THE USE OF EARTH OBSERVATION SETELLITE FOR IDENTIFICATION OF POTENTIAL FISHING ZONES IN TANZANIA

Submitted

to

DEEP SEA FISHING AUTHORITY

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Abstract
Study on "Application of remote Sensing technology for identification of preferred fishing habitats (PFZ) for the pelagic species was conducted in Mafia and Nungwi along continental shelf of Tanzania. Three days composite of the Chl a, SST and the SST front images (1 km spatial resolution) as well as monthly mean Chl a and SST (4 km spatial resolution) were

derived from the e-station and used for production of PFZ and the climatological bulletin respectively. Geo-referenced fish catch data information collected by fishers was accessed through mobile fish catch data system. Fishers in both sites Mafia and Nungwi were observed to regularly venture their traditional fishing grounds. Good profiles of PFZ were observed in Zanzibar and Pemba channels. Geo-referenced fish catch data collected from Mafia and Nungwi marched with the PFZ lines. A bulletin which reveals the status of climatic condition within a month, specifically Chl a and SST anomalies provide essential information for policy makers in designing or revising fisheries management tools has been produced.

1. Introduction

Tanzania Fisheries Research Institute (TAFIRI) in partnership with Deep Sea Fishing Authority (DFSA) has been implementing a project study on "Application of Remote Sensing technology on the identification of preferred habitats known as potential Fishing zones (PFZ) for the pelagic species in the continental shelf of Tanzania". The overall goal of the project was to use remote sensing technology to reduce fishing pressure in territorial waters by encouraging small scale fishers to venture off shore fishery for Tuna and Tuna like species. Currently, offshore pelagic fish stock resources are underexploited due to inadequate knowledge of locating good fishing grounds.

Remote sensing in the marine environment is an established field, exploiting satellite data to study the development and distribution of oceanic processes (e.g. Haynes et al., 1993; Peckinpaugh and Holyer, 1994), and their effect on fisheries, sea mammals, ocean margin exchange and global warming (Podesta et al., 1993; Huthnance, 1995; Bost et al., 2009). Oceanic fronts are formed at the boundary between water masses of different temperature or density, and are often associated with mixing and enhanced biological production. Fish aggregate in areas where environmental conditions are favorable, specifically in terms of food availability. Through satellite images, these feeding areas (fronts/PFZ) can be identified (Worm et al., 2005, Solanski et al., 2010).

Relationships have been established between fronts and fish abundance, for instance swordfish (Podesta et al., 1993), tuna and billfish (Worm et al., 2005). In addition, Worm et al. (2005) determined a global correlation of predator diversity with fronts. Priede and Miller (2009) applied front detection techniques to reveal a strong relationship between the track of a tagged basking shark and a thermal front. The shark followed the N-S front for a whole day, keeping just to the warmer side. Other studies have referes fronts as potential fishing grounds. Miller and Christodoulou(2014) and used PFZ maps as a proxy for pelagic biodiversity.

Tanzania has a great potential of pelagic species specifically in EEZ, however there is a limited information for identification of the potential fishing zones for pelagic fishery. Recently TAFIRI through EU funded project got a remote sensing e station which can process remotely sensing Earth Observation environmental variables. The most important part of this

study was the actual field verification in terms of geo-reference fish catch data and remote sensing oceanographic variables (fronts) captured by e station.

The objective of the project was to Application of Remote Sensing technology on the identification of preferred habitats known as potential Fishing zones (PFZ) for the pelagic species in the continental shelf of Tanzania. The specific objectives of the study were:

1. To train fishers how to collect Geo-referenced fish catch data at both study sites (Mafia and Nungwi)
2. To established a mobile based fish catch data collection system at TAFIRI, (Smart Data Collect)
3. To produce potential fishing zone maps
4. To correlate/ validate EO derived Potential Fishing Zone to fish catch data
5. To correlate/ validate EO derived of remote sense Earth Observation satellite SST to *institute* data PFZ to fish catch data
6. To Produce Climatological bulletin which reveals the status of climatic condition monthly

2. Methodology

2.1 Study area

This project is Public Private partnership between TAFIRI, Fisheries Divisions both in Zanzibar and Tanzania mainland and fishing communities in Mafia District in mainland Tanzania and Nungwi District in Zanzibar Island .Fig 1 shows the most important part of this study which is the actual field verification PFZ oceanographic variables in relation with fish catch for production of Potential Fishing Zone maps.

Fig 1: Project study sites

2.2 Specific Objective # 1: Fishers in Mafia and Nungwi were given training on the use of GPS. In each fishing trip the captain of fishing boat of each fisher group collected GPS position and total fish catch (Geo-referenced fish catch data) in a collection form. After every fishing operation, data entry of geo-referenced fish catch data was done through the use of smart phone application.

2.3 Specific Objective # 2: A mobile base data capturing system (Fig 2) was developed whereby fishers through their smart phone send information of geo-location, total catch and species composition to a mobile getaway number connected to cloud database and application for data repository and sharing centre. Long term objective of the developed mobile system is that, fishers will be able to query PFZ information through their mobile phones and receive immediate response from the server.


