Satellite Derived Sea surface temperature fronts in relation with Tuna catch In the EEZ of Pakistan

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***Abstract*- Sea surface temperature (SST) is an important parameter in marine ecosystem studies as its relations of Fishery and other marine resources. In this study SST fronts have also been studied with relate to tuna fish catch data of April and August 2014 was acquired. Satellite derived MODIS daily products have been used to derive thermal fronts in the exclusive economic zone (EEZ) of Pakistan. Research results indicated that the Sea surface temperature gradually changed from 22C to 24C where Tuna catch is high and By Catch is low in frontal region. The further Relationship between these two data are discussed in this study and also made recommendations for in what way these two datasets should be handled. Remote sensing data and GIS tools are efficient and less time consuming for mapping and classifying sea surface temperature in a broader way. Survey of fishing resources is really time consumed and costly, Satellite Remote sensing data shows a promising tool to monitor fishery resources in a cost effective manner. Satellite data play an important role to identify fish aggregation zones and these techniques could also be used to forecast potential fishing zones by measuring oceanic parameters which influence on fish distribution on a broader scale and these techniques can help to local fisherman and fishery organizations to observe fishery resources.**

Keywords: SST, Remote Sensing, GIS, EEZ, SST Fronts.

I. INTRODUCTION

One of the important variable for the assessment of the world climate is sea surface temperature (SST) [7]. SST is considered as one of the important variables by WMO (World Meteorological organization). For various application such as weather prediction, ocean estimating, climate research studies, marine fishery resources high quality of SST datasets are necessary. Sea surface temperature can be obtain with different sensors but these sensors do not provide a similar estimation of the SST because of each sensor type [1]. Sea surface temperature maps are important for commercial and fishing communities as well as provide critical information for gases between ocean and atmosphere [8]. In ocean, fronts are narrow zones of gradients of biological, chemical and physical properties [29]. Frontal zones are abundant in the marine water with spatial measures from 1 to 1000km [9]. Frontal regions are very dynamically active and its presence in location where large energy scale

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transfer to small scale is most strong. Such as upwelling process, water mass interleaving happening at frontal region that share to vertical exchange of ocean properties [29]. So high biological productivity present in frontal regions due to vertical fluxes of nutrients et al [11, 21]. Species Distribution identification and its relations to particular marine habitat features is important for marine conservation and efficient marine management [24]. So, Considerable attention needed at classifying marine biological hotspots and relation with ecologically significant zones et al [20, 27, 17]. Many Studies mentioned that Sea surface temperature (SST) fronts are vital habitat features that effect the distribution of pelagic species, marine ecologist have been interested in SST fronts because of productivity associated with Fronts [24]. Frontal regions are characterize by upwelling events, but change over a short time period. Upwelling event power will also impact the distribution of food resources [5]. So techniques of defining the locations of marine fish while considering SST coverage in these frontal areas would be a good utility. Because of the spatial range and dynamic environment of Upwelling areas, it is tough to map from ships because it do not allow ships to sample the whole point of interest within a specific time. In modern era different image processing techniques have been developed such as edge detection analysis and automated features extraction using SST imagery [14, 26, 4]. The visible and infrared spectrum of the satellite image has great potential to study fronts [15]. Satellite based remote sensing methods seems to be cost and time effective for examining the biological and physical relations between the fish species and their environment at temporal and high resolution datasets [13].

In National economy fishery plays an important contribution, marine fisheries sector provide a key role in contributing approx. 57% in terms of fish production. For local fisherman fishing provides an important source of income. Fishery provides economic benefits and sole source of employment to the community living along the coast. On the basis of repeated experiments and local knowledge, fishermen employ fishing. Due to the lack of information, fishermen face problems about the particular potential fishing grounds which in turns cause problems in terms of money, time and fishermen's incomes.

The prime objective of this research is to identify aggregated hotspots of fish resources by evaluating different environmental factors in EEZ of Pakistan. Remote sensing and GIS techniques in connection with the usage of GPS allow us to predict hotspots for fish catching by using ocean parameters, which primarily include sea surface temperature. However, this method is helpful in improving the fish yield.

