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Increase in fish catch after the cyclone *Phailin* in the northern Bay of Bengal lying adjacent to West Bengal coast – A case study

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The present paper reports an enhancement in fish catch in the northern Bay of Bengal lying adjacent to West Bengal coast after the occurrence of the cyclone *Phailin* on the 12th October, 2013. MODIS L3 monthly composite data for both chlorophyll and SST of two consecutive years 2012 and 2013 were investigated to see the aftereffects of cyclone on these two parameters. Generally, during a cyclone vertical mixing of the water column uplifts nutrients to mixed layer depth that results in the increase in chlorophyll-a and decrease in sea surface temperature (SST). In this study a substantial increase in mean chlorophyll was observed in October, 2013 in comparison to 2012 (no severe cyclone was reported in Orissa-West Bengal coast). However, no significant change in SST was observed. Mean chlorophyll concentration in October 2012 was 3.12 ± 1.97 mg m^{-3}, however, in October, 2013 it increased to 4.50 ± 2.09 mg m^{-3}. Following this event, a huge increase in fish catch and Catch Per Unit Effort (CPUE) were also observed. Mean CPUE in October 2012 and 2013 was observed as 9.04 ± 4.70 and 18.63 ± 11.54 respectively. This increase in CPUE after cyclone *Phailin* might be due to enhanced productivity.

[**Keywords:** *Phailin*, Chlorophyll, SST, CPUE]

Introduction

Ecologically, fisheries yield is used as one of the important indicators of the marine productivity. Fisheries data is also used for describing the climate related changes in the marine ecosystems[1]. Bay of Bengal is a semi enclosed tropical marine basin in the northern part of the Indian Ocean which is known to be very cyclone prone[2]. About 5% of all the global tropical cyclones occur in the Bay of Bengal[3]. In the northern part of the Bay of Bengal, the bathymetric depth in the continental shelf areas is very low[4,5]. Moreover, the funnel shaped confluence of the northern end of the Bay of Bengal amplifies the wave height and facilitates severe storm surges. Frequent occurrence of the cyclones and their impacts on Bay of Bengal is mainly found during the southwest and northeast monsoon periods.

Bay of Bengal has experienced almost 12 cyclones and 27 tropical storms in the last decade. Last one was a cyclone named *Phailin* which developed over the north of Andaman and Nicobar Islands on the 9th October 2013. After that, the eye of cyclone propagated towards the north to northwest and made landfall at Gopalpur coast of south Odisha on 12th October 2013. Cyclone *Phailin* was equivalent to a category-5 hurricane on the Saffir–Simpson hurricane wind scale (SSHWS). Although the cyclone sustained for four days in Gopalpur coast, the after effects were found to persist for the next two weeks in the West Bengal coast[6,7].

As a consequence of cyclones, the surface water chlorophyll is sometimes found to increase which in turn alters the productivity and leads to enhancement of the fishery resources. Generally strong cyclonic wind mixes the surface layer up-to greater depths. It uplift nutrients to the mixed layer depth that results in increase in Chlorophyll and decrease in sea surface temperature (SST)[6].

Based on the above mentioned hypothesis, the present study was conducted with an intention to see whether there was any significant change in the SST or Chlorophyll in the surface waters of northern Bay of Bengal lying adjacent to West Bengal coast during the post-*Phailin* phase.

Moreover, the present study also looked at the fish catch per unit effort (CPUE) in this region and compared the data with previous year's catch so as to find out the effect of this super cyclone on the availability of fishes.

Materials and Method

Ground fish catch data of the respective days in both the years were acquired directly from the fishermen who regularly went for fishing during that time period. In order to accomplish this tedious task, five fishing boats were hired. They conducted random fishing as they usually do throughout the stretch of the northern Bay of Bengal lying adjacent to the coastline of West Bengal. The time duration of hauling, number of fishes caught and their corresponding weights were measured on-board to calculate the CPUE. Apart from the total CPUE, the CPUE of Hilsa was calculated separately. CPUE is a measure frequently used in the fisheries sector, which denotes the efficiency of fishing in a particular area at a particular time. All the data were collected from six cylinder mechanized boats which operated the gill nets of mesh size 90 – 95 mm as per the standard protocol laid by Government of West Bengal, India[8]. In order to standardize the CPUE computation the time of fishing was fixed for all the boats. Only the fish catch data between 800 hours and 1600 hours were considered for this study. All the boats were equipped with GPS by means of which their fishing locations were recorded. The CPUE was calculated dividing the total fish catch by the total hour of hauling for respective boats.

The sea surface chlorophyll and temperature in the present study area was obtained by implementing remote sensing tools. The data for the above mentioned parameters were obtained for the month of October, November and December in the year 2013 (i.e. when *Phailin* took place) and in the preceding year 2012 (in order to compare the situation that prevails under normal circumstances, i.e. under no cyclonic disturbance). MODIS L3 SMI (Standard Mapped Image) monthly composite data of 2012 and 2013 for both the chlorophyll and SST were downloaded from OceanColor website[9]. The data sets were then re-projected to UTM WGS 84. These re-projected data were subset with a spatial extent of 20º 40′ N to 21º 30′ N latitude and 87º 20′ E to 89º 00 E longitude.