Fig 2 : A mobile base data capturing system

2.4 Specific Objective # 3 & # 5: Three days composite of the Chl a, SST and the SST front images (1 km spatial resolution, Fig 3b) as well as monthly mean Chl a and SST (4 km spatial resolution) were derived from the e-station (Fig 3a) and used for production of PFZ and the climatological bulletin respectively.

Fig 3a: TAFIRI e station with antenna, 3 computers (Acquisition, processing and visualization PC)
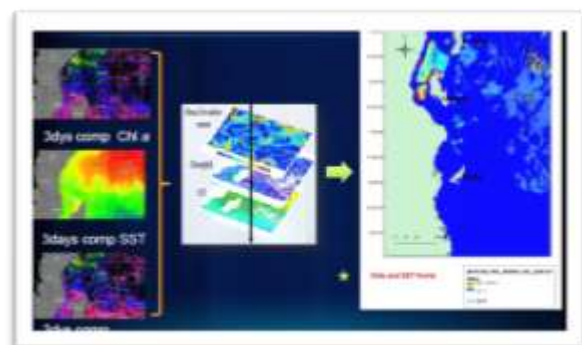
Fig3b: 3 days compos site Chla, SST and SST fronts overplayed together using GIS to produce PFZ map

2.5 Specific Objective # 4 The generated PFZs were validated through overlaying geo-referenced fish catch information collected by local fishers using mobile based fish catch data collecting system from pilot study (Fig4) sites (Mafia and Nungwi).
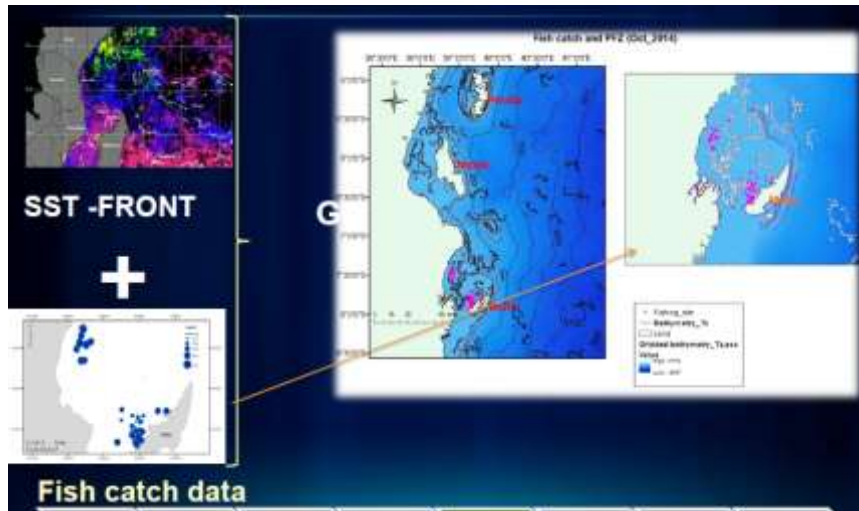
Fig 4: PFZs validated through overlaying geo-referenced fish catch collected by local fishers

2.6 Data processing and analysis

Fish catch data were exported from the TAFIRI cloud data repository,(www.tafiri.go.tz/site/samakisystem) to excel data sheets. The data were formatted to a GIS format. Through the use of Arch GIS software, Geo-referenced fish catch data were overlaid and assessed if they were corresponding to PFZ image.

3. Results and Discussion

Two fisher groups were formed through public private partnership both in Mafia and Nungwi (Fig 1). Fishers managed to use GPS to collect Geo-referenced fish catch data and share the information to TAFIRI portal through a developed mobile based fish catch data system (Fig **2**).