I. Material And Methods

In this study, Pakistan Exclusive Economic Zone (EEZ) has been selected as shown in (Fig 1). The continental shelf area of Pakistan is about 50,270km2 [28] and coastline length of Pakistan is 1,050 km [16]. Coastline of Pakistan is separated into two states, one is Sindh coast and the other one is Baluchistan coast. Sindh coast is about 250km including Indus delta region and Karachi coast. Balochistan coastline is spreading approximately 800kmand the Pakistan Exclusive Economic Zone (EEZ): It is about 240,000 km2 [16]. Jiawani, Gwadar, Pasni, Ormara and Sonmiani are regions of Baluchistan's coastline having a population of about one million [23]. For this research daily Tuna fish catch data of 2014 year have been acquired from World wild Fund (WWF) Pakistan. Satellite data MODIS product such as Sea surface temperature (SST) of same year 2014 daily product acquired from NASA ocean color (oceancolor.gsfc.nasa.gov) to correlate with in situ data as shown in (Table 1).

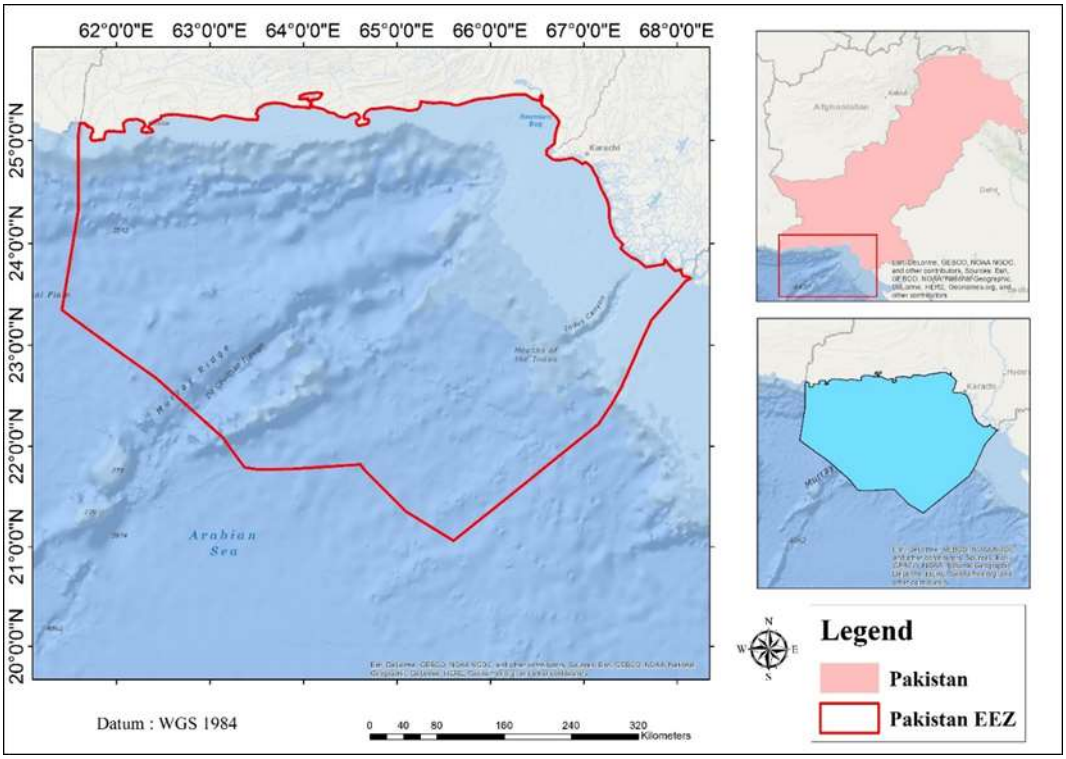

Figure 1: Study Area the EEZ of Pakistan

TABLE I
FISH CATCH GIS DATABASES WITH DIFFERENT SPECIES: TOTAL CATCH AND SST VALUE

Other[Kg]	Dolphins[Kg]	Turtle[Kg]	Bycatch[Kg]	Total Catch[Kg]	Raster value[C°]
16	0	14	111	199	24.93
224	0	0	129	248	25
21	0	0	506	558	24.96
5	0	0	81	107	25.03
10	7	0	161	309	25.02
16	0	0	185	329	24.83
7	0	0	98	168	24.5
8	0	0	69	150	24.83
1	0	15	88	160	25.06
0	0	0	95	172	24.73
0	0	0	115	208	24.27
30	0	0	92	135	24.34
12	0	0	93	180	24.4
16	0	0	72	134	24.38
12	0	0	118	263	24.32
1	0	12	93	270	24.27
28	0	0	127	206	24.2
20	0	0	120	260	24.39
14	0	0	75	233	0
26	0	0	137	216	0
0	0	0	89	330	0
0	0	0	69	232	0
37	0	0	114	229	0
49	0	0	143	314	0
12	0	0	139	287	0
28	0	0	225	363	0
4	0	0	135	220	23.89
12	0	12	61	113	23.92
24	0	0	66	324	23.97
7	0	0	80	240	24
18	0	12	53	134	23.82
12	0	0	65	111	1

