Observation of Current Pattern Using Acoustic Doppler Profiler Vs Recording Current Meter at Ennore Tamil Nadu, India

M. Manikandan *1 R. Venkatachalapathy*2
Research Scholar*1, Professor*2
C.A.S in Marine Biology
Faculty of Marine Sciences,
Annamalai University, Parangipettai 608 502, India

ABSTRACT: Coastal regions are well known for their dynamic flow and they are influenced by water current along the shore, and especially, port regions highly depend on physical oceanographic parameters. The present investigation is aimed to record the field observations and validation of southwest monsoon current pattern at Ennore, Chennai using bottom tracking profilers of Acoustic Doppler Profiler (ADP) and Recording Current Meter (RCM). The results clearly indicated that south side of Nettukuppam recorded the average current speed 50.64 cm/s. On the other hand, north side of Kattupalli recorded the average current speed 15.99 cm/s. This variation could be the effect of bathymetry and ship movements-induced water current at Ennore. South side of the port depth varied up to 13 m, but on the north side of the port, there is only a 6 m variation, which may highly influence the changes in the current pattern. On observation part, from the 5m depth data that was examined, ADP vs RCM clearly indicated the same current movement towards north direction. RCM provides a more consistent result with the ADP high-performance 3-axis (3D) water current profiler. In the present study, we observed and analyzed directional measurements obtained from ADP and RCM. However, future works may evaluate and compare meso-scale and sub-meso-scale processes using the ADP and RCM data, which will provide much more significant information.

***Index Terms* -** Ennore, ADP, RCM, Current, Validation

I. INTRODUCTION

Generally, coastal process is highly influenced by the physical oceanographic parameters, especially around the port regions, tides, waves and currents are the three major phenomena which maintain the stability of port and also the coastal belt (Baer, 1981). Worldwide, many of the observational studies on physical oceanography have reported and documented the processes of tides, waves and currents (Amol et al., 2012; Joshi et al., 2016; Mukhopadhyay et al., 2017; Chatterjee et al., 2013). Ocean current is the important parameter which highly depends on the coastal geography. Among the oceanographic parameters, coastal water currents are highly influenced by changing shoreline and it's evident that it also changes seasonally (Albert and Jorge, 1998; Shankar et al., 2002). Once a coastal area is changed or modified, it eventually leads to changes in the current pattern along the shore. This will automatically change the erosion and accretion along the coast, resulted with the coastal ecosystem alteration. Based on the tides, waves and currents observations, many of the application oriented studies have been reported on shoreline changes, sediment transport, turbidity, long shore currents and its dynamics (Guerra and Thomson, 2017). Recently emerged trends provide advance instruments and techniques for quantifying oceanographic parameters as 3 dimensional, layered and its influence on coastal regions in detailed manner. However, cost, safety and installation are the major concerns while using advanced instruments.

Using advanced instruments in port, bays, seas, and oceans has been reported with the ADP/ADCP, RCM, altimeter and glider to work on validations, meso-scale dynamics, underwater glider, particle tracking, suspended sediment investigation, hydrodynamic modelling, sediment transport, erosion and accretion (Shetye, 1999; Rudnick et al., 2004; Vethamony et al., 2004; Kankara et al., 2007; Bouffard et al., 2010; Kankara et al., 2011). Especially, in turbulence model, recent trends provide more knowledge with the upper-ocean turbulence and wave-breaking turbulence (Guerra and Thomson, 2017).

Port region needs high attention due to ship movements and handling of cargos. This region should be monitored continuously for the purpose of economically important zone. It is very difficult to record continuously due to the different criteria such as, operational ease, cost effectiveness and safety of instruments. Among the different criteria, cost effectiveness plays an important role which indirectly states accuracy of the data. In order to reduce the cost, validation of the data will be helpful for altering the sources. Only a very few validation studies were reported and those are focused with the high frequency radar data, OSCAR ocean current data with the ADCP (Emery, 2004; Cosoli et al., 2010; Robinson et al., 2001; Mukhopadhyay et al., 2017). Hence, in a different manner, the present study attempted to make an observation and validation between two different instruments - Acoustic Doppler Profiler (ADP) and Recording Current Meter (RCM). Real time current data has been collected at Ennore, Chennai during southwest monsoon. This paper will provide adequate knowledge on ADP and RCM data comparison during southwest monsoon current pattern.

