Limicola falcinellus*	M	+			+	+		
Laridae									
Heuglin's Gull	*Larus heuglini*	M					+		
Pallas's Gull	*Larus ichthyaetus*	M	+				+		
Brown-headed Gull	*Chroicocephalus brunnicephalus*	M	+	+	+	+	+	+	+
Black-headed Gull	*Chroicococephalus ridibundus*	M	+		+	+	+	+	+
Slender-billed Gull	*Chroicocephalus genei*	M	+			+	+		
Gull-billed Tern	*Gelochelidon nilotica*	M	+	+	+	+	+	+	+
Caspian Tern	*Hydroprogne caspia*	M	+		+	+	+	+	
Common Tern	*Sterna hirundo*	M					+		
River Tern	*Sterna aurantia*	M	+		+				
Little Tern	*Sternula albifrons*	M	+				+		
Whiskered Tern	*Chlidonias hybrida*	M	+	+	+	+	+	+	+
Alcedinidae									
White-throated Kingfisher	*Halcyon smyrnensis*	R	+	+	+	+	+		+
Common Kingfisher	*Alcedo atthis*	R	+	+	+	+	+		
Black Capped Kingfisher	*Halcyon pileata*	R					+		

Abbreviations

R/M = Resident / Migratory, BPS = Bhandup pumping station, BEL = Belpada, NRI = Non-residential Indian Complex, TSC = Training Ship Chanakya, TC = Thane Creek, SEW = Sewri, NS = Nhava-Sheva