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Evaluation of Temperature, Salinity and Bathymetry in the Indus Delta Creek System

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Abstract: The Indus River Delta is ranked the fifth largest in the world, and is located at the periphery of the Indus River determining 563 km of the entire coast of Sindh. This delta plays animportant role in enhancing the economic, environmental and ecological welfare of the people in this region. This delta constitutes seventeen main creeks. It forms a remarkably uniform landform with large extensive mud flats being intervened by narrow creeks, which are remains of old Indus tributaries.The ecosystem of Indus Delta is characterized by having rich nutrients which offer a nursery as well as an early feeding ground for many varieties of shrimps and fish as well. This study provides the baseline information about temperature, salinity and bathymetry in different creeks of Indus delta.Out of 17 creeks, 13 creeks were studied during the survey period. In the study area, temperature ranged from 14.5 ºC- 31.1 ºC in a year. The temperature difference is nearly constant in mid-May toward mid-September (29.60 ºC -31.10 ºC), except in the Chani Creek area, where it remained as 28 ºC- 29.4 ºC.During mid-September to November (Post Monsoon), the temperature was slightly lower than monsoon (23.2 ºC to 29.4 ºC). There is little effect of seasonal shift at the western creeks, Issaro, Waddi Khuddi, Patiani, Mal, Dabbo, Richhal, Chann, Chani and Hajamro as compared to eastern Creeks and Jhang River. During Monsoon, the highest salinity values (32.9 to 36.9 psu) have been recorded at Issaro and Waddi Khuddi Creeks. The sea temperature and salinity has greatly affected the otholith formation in fish species.

Keywords: Environmental parameters, Seawater quality,Indus Delta, Creeks, Sindh coast

1. INTRODUCTION

The Indus River Delta plays an important role in enhancing the economic, environmental and ecological welfare of the people in this region. Given its prominence especially towards the agrarian based economy of Pakistan, it remains a key area of interest for policymakers, academics and government bodies. At present, the water in the River Indus has been diverted upstream, pronouncing vulnerabilities for small-scale farmers. Further, only a fraction of water and most of the times no water is released to the Delta region.Indus River originates from the Mansarovar Lake in Tibet at preferment of about 5182 meters (Saleem *et al.,* 2014; Qureshi *et al.,* 2015). This delta constitutes seventeen main creeks. It forms a remarkably uniform landform with large extensive mud flats being intervened by narrow creeks, which are the remains of old Indus tributaries. The ecosystem of Indus Delta is characterized by having rich nutrients which offer a nursery as well as an early feeding ground for many species of shrimps and fish as well (Saleem *et al.,* 2014). This research paper provides thorough quantitative baseline information of the fauna and temperature, salinity and bathymetry, conducted during the period of 2013-2014 under the Fisheries Resources Appraisal in Pakistan project, which will serve as a critical resource guiding informed decision and policymaking.

2. MATERIALS AND METHODS

Although, there are more than 50 creeks along the coast of Sindh, this study has been focused on only thirteen big creeks constituting,1. Jhang Creek, 2. Issaro Creek, 3. Patiani Creek, 4. Mal Creek, 5. Dabbo Creek,6. Chan Creek, 7. Richhal Creek, 8. Waddi Khuddi Creek, 9. Chani Creek, 10.Hajamaro Creek, 11. WariCreek,12. Khar Creek, and 13. Khajar Creek. **(Table 1).**The hydrographic profiling of environmental parameters consists of temperature, salinity,pressure, conductivity and depth.All these parameters are used to analyze the seawater quality which is easily identified, and the overall environmental condition of water to sustain marine life. For this study, three major parameters including temperature, salinity and depth were selected.

Castaway CTDs (SonTeck, a xylem brand)were deployed on the bottom of each creek for a full 24 hours to measure the tidal range and timing in each study area relative to the tide station at Karachi**(Fig. 1).** The depth readings from the bottom were analyzed to determine maximum (high tide) and minimum (low tide) timing. All of the study sites were within 30 minutes of the times given for Karachi and no further adjustment was required

The Castaway-CTD is a small, rugged and technically advanced CTD designed for profiling to depths of up to 100m. The system incorporates moderntechnical features which allows it to achieve a 5 Hz response time, fine spatial resolution and high accuracy. It uses a six-electrode flow-through conductivity cell with zero external field coupled with a rapid response thermostat to attain high measurement accuracies. The instrument is simple to deploy, does not require a pump and is hydrodynamically designed to free fall rate of 1 m/s.