II. STUDY AREA

The present observation was made during 2016 southwest monsoon at Ennore, Chennai. The study area Ennore is located 24 km away north of the Chennai. In order to investigate the current circulation pattern off the coast of Ennore, the acoustic doppler profiler (ADP) and recording current meter (RCM) were deployed in the northern and southern points of Kamarajar Port. The deployment of instrument in north location (Lat.13.292°N, Long. 80.363°E) was at Kattupalli and in south location (Lat. 13.240°N, Long. 80.354°E) was near Nettukuppam (Fig. 1). The distances between the deployments were nearly 6 km. The sites of deployment were 13m deep on the south and 6m deep on the north, considering the practical difficulties for watch and ward for the safety of the instruments. The observations were made for a period of 15 days, starting from 22/06/2016 to 07/07/2016.

III.MATERIALS AND METHODS

3.1 Acoustic Doppler Profiler (ADP)

SonTek ADP, a high-performance 3-axis (3D) water current profiler, was used to record the ocean current pattern along the study area. The ADP measures water current in all directions and velocity of water column was measured by ADP transducer with the projection of the 3D velocity onto the axis of the acoustic beam. The ADP samples (or "pings") were obtained as rapidly as possible over a user-specified averaging time and the mean 3D current profile was reported. The mean profile includes velocity and a variety of associated data. The ADP has been set up to measure 25m depth (each bin size 1 m), blanking distance will be 0.5 m and data collection has been done for every 10 minutes for 15 days at 13m depth, one on the south side and 6 m depth on the north side.

3.2 Recording Current Meter (Seaguard RCM)

The Seaguard RCM series is based on the Seaguard data logger platform and the ZPulse Doppler Current Sensor. Modern computer technology combined with advanced digital signal processing provides accurate and detailed measurements with almost unlimited resolution. Here, we have collected the data at 10-minute interval with all available parameters. From that, we have taken only speed and direction. The current measurement range will be 2.2 m and blanking will be 0.4 m horizontally. Seaguard RCM was deployed near I mooring on the north side at 5 m depth.

3.3 Validation

To validate the ADP data with the recording current meter (RCM) data, the north Kattupalli (Fig. 2) was selected based on the feasibility. RCM was deployed (Lat.13.292°N, Long. 80.363°E) near ADP site and measurement was taken for validation process.

IV.RESULT AND DISCUSSION

The present study successfully observed the current pattern along the Ennore during southwest monsoon period 2016 and the results clearly indicate that south side of Nettukuppam recorded average current speed 50.64 cm/s. North side of Kattupalli recorded average current speed 15.99 cm/s. The observed current speed and direction were measured up to 13m from the bottom at every 1m interval of depth and the current direction was in inconsistent diurnal direction during the measured period as the instrument was deployed near breakwater mouth at Nettukuppam. During the observation, the maximum of current speed recorded was 222.80 cm/s, 3m from bottom current and minimum was observed in the surface as 0.1 cm/s at the south side of Nettukuppam region (Fig. 3 & 4).

On the north side of Kattupalli, ADP observation on the current speed and direction were measured up to 6m from the bottom at every 1m depth and the current direction was towards north due to breakwater intrusion. From the observations, rose diagram clearly portrayed that maximum current speed recorded with surface was 60.3 cm/s and minimum was 0.1 cm/s at 2m from the bottom (Fig. 5). During the observation period, the direction was changing from bottom 6m to 2m towards north and the surface water was changing the direction from the north to northeast because it was diffracted by another port breakwater.

The current speed on north side of Kattupalli was less (15.99 cm s^{-1}) compared to south side of Nettukuppam due to bathymetric effect. The measurement showed that the movement of southwest monsoon water is towards north and if there is any obstruction, its aligning direction depends upon influencing factors such as, shoreline, port construction and ship movement. During the observational period, the current flow from the south to north and the same during NE monsoon, the current flow will be towards south. Hence the littoral sediment movement was a little high during the monsoon period.

Based on the depth variations between two sites, the validation studies were only considered for 5m deep and results indicate that both instruments show that the current movement was towards North direction at 5m depth (Fig. 6). To support our present investigation, the Chennai coastal water current during southwest monsoon was reported to be 17 cm/s (Kankara et al., 2011), but our study showed south and north average speed as 50.64 and 15.99 respectively. This indicates that the variation was due to the port activities caused by ships-generated water movements in this region.