3	0	0	100	202	23.51
18	0	4	76	134	23.5
6	0	0	103	195	22.95
3	0	0	321	387	22.78
16	0	0	168	393	22.83
20	0	0	98	239	22.78
12	0	0	131	217	22.78
1	0	0	161	328	22.95
35	0	0	139	186	22.57
9	0	0	53	112	22.65
9	0	0	133	202	23.04
0	0	0	57	111	23.01
6	0	0	104	200	23.18
0	0	0	37	119	23.15
3	0	14	134	204	23.11
12	0	0	54	301	23
0	0	0	98	248	22.94
0	0	0	31	182	22.99
28	0	0	225	363	23.55
4	0	0	36	204	22.96
3	0	12	43	134	22.97
3	0	0	37	173	22.92

A. Methodology

The workflow of the study is shown in (Fig 2). A detailed description of each step is presented in the following subsections.

B. Fish Catch Data

Daily in situ data of year 2014 acquired from WWF Pakistan in the excel sheet form this data includes many species of fish and turtle, fish data include Tuna fish, jelly fish and other species for whole year excluding breeding months i.e. June and July as shown in Fig 3.

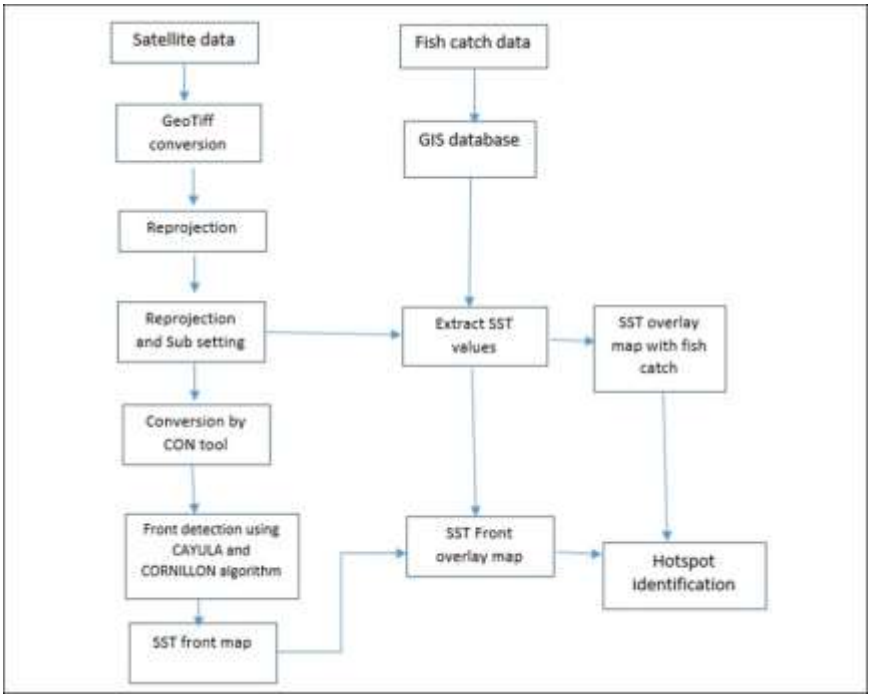

Figure 1: Workflow Diagram

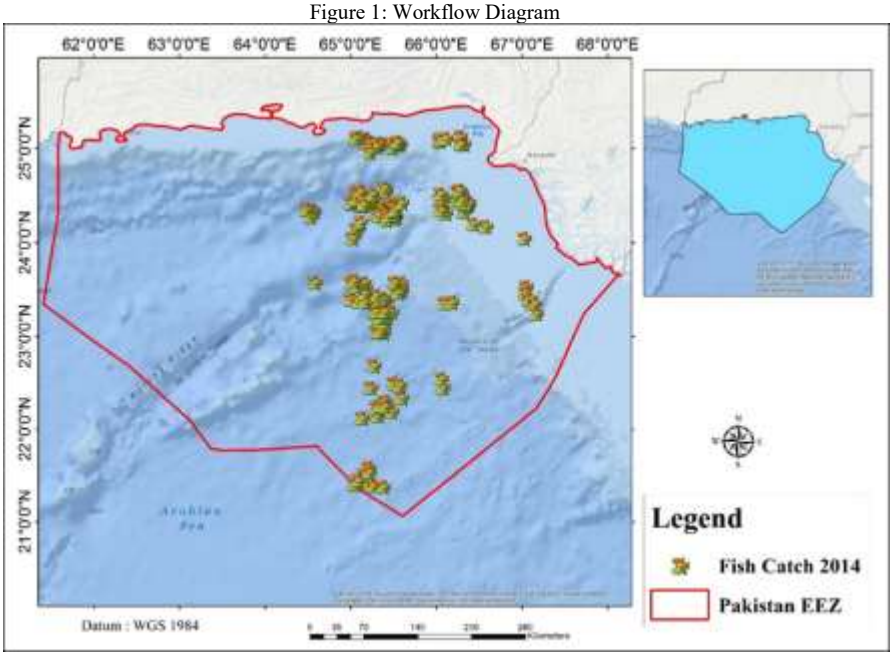