The integrated real-time data display screen, internal GPS sensor and automated wireless data transfer are unique features that simplify data collection with following specification:

- Salinity Accuracy: 0.1 PSU
- Temperature Accuracy: 0.05°C
- Small sizeIntegrated GPS position
- Real-time display screen
- Wireless data transfer
- 5 Hz sampling rate

Each CastAway-CTD cast is referenced with both time and location using its built-in GPS receiver. Latitude and longitude are acquired both before and after each profile. Plots of conductivity, temperature, salinity and sound speed versus depth can be viewed immediately on the CastAway's integrated color LCD screen in the field. Raw data can be easily downloaded via Bluetooth to a Windows computer for detailed analysis and /or export at any time. Survey was conducted every month during the period April 2013 to May 2014. Data on physical parameters were collected using the CastaWay CTD.

Fig.1. Castaway System Components

3. RESULT

Temperature

Temperature of the study area ranged between 14.5ºC-31.1ºC in a year **(Fig.2).**Temperature difference was virtually constant during May-September in all creeks (29.6ºC-31.1ºC) except in Chani Creek where it ranged between 28ºC-29. ºC, but slight variations at the entrance of Jhang River, Hajamro and Dabbo Creeks has been also observed where the temperature was slightly lower as compared to the rest of the creeks. This change might have been due to rains in monsoon season in May to September.