Even though studies on validation of the ADP with different data have been reported widely, studies with the ADP and RCM were very scarce. In the case of ADCP, data with the radar measurements showed that 3° directional differences and 0.93

root mean square values (Robinson et al., 2013). High Frequency radars showed the root mean square differences of radial currents in the range of 8.7–14.7 cm s^{-1}. Angular offsets ranged between +6° and +11° (Cosoli et al., 2013).

In contrast, there was no significance found with radar data and noise levels corresponding to 6 cm s^{-1} root mean square were evident in the radar data. Error was found in 10 out of 18 comparisons, with changing magnitude of 5°–10°, and a maximum of 19°. The overall error showed up to 15% in computed flow speeds, and up to ~9° errors in flow directions with the speed differences of 7–19 cm s^{-1} (Emery et al., 2004). Likewise, the present study also found the differences between the ADP vs RCM and overall root mean square value showed below 0.35 among the direction and speed differences. This could be the result of noise levels corresponding to the ship movement in the study area and depth playing major role in changing above parameters with the instruments.

In the present study, we analyzed the observed data and validated between ADP and RCM directional measurements. However, future works could be evaluated and meso-scale and sub-meso-scale processes using the ADP and RCM data could be compared, which will provide much more details.

V.ACKNOWLEDGEMENT

This study was undertaken as part of in-house research on “Assessment of Cumulative Coastal Environmental 359 Impacts [ACCES]” (# IR 12003) of NCSCM. The authors acknowledge the financial support of the Ministry of Environment, Forest and Climate Change, Government of India, under the World Bank India ICZM Project