Figure 3: Fish Catch GIS Database

C. Raw data to GIS

As mentioned above the date was in excel form which was exported in GIS to make GIS database of daily fish catch with detailed attribute of each species with date, Location and catch frequency as shown in Fig 4.

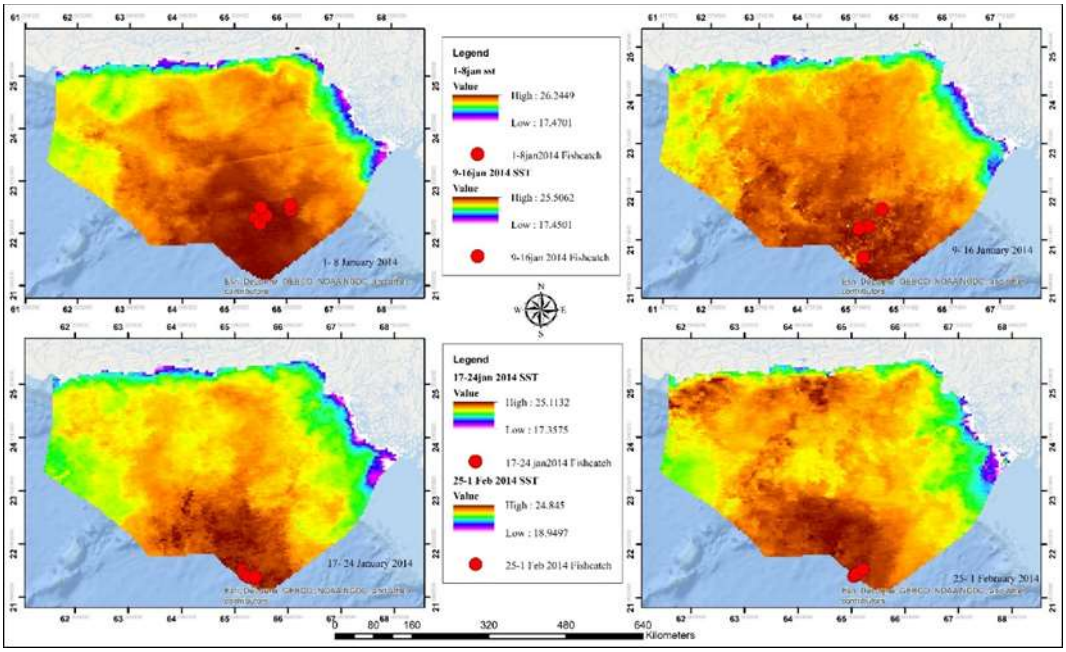

Figure 4: Sea surface Temperature (SST) overlay on respective Fish Catch data

D. Satellite data processing

MODIS data cover 36- Bands in visible and infrared spectrum to produce land and ocean products such as vegetation, cloud, aerosol, chlorophyll and SST. The product from Ocean color data used in different aspects to study coral reef ecological health, algal bloom monitoring and water quality of coast and estuarial water and this satellite data help fish resources management [18]. 45 images of MODIS 8 day satellite data of sea surface temperature were acquired. The data has been filter by excluding fish breeding months (June and July).