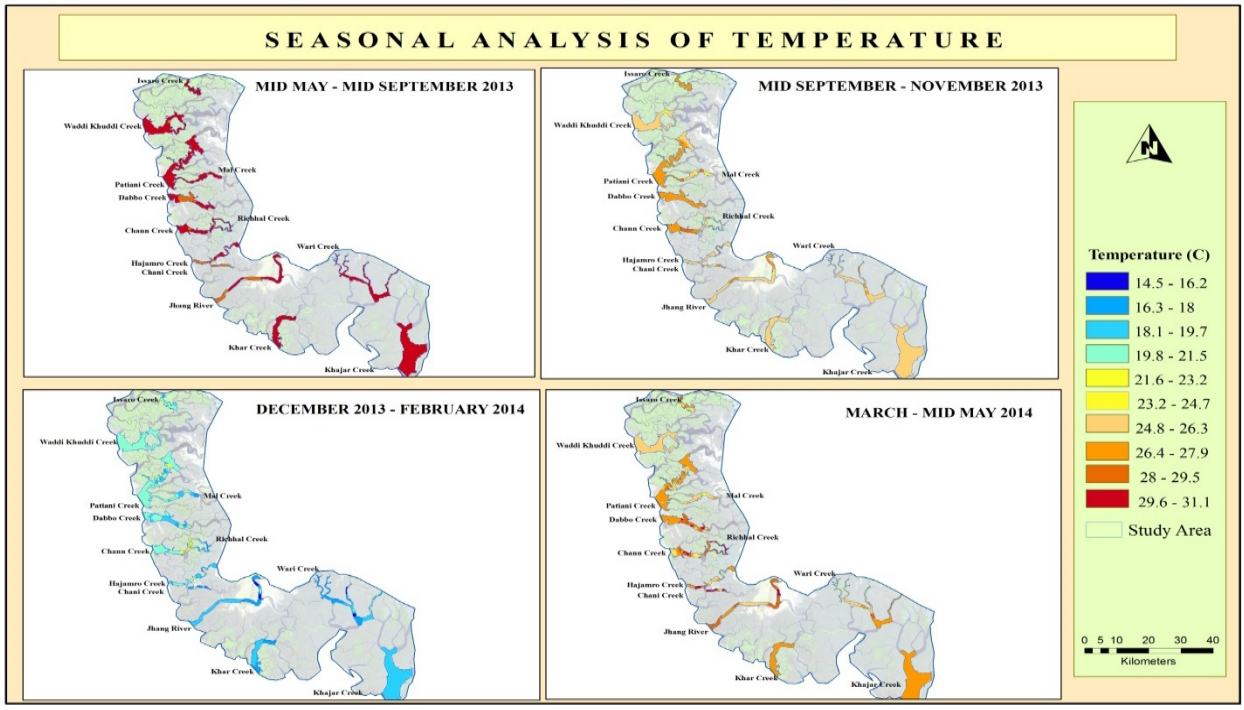

Fig. 2. Distribution of temperature in different creeks of study area

During this season constant temperature range has been observed in Issaro and Dabbo Creeks i.e. 26.4ºC to 27.9 ºC. While at Patiani and Chann Creeks the same range of temperature has been noticed but it slightly varies in the mid of Dabbo Creek, ranging from 28 ºC to 29.5ºC, and the North of Patiani Creek, ranging between 24.8 ºC to 26.3 ºC. The rest of the creeks at Waddi Khuddi, Mal, Richhal, Hajamro, Chani, Jhang, Khar, Khajar and Wari Creeks depicted the same range of temperatures between 23.3 ºC to 26.3 ºC.

The creeks on the west of Jhang River have shown moderate temperatures during winter whereas the Jhang River and the Creeks on the east have shown low temperature ranges comparatively. But overall the winter temperatures have been considered as moderate at the study area and these moderate temperatures are because of the warm and less dense sea water entering with the tide into the creeks. The recorded temperature ranges in creeks located on the west, Issaro, Waddi Khuddi, Patiani, Mal, Dabbo, Richhal, Hajamro and Chani Creeks were 18.1 ºC to 23.2 ºC. On the other hand the temperature ranged between 14.5 ºC to 18 ºC at Jhang River, Wari, Khar and Khajar Creeks.

Salinity

Fig.3,shows the seasonal change in salinity at the study area. During Monsoon the salinity remained significantly high at Issaro and Waddi Khuddi Creeks which range from 32.9 to 36.9 psu. Whereas at Patiani and Mal Creeks salinity during monsoon ranging from 28.8 to 32.8 psu and slightly higher in some parts of these two creeks ranging 32.9 to 36.9 psu. Salinity ranging from 28.8-32.8 psu at the mouths of Dabbo and Chann Creeks while the rest of the creeks including Richhal have shown a range from 24.8 to 28.7 psu, at the mouth Hajamro and Chani Creeks i.e ranging from 24.8 to 28.7 psu while at the rest of the creeks it has been ranging from 20.7 to 24.7 psu. Whereas Wari and Khar Creeks have also shown low levels i.e. ranging between 8.35 to 16.5 psu. Therefore, during Mid-September to November (Post monsoon) all the creeks on the west of Jhang River have shown salinity levels ranging between 32.9 to 36.9 psu and from 20.7 to 32.8 psu at the east of Jhang river i.e. Wari, Khar and Khajar Creeks. During the same season at Jhang River lowest level of salinity has been recorded at the north i.e. ranging from 0.176 to 4.26 psu and it continues varies till the mouth of Jhang River i.e. ranging from 32.9 to 36.9 psu. At Dabbo, Chann and Richhal Creeks different levels of salinity has been identified during these seasons i.e. ranging from 32.9 to 36.9 psu during February and March (winter) and 32.9 to 41 psu during March to Mid-May (Pre-Monsoon). A significant variation has been observed in salinity level of Jhang River during March to Mid-May as compared to all the seasons i.e. the complete River has shown high salinity level ranging from 32.9 to 36.9 psu. The high levels of salinity during this period may be associated to low or no rainfall in 2014 before and during these months which resulted in the high values of salinity. On the

other hand, salinity levels also increased during March to Mid-May in Wari and Khajar Creeks i.e. 41.1 to 45.5 psu **(Fig.3).**

4. DISCUSSION

It is well known that climate change has substantial impacts on many environmental variables that are related to fish production. Among them, effect on water temperature is significant and any change in water temperature can lead to equatorial under currents that has high oxygen concentration (Tsuchiya, 1981; and Agbesi, 2002). It is also stated that these currents mainly disturb dissolved oxygen and nutrients which ultimately affect the distribution of fish species (Agbesi 2002). Therefore, seasonal changes in the sea temperature and salinity of the study area have been analysed. In this analysis, overall large variation in the values of temperature and salinity has been identified during summer and winter seasons.However, these observations were close to those of theprevious studies that have been done on sea temperatures of tropical regions. For instance, (Espino *et al.*2014) explained that temperature range in tropical lagoons was 8 ºC to 32ºC depending on the seasons. Hence, during December to February low temperature ranges have been identified in the study area during present survey.Generally, temperature in the months of March and May was nearly the similar as in September to November. It means that it ranged from 24.8ºC to 29.5ºC excludingin Chani Creek area where at temperature was29.6ºC to 31.2ºC.Evidence to support this is available in another study of ADB and IUCN (2002). According to them, the temperature for the Indus Delta remained as 23.8 ºCand 28.7 ºC. This shows that the average temperature observed in the present study is slightly higher than their observations.