Figure. 1 - ADP deployment location at Ennore North and South location

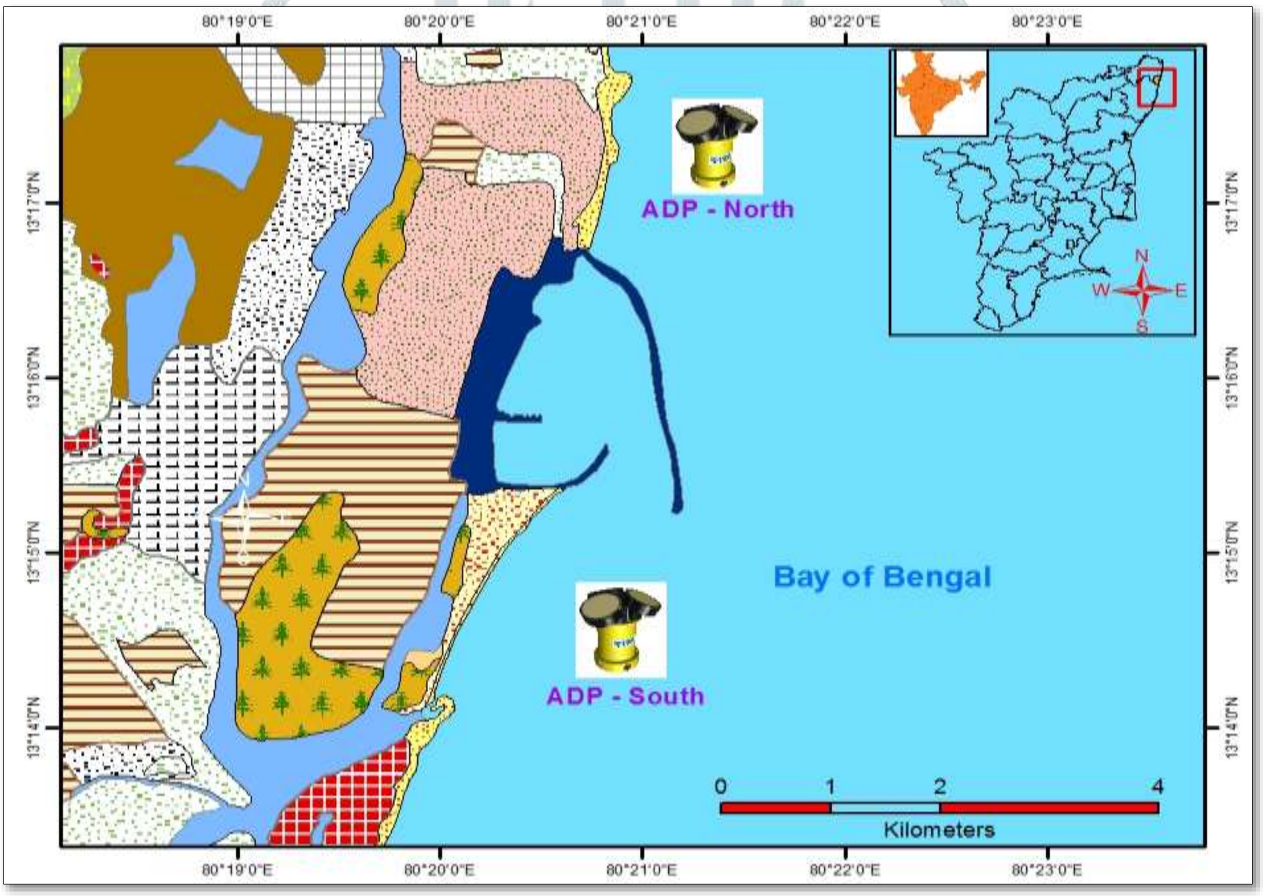

Figure. 2 - Validation of ADP and RCM location at North Kattupalli

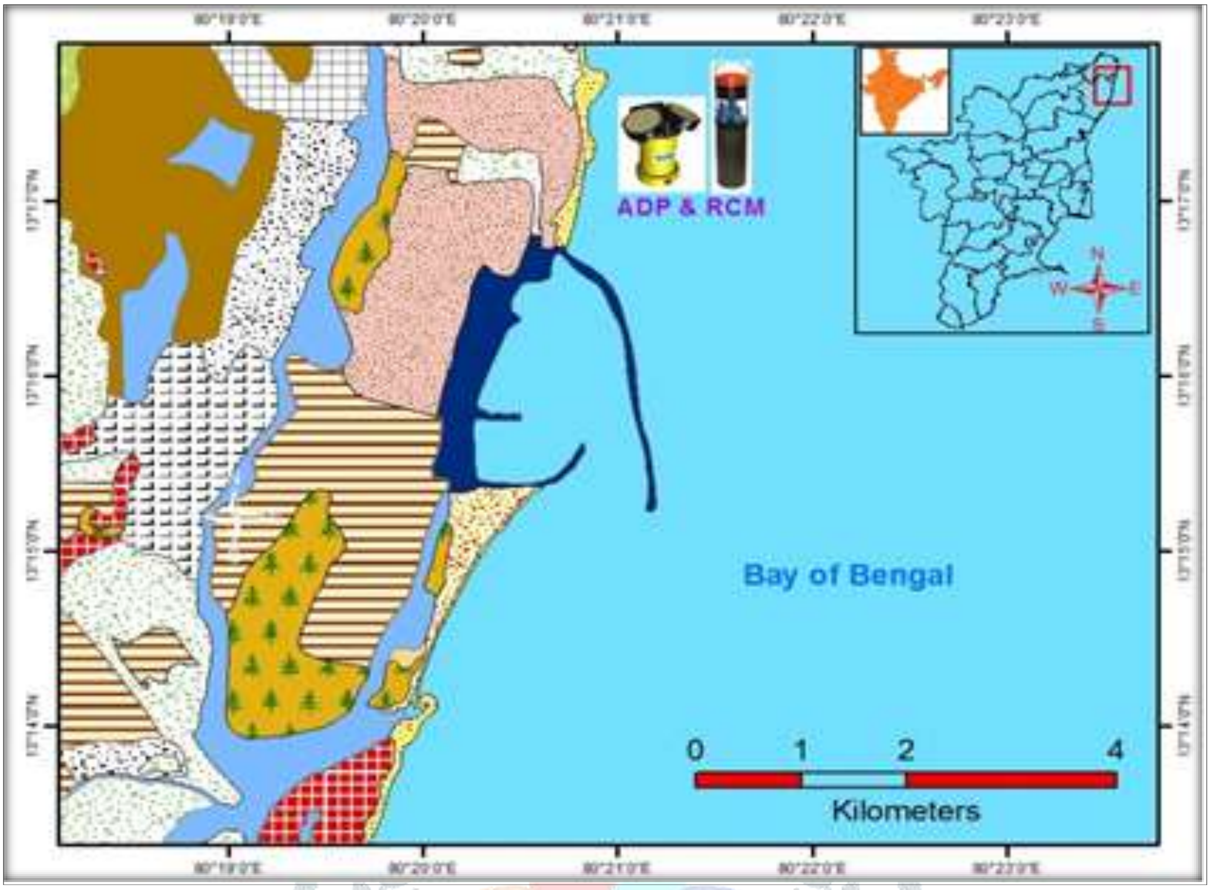

Figure. 3 - Rose plot for Ennore South - Current Speed and Direction

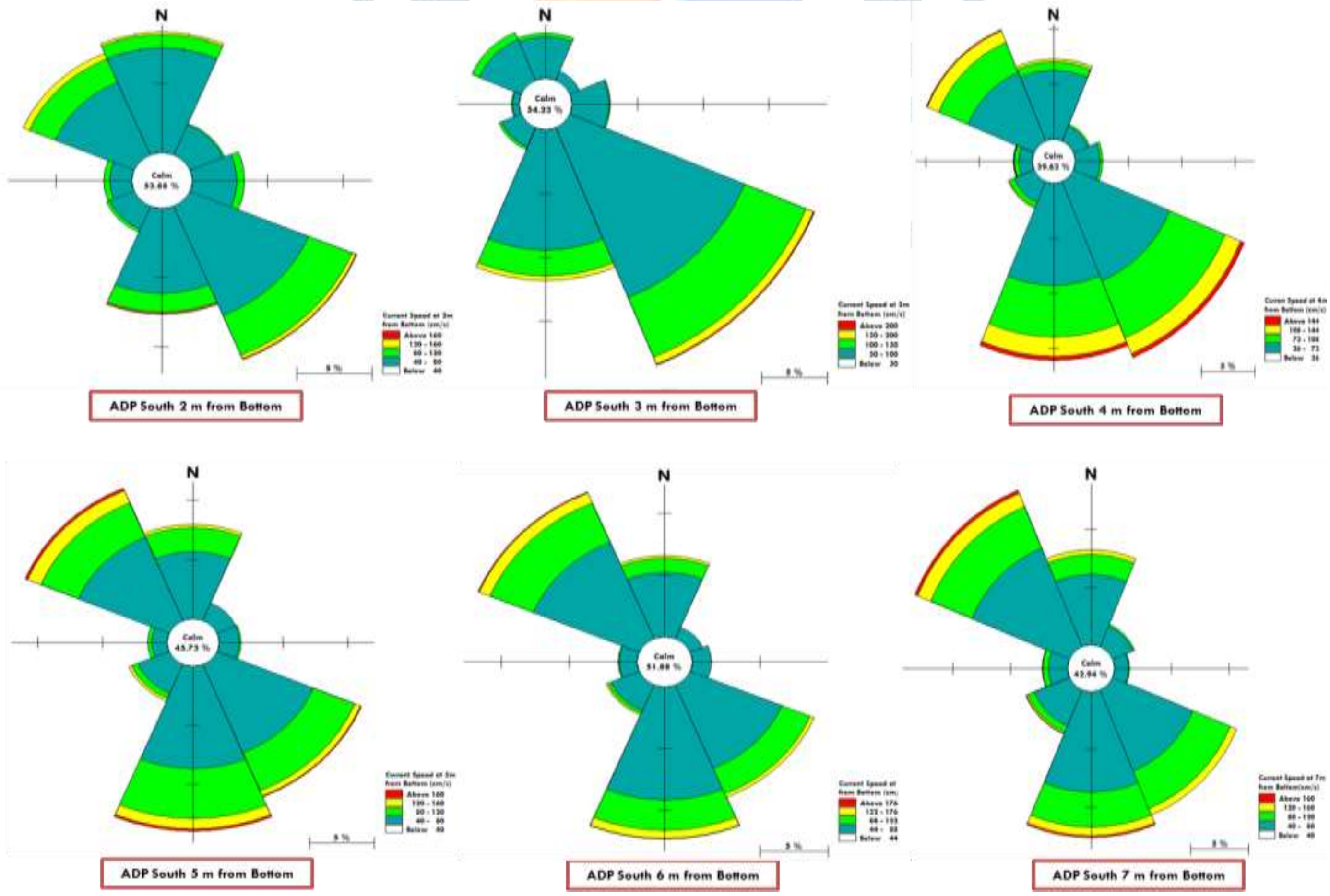