E. Re-projection and Sub setting

Images were converted into Geo-Tiff format, which can be readable in GIS software and then applied reprojection tool on these images using SeaDas which was an open source software and

downloaded from ocean color website. After Conversion and re-projection the next step is to extract Pakistan Exclusive economic zone (EEZ) from all forty five images of MODIS by Extraction of the study area.

F. Extract SST values

GIS database was use to extract sea surface temperature values from MODIS product and identify temperatures values with respect to fish catch data as shown in Fig 5. And further overlay on fish catch data.

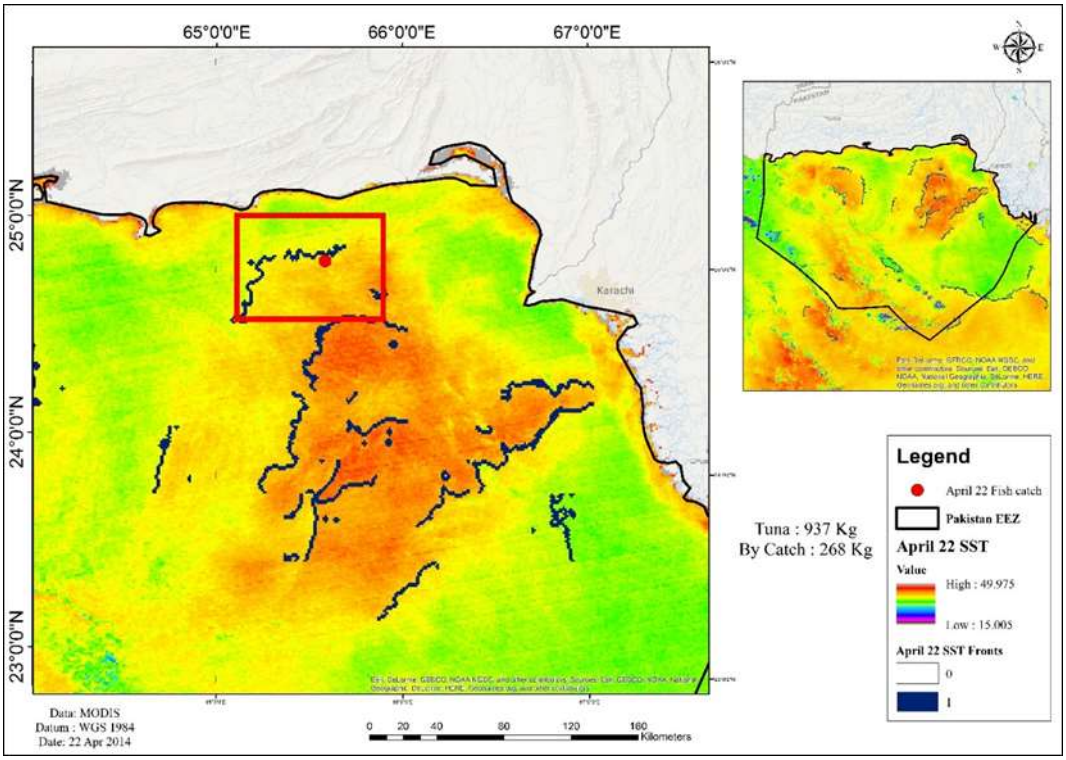

Figure 5: Ocean front Sea surface temperature map with Fish catch data (22 April, 2014)

G. Con Tool

After Re projections in GIS software. The Con tool allows to manage the output values of raster datasets. This tool helps you to control the result values of each raster cell, which based on whether the value of the cell is estimated as true or false in a quantified conditional statement

H. Front Detection

In this study thermal front were identified along the EEZ of Pakistan using MODIS satellite imagery. The SIED algorithm, which was used in this study for Front detection were developed by [2]. This algorithm shows the region where there is a gradient change in SST. The statistical sequence of single image edge detection (SIED) algorithm on temperature field is within 32*32 pixel window to detect the presence of front.

III. Results And Discussion

Since the main objective of this research is to identify the thermal fronts regions with respect to tuna fish catch. Hence, a database of 2014 was created of fish catch provided by WWF-Pakistan, which includes various species of fish. With the assistance of this database, raster values of SST of each point were extracted. Once the points were extracted, no data values were deleted and exported to excel in order to get the knowledge of the best value of SST as shown in Fig 3. GIS based fish catch were comprised of daily data of 2014, each species of Tuna fish and other fish species were defined with Total Tuna Catch , By Catch of whole 2014 year excluding June July months due to fishing season off as shown in Fig 4.