Another important variable that has a large impact on fish production is salinity. In the present study, sea temperature and salinity have greatly affected the otolith formation in fish species. Generally, little effect of seasonal shift at the western creeks, Issaro, Waddi Khuddi, Patiani, Mal, Dabbo, Richhal, Chann, Chani and Hajamro than the eastern Creeks and Jhang River was observed. A significant variation has been noted in salinity level of Jhang River during March to Mid-May as compared to all the seasons. This reveals that the complete River has shown high salinity level ranging from 32.9 to 36.9 psu. The high levels of salinity during this period may be associated to low or no rainfall in 2014 before and during these months which resulted in the high values of salinity (ADB and IUCN, 2002).

Ahmed *et al*,(2013) while studying on the post larval development of some marine shellfish species, suggested that salinity of 12-16 ppt is tolerable for post larval prawns for good survival keeping in view of the fact that these species are more sensitive to high saline waters and high temperatures (28-31ºC).Consequently, beyondthese limitsmayaffecttheir survival.. It is concluded from this study that water temperature and salinity that ranges from 27.3 ºC to 31.2 ºC and 10.7-41.1 psu, respectively, therefore, this is the suitable condition for the marine water species, selected in our study area.Akhtar, (1995; 2010) considered that, Indus delta and particularly our study area is the major breedingand nursery ground but overexploited for *Penaeus* sp and other species.The confinement of this species was only in the high mangrove cover area but their catch is very low than other species. The habitat specifically high mangrove cover area showed high abundance of fish stock which was analysed by GIS. Furthermore, mangroves also help to maintain salinity and temperature of the water besides providing nursery grounds.

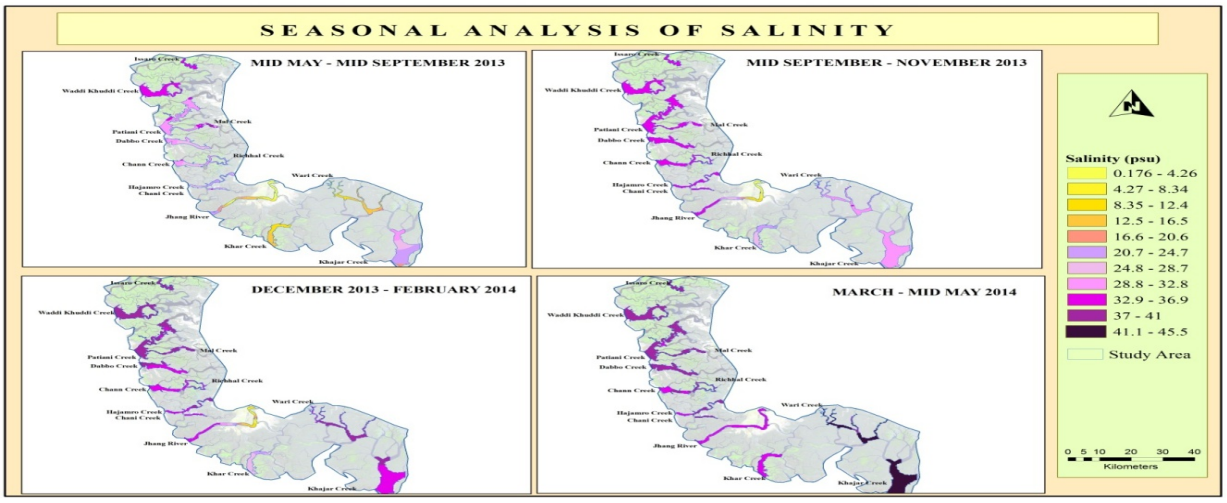

Fig. 3. Distribution of salinity in different creeks of study area

Bathymetry

Fig. 4 shows that sea water depth in the creeks is important to maintain the balance of aquatic life. Some species are sensitive to depth and found at particular depth ranges.The depth range at study area is -1.68 m to 85 m **(Fig.4)**.