A paired samples Student's t-test was performed to test any difference in mean of CPUE, SST and chlorophyll variability between both the years studied. All statistical analysis was conducted using SPSS version 13.0.

Results and Discussion

The monthly mean SST and chlorophyll data obtained from the satellite imagery depicted different trends (for the month of October and November) in the years 2012 and 2013. In the year 2012, during the months of October to December, no severe cyclone was reported in the Orissa-West Bengal coast[10]. It has been previously discussed that SST under general circumstances decrease due to the effect of a cyclone[6], however, no significant decrease in SST was observed post cyclone *Phailin* period. A mean sea surface temperature decrease of only 0.11ºC was observed in October, 2013 as compared to that of October, 2012 (Fig. 1), however, the decrease was not statistically significant. Unlike other conservative parameters, SST under normal circumstances does not show a sustained change from equilibrium in monthly scale. However, due to cloud intervention most of the MODIS derived daily data was not regularly available in this study area. Should there be any drastic change due to the aftereffect of cyclone on SST, it is most likely to be observed in the proximal days just after the cyclone passes by.

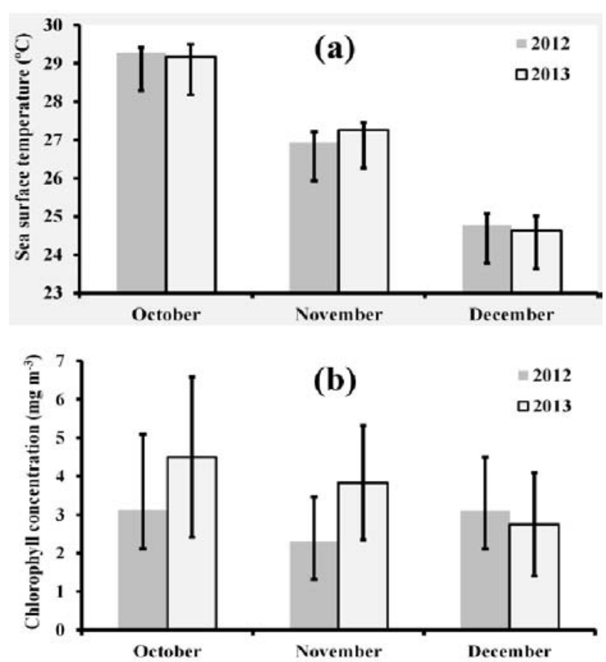

Fig. 1—Monthly mean (a) SST and (b) chlorophyll concentration for the months of October, November and December in both the years 2012 and 2013. The error bars denoting the standard deviation.

Table 1—The range of monthly composite Chlorophyll (mg m^{-3}) and SST (ºC) values obtained from MODIS Aqua L3 data in the present study area for the two consecutive years - 2012 and 2013

Month	2012				2013			
	Chlorophyll		SST		Chlorophyll		SST	
	Min	Max	Min	Max	Min	Max	Min	Max
January	0.28	4.17	21.85	24.24	0.22	5.05	21.51	24.95
February	0.17	4.74	23.29	25.05	0.23	4.86	23.22	25.30
March	-	-	26.37	27.01	0.16	4.01	26.46	27.57
April	0.56	3.31	27.96	29.06	0.17	3.68	28.19	29.05
May	-	-	28.48	29.61	-	-	27.47	29.08
June	-	-	28.32	32.25	-	-	28.80	31.61
July	-	-	28.01	31.23	0.16	3.32	27.45	31.44
August	0.28	3.44	27.99	31.34	0.41	3.59	28.84	30.96
September	0.20	5.64	28.03	31.61	0.87	6.33	29.21	31.75
October	0.19	6.63	28.92	30.31	0.22	9.35	28.18	31.36
November	0.29	5.15	24.97	27.48	0.40	7.72	26.55	28.29
December	0.24	6.34	23.93	25.45	0.46	5.45	23.10	27.06

Hence these minute changes in diurnal scale could not be addressed from the monthly composite mean observation. On the contrary, the chlorophyll concentration was found to have increased by a substantial margin when compared to previous year's data. In the month of October, 2012 the mean chlorophyll concentration was 3.12 ± 1.97 mg m^{-3}, however, in October, 2013 it increased to 4.50 ± 2.09 mg m^{-3}. The increase in the monthly mean chlorophyll concentration was statistically significant (paired sample Student's t-test shows $t = 20.71$, $p < 0.05$). Maximum and minimum chlorophyll concentration in the month of October, 2012 was observed to be 6.63 mg m^{-3} and 0.19 mg m^{-3} respectively, which increased to 9.35 mg m^{-3} and 0.22 mg m^{-3} in October, 2013 (Table 1). Similar enhancement of chlorophyll concentration was also evident in the month of November as well. In November, 2012 the mean chlorophyll concentration was 2.31 ± 1.15 mg m^{-3}, while in November, 2013 it increased to 3.83 ± 1.49 mg m^{-3}. In order to see the temporal extent of this cyclone induced changes, the month of December was also studied for the two consecutive years. In the month of December, the scenario got reversed, i.e. the chlorophyll concentration in 2013 became lower than that observed in December, 2012. This implies that the aftereffects of *Phailin* which took place in the mid of October' 2013 dissipated by the beginning of December, 2013.