Sea surface temperature (SST) 8 Day composite images of 2014 year were analyzed. All satellite images were preprocessed and extracted sea surface temperature values by overlaying fish catch data of 2014. Fig 4 shows the SST map from January 1st, 2014 to February 1st, 2014: 8 day composite.

During analysis, it has been noted that on 1- 8 January, 2014, Total Tuna fish catch was 577 kg and Total By Catch 1173kg was observed at 24 C to 25C. The highest Tuna fish catch of 148kg which was recorded on January 6th, 2014 was observed at 25.02C and highest by catch of 506 kg, which was recorded in January 4th, 2015 which was observed at 24.98C as shown in below mentioned Table 2.This relation method applied on all MODIS SST images and relate with respective Tuna fish catch data as shown in graphical format in Fig 6. During analysis it has been observed that the maximum Fish catch were observed at 25C to 27C. [3] Mentioned in his research that the physical and climatological parameters are seriously inclined the Fish abundance and other marine organisms. World climate changes affect the marine resources such as fishery production due to sea surface temperature, currents and other ocean parameter changes and this also can be affect on species and food distribution.

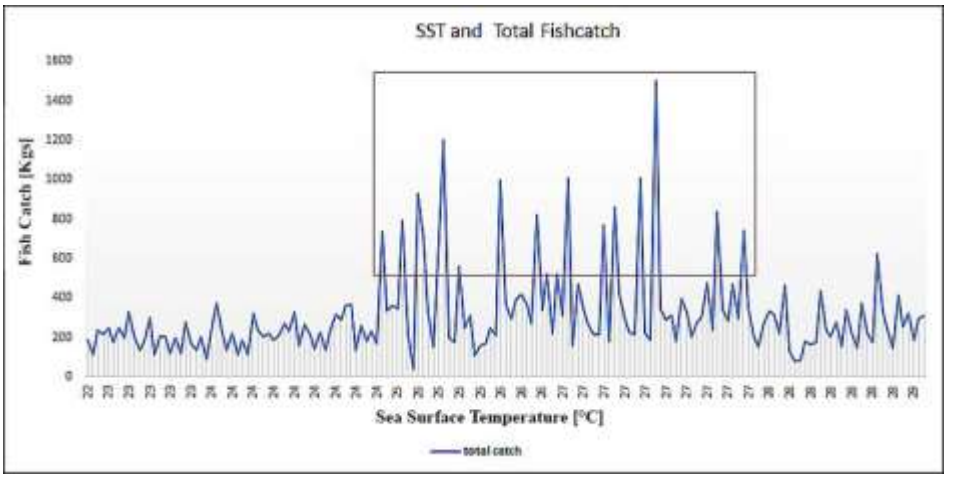

Figure 6: Sea surface Temperature values and Red Highlighted box shows Tuna Fish Catch

Thermal fronts have been analyzed and incorporate with fish catch data for understanding the ocean parameter such as Sea surface temperature relation with Tuna fish. Fish abundance of species like Swordfish, Tuna and Billfish with fronts have been used for establishing relationships [30]. [30] Determined a relationship of predator variety with ocean fronts. [22] Applied the fronts techniques to define the strong relationship between the shark and thermal front. In this study fronts area identified on Sea surface temperature (SST) daily L2 dataset has been used. Ocean front detected on Sea surface temperature L2 daily image of April 22, 2014 and overlaid fish catch datasets which revealed the strong relationship between SST and Tuna catch. During analysis, it is observed that the Tuna fish catch which around 937kg was found on front edge as shown in Fig 5.

On August 20th, 2014 Satellite image shows ocean front detect on the point where tuna catch about 610kg and temperature were gradually changed from 22C to 24C as shown in Fig 7. Results also showed that the by catch frequency was very low as compared to tuna fish catch on frontal regions. According to et al [6, 10] the features of ocean circulation which include fronts, eddies show higher biological productivity as compared to other region which are more inactive or calm flow and these features are strongly related to SST gradients.20th August, 2014 image also showed high tuna catch 601kg on sea surface temperature fronts region it is noted that the by catch very low as compared to tuna catch. [19]. Also mentioned in study that the fish-catch estimations indicated that the Potential fishing zone located by detecting the ocean features using satellite data produce high fish catch data. August 21st, 2014 also showed a good relation between tuna fish catch and Sea

surface temperature (SST) as shown in Fig 8. Tuna catch was recorded around 798kg whereas by catch data was recorded 37kg on frontal regions. These areas might be further evaluated as Potential location for MPA (marine protected areas) [12]