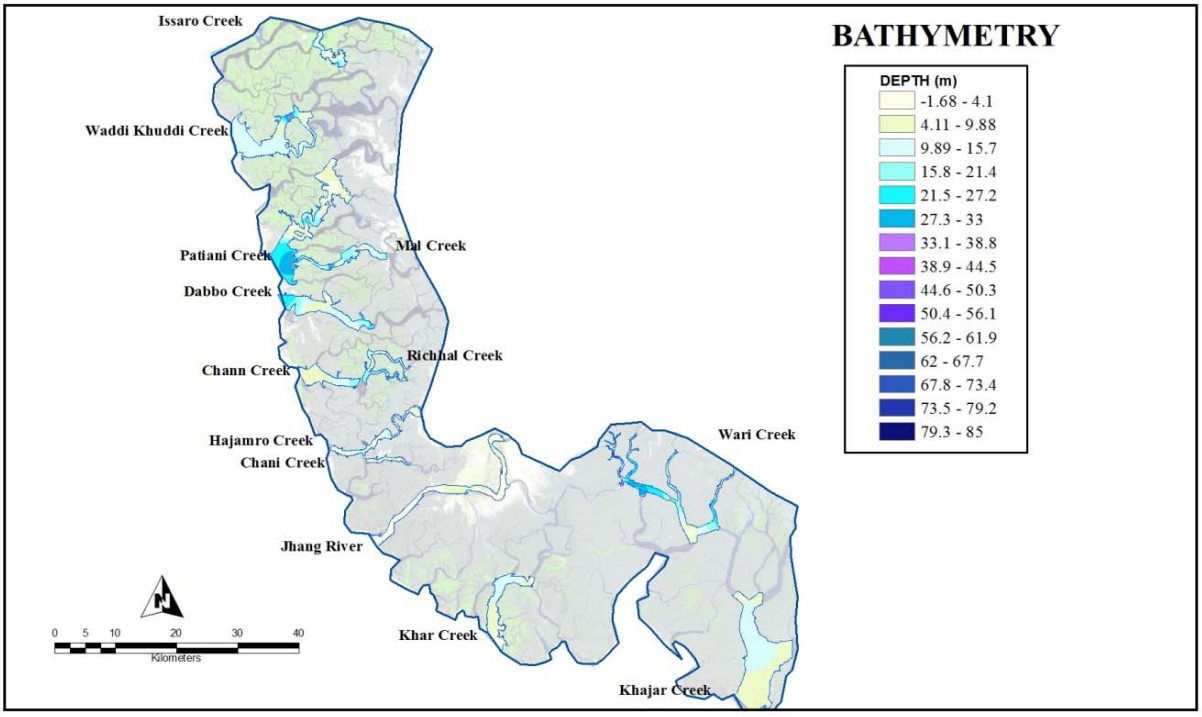

Fig.4. Analysis of bathymetry in different creeks of study area.

Table 1. Total area, distance from sea, length of survey area, proportion ofsurvey and number of stations for survey in each creek surveyed.

NAME	AREA (km2)	DIST_SEA (km)	LENGTH (km)	PROP	STNS
Chann Creek	20.7	1.04	6.65	26.50	10
Dabbo Creek	7.355	4.09	4.01	9.42	5
Hajamaro creek	2.208	1.64	2.26	2.83	3

ShahBandar 2	9.018	2.2	3.6	11.55	6
Shahbander	2.684	2.24	2.48	3.44	4
Kharak Creek	2.738	35.5	3.4	3.51	4
off Paittiani Creek	5.035	5.25	2.93	6.45	4
Rahppato	0.421	21.04	0.91	0.54	3
Richal Creek	0.236	6.55	1.08	0.30	3
River Indus Site	2.685	27.48	2.64	3.44	4
Upper Chann Creek	0.421	28.12	0.78	0.54	3
Upper Dabbo Creek	2.394	27.58	1.9	3.07	3
Upper Paittiani Creek	0.741	20.21	1.37	0.95	3
Waddi Khuddi Creek	20.541	7.56	6.01	26.30	10

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