The daily fish catch for the months of October and November in both the years 2012 and 2013 were acquired and accordingly the CPUE for total fish catch and Hilsa fishes were computed. In the year 2012, the average CPUE (total fish catch) for the above mentioned months was 9.04 ± 4.70. The average CPUE for Hilsa during that phase was recorded to be 3.20 ± 2.73. However, in the year 2013, the average CPUE (total fish catch) during the same period increased to 18.63 ± 11.54 (paired sample Student's t-test; $t = 5.95$, $p < 0.01$), whereas, for Hilsa it went up to 10.24 ± 7.08 (paired sample Student's t-test; $t = 7.60$, $p < 0.01$). This enhanced fish catch in the post-*Phailin* phase coincided with the increase in surface chlorophyll content (Fig. 2).

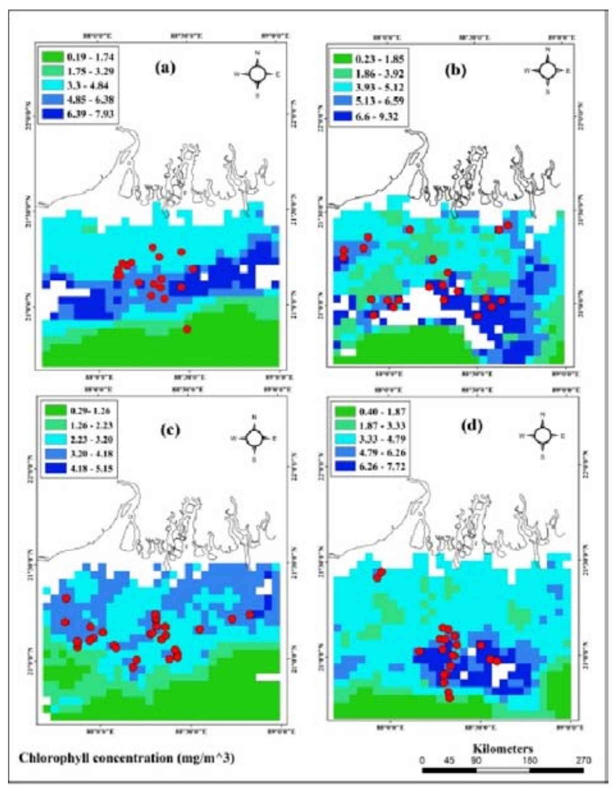

Fig. 2—The plots of high fish catch locations along with the spatial extent of chlorophyll variability for the months of (a) October' 2012 (b) October' 2013 (c) November' 2012 (d) November' 2013.

The enhanced productivity (by means of increased abundance of chlorophyll) might have resulted in the sudden hike in the fish catch. In the year 2013, prior to the occurrence of *Phailin*, the average CPUE for total fish catch was 5.96 ± 3.67, which increased to 23.04 ± 9.96. The same trend was also observed for the Hilsa fishes. The trend of CPUE for total fish catch and Hilsa fish catch has been portrayed in Fig. 3. Before *Phailin*, the Hilsa CPUE was 3.77 ± 2.78, however, in the post-*Phailin* phase it became 12.48 ± 6.73. Along with Hilsa, high catch of Sardine was also observed during the post-cyclone phase. Incidentally, these two fishes belong to the same Clupeid family.

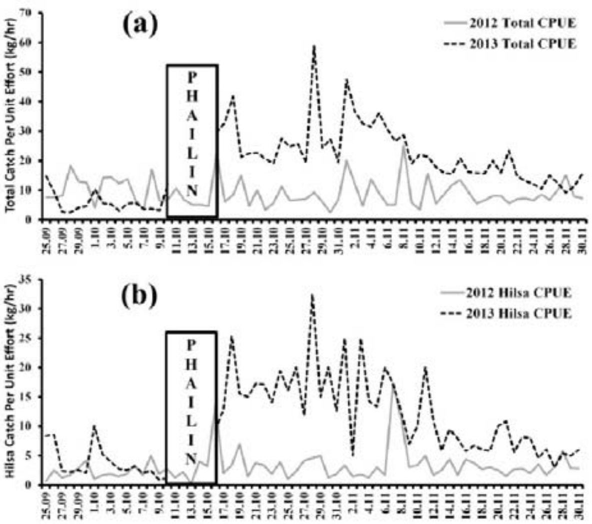

Fig. 3—The trend of (a) total CPUE and (b) Hilsa CPUE before and after the cyclone *Phailin* in the year 2013 along with the corresponding CPUE of the same time period in the year 2012.

It can thus be concluded that occurrences of cyclonic events indirectly lead to temporary high productivity zones in the open sea regime, which in turn lead to an enhancement in the fish catch. Particularly noted was the increase of the fishes belonging to Clupeid family in the fish catch suggesting a probable inter-relationship between these fishes and the cyclonic phenomenon, which can be studied with more emphasis.

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