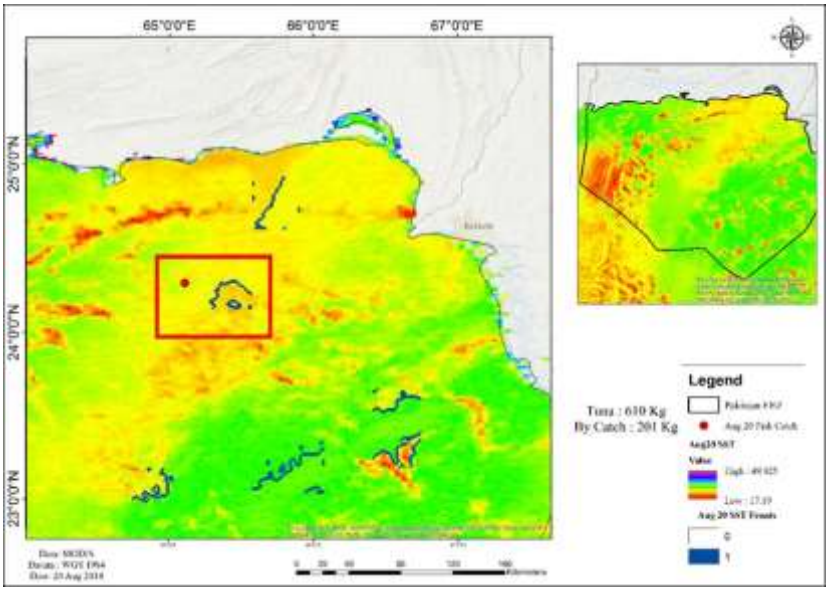

Figure 7: Ocean front Sea surface temperature map with Fish catch data (20 Aug, 2014)

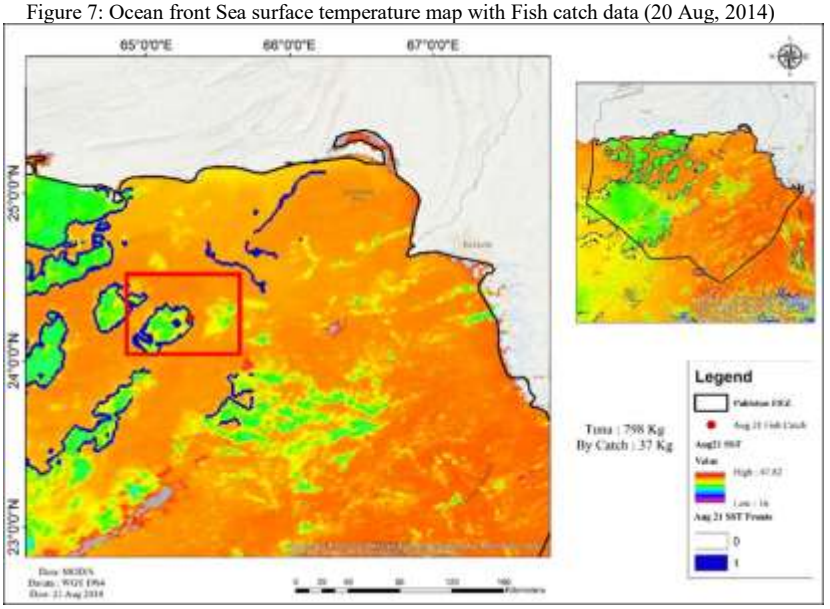

Figure 8: Ocean front Sea surface temperature map with Fish catch data (21 Aug, 2014)

IV. CONCLUSION

By concluding this research, it is assured that, the thermal fronts in a marine upwelling phenomena; although lasting for a very short time but it provide a suitable environment for tuna fish in EEZ of Pakistan. Additional datasets and sampling would need to understand Tuna fish association with thermal fronts. By identifying the location of thermal fronts in coastal waters this could be beneficial for marine management and conservations. As mentioned above SST fronts are important for fish species in marine upwelling areas so remote sensing play a vital role in monitoring of these features. There is an alarming need to obtain information on temporal and spatial variability of ocean processes for managing fish resources in Pakistan.

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