Figure. 4 - Rose plot for Ennore South - Current Speed and Direction

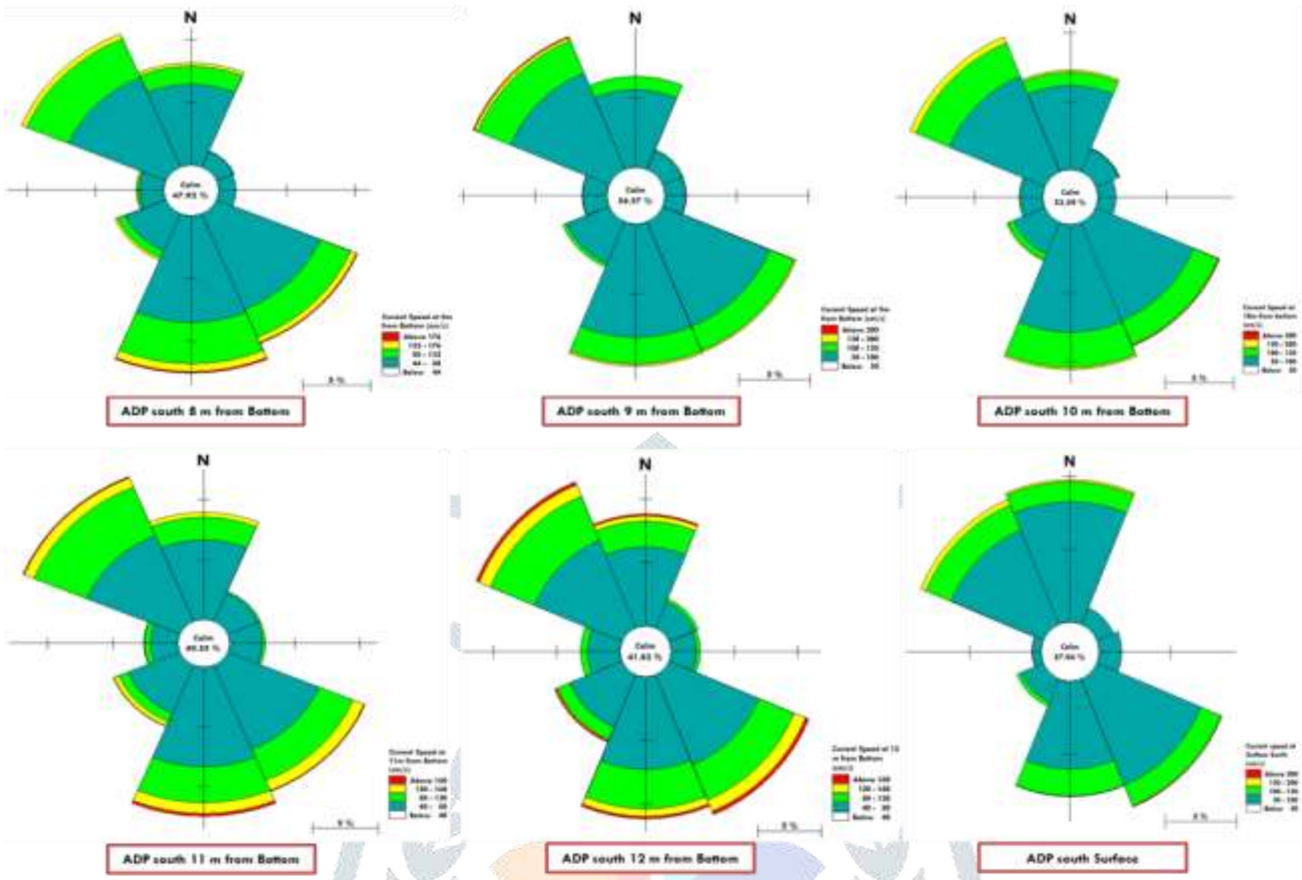

Figure. 5 - Rose plot for Ennore North - Current Speed and Direction

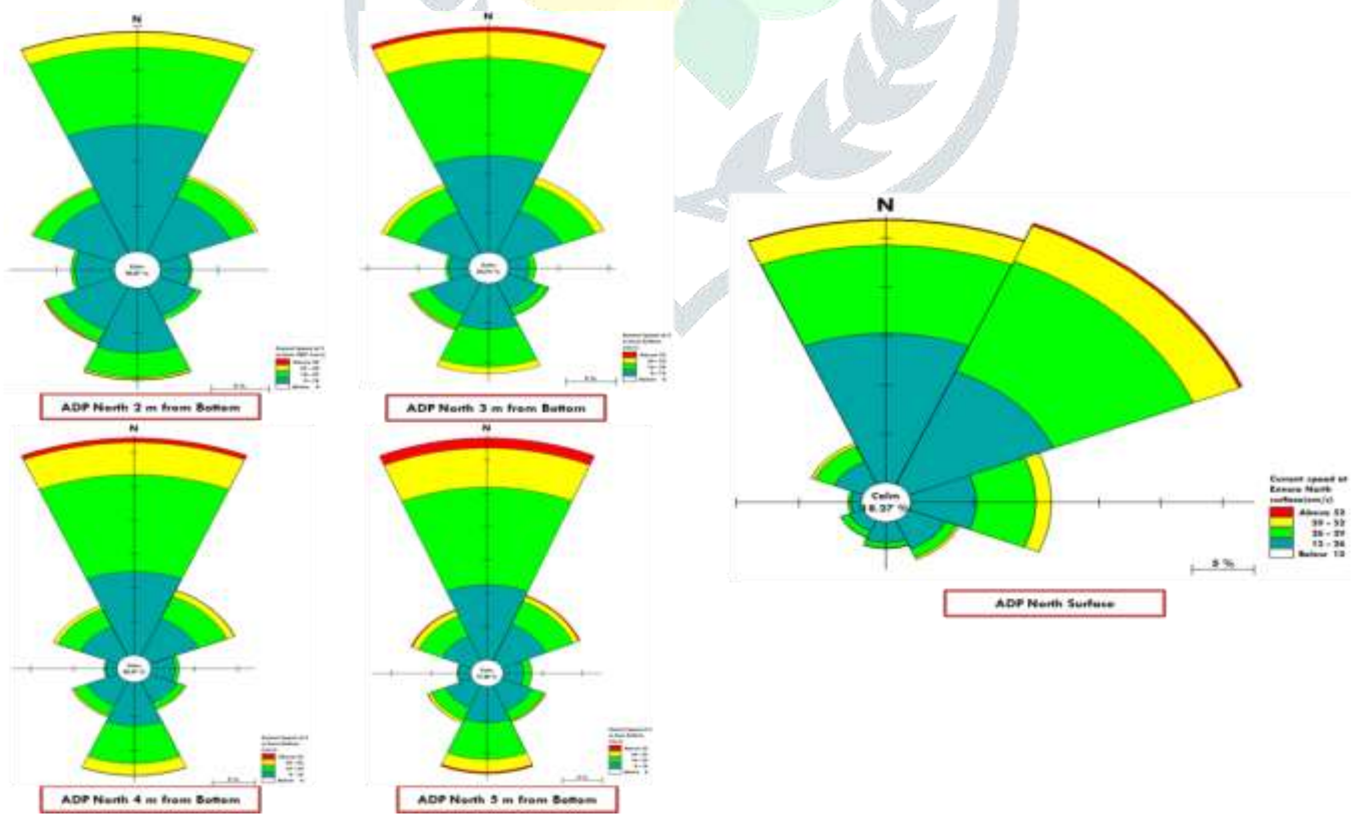

Figure. 6 - Validation of current movement at Ennore north Kattupalli

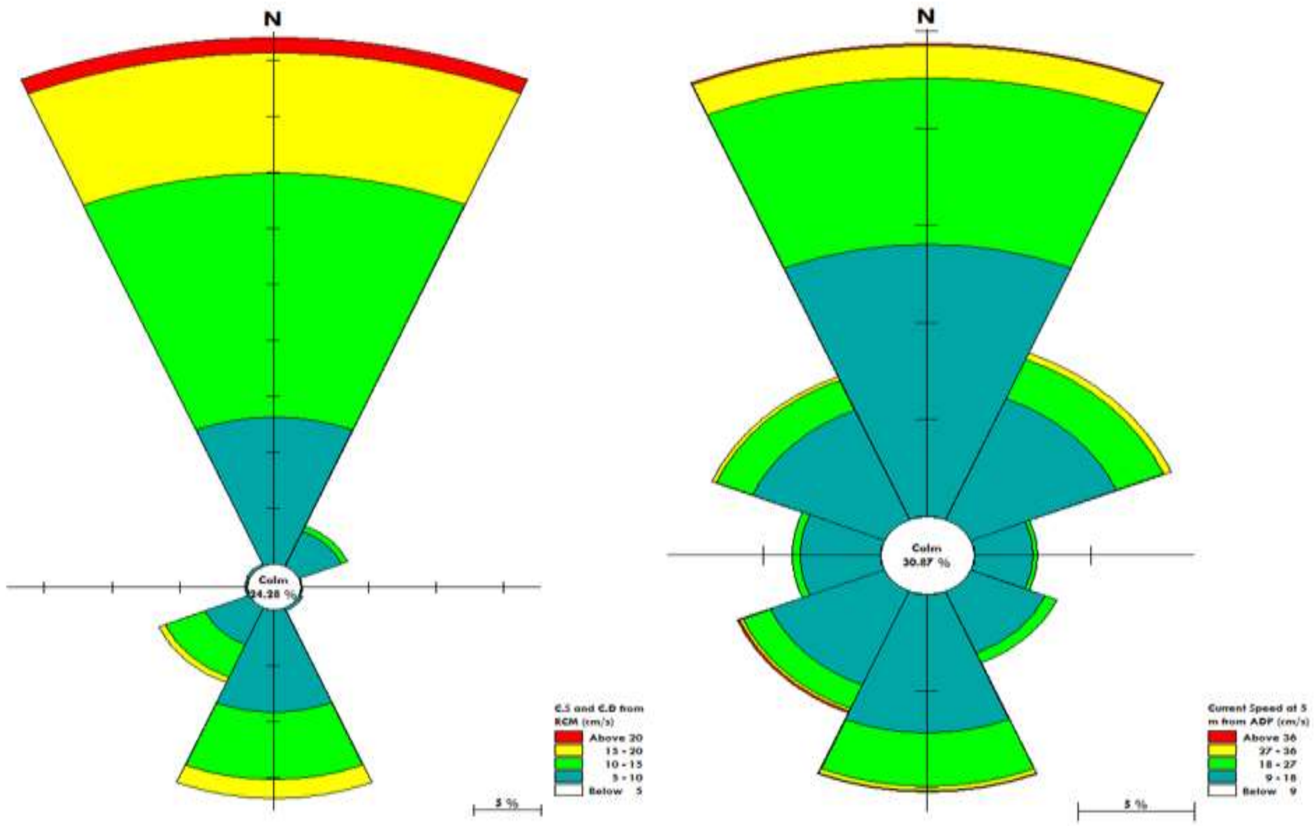

Table. 1. Current speed minimum, Maximum and Average on Each depth profile

Location-ADP South					
S.No	**Depth**	**Avg Speed (cm)**	**Minimum (cm)**	**Maximum (cm)**	**Remarks**
1	**2m from Bottom**	42.47	0.60	180.30	Because of the ship movements some times maximum current speed was observed
2	**3m from Bottom**	52.86	0.60	222.80	
3	**4m from Bottom**	49.72	1.30	177.30	
4	**5m from Bottom**	50.16	1.10	193.70	
5	**6m from Bottom**	49.5	0.4	200.3	
6	**7m from Bottom**	51.26	1.1	194.1	
7	**8m from Bottom**	51.61	0.7	200.7	
8	**9m from Bottom**	51.68	0.9	204.8	
9	**10mfrom Bottom**	53.41	0.2	202.2	
10	**11m from Bottom**	52.33	0.4	191.5	
11	**12m from Bottom**	52.98	0.1	197.7	
12	**Surface**	49.69	0.1	202.1	

ADP Ennore port North					
1	**2m from Bottom**	12.97	0.1	41.3	Because of the lower depth current speed was less compare to south
2	**3m from Bottom**	13.56	0.6	37.3	
3	**4m from Bottom**	14.46	0.4	39.7	
4	**5m from Bottom**	15.4	0.2	37.9	
5	**Surface**	23.6	0.4	60.3	

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