3.1 Data collection system

Figure 5 show the three windows of a smart phone mobile data collecting system developed by TAFIRI revealing geo reference information collected by fishers written in Swahili. The system has an option of exporting captured data to Excel for further processing and analysis. The same system will be used to give feedback and PFZ point to fishers.
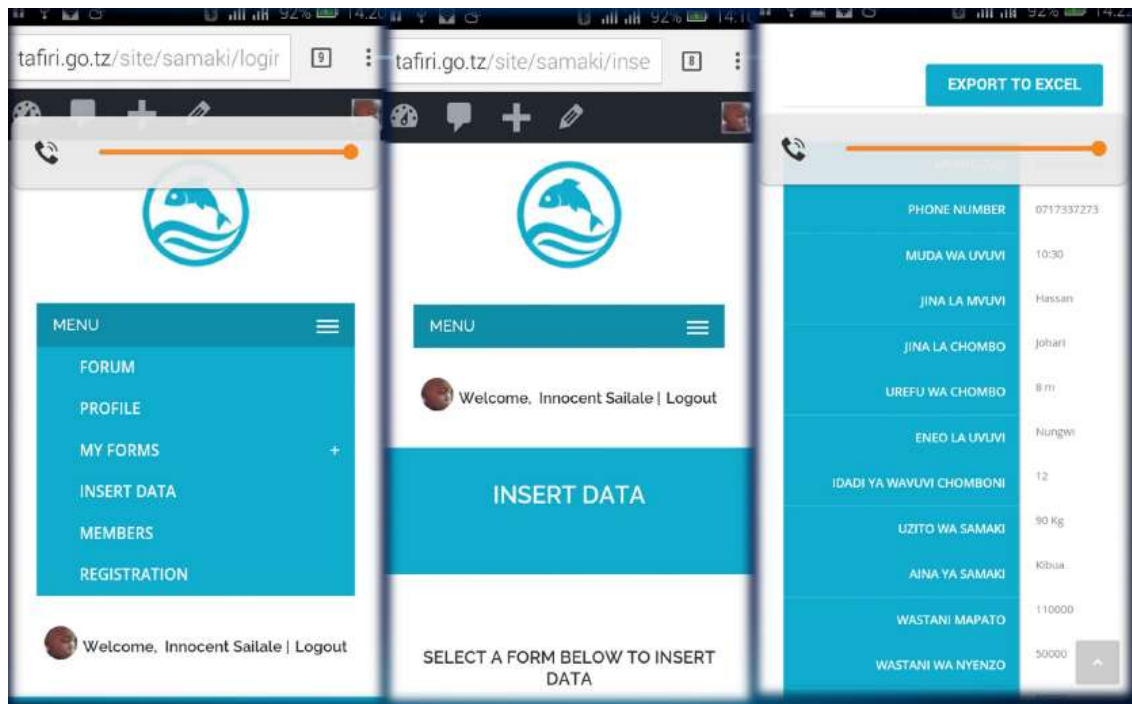
Fig 5: Developed mobile fish catch data collection system windows

3.2 Potential Fishing zone (PFZ)

The figure below (Fig 6) shows PFZ maps in both Mafia and Nungwi. During this study good profiles of PFZ areas (black lines overlaid on Chl a image map) were observed in Zanzibar and Pemba channels. However not all days SST- fronts (index of PFZ) were detected in coastal waters of Tanzania. With this regards there is a need to validate fish catch data to SST-Fronts in Pemba Chanel too as this area will add value to the validation process. Several studies went over the same process or used long time series data to establish predictions of global change accurately enough to assist policy makers in making sound decisions concerning the protection of marine ecosystems (Miller and Christodoulou 2014)
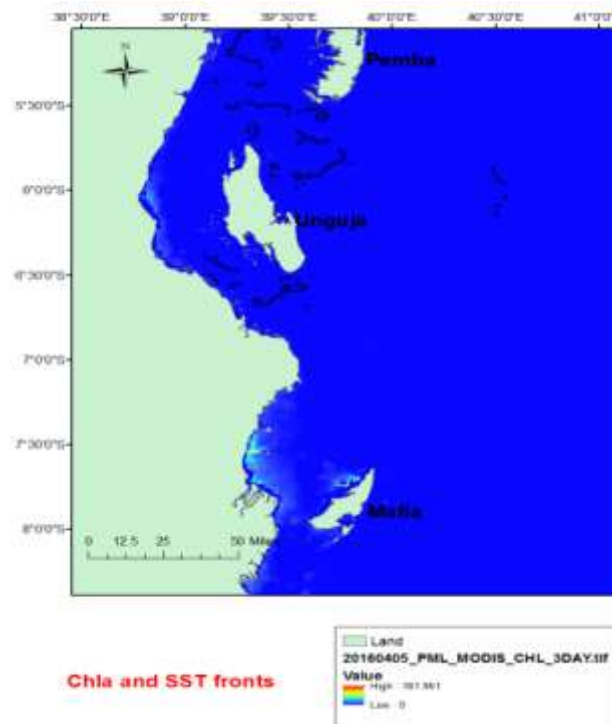
Fig 6: More PFZ lines observed in Pemba Channel (black lines)

3.3 Collection of Catch data

Fishers in both sites Mafia and Nungwi were observed to regularly venture their traditional fishing grounds (Fig 7). Fishers in Nungwi were fishing in the northern part of Nungwi towards Pemba Channel. They used gillnet drift fishing method targeting tuna and tuna-like species. Fishers in Mafia were observed to fish in Kilindoni bay and sometimes headed towards fishing grounds next to Rufiji delta.. They used ring net fishing gear to capture small pelagic fishes. Both Fisher will be given more optional potential fishing grounds once the validation process will be done.

Fig 7: A map showing fishing ground sites in Nungwi and Mafia study sites.

3.4 Validation of Fish catch data to PFZ

The figure below show Geo-referenced fish catch data collected from Mafia and Nungwi marched with the PFZ lines (Fig **8**). PFZ line in part matched with catch data both in Mafia and Nugwi. This observation is in agreement with previous study by Laurs et. Al, (1984) who found Albacore tuna catch data matched on concurrent satellite images of sea surface temperature and phytoplankton pigment concentration. However to be more accurate more validation is needed with more fish catch data, as the PFZ line may have been influenced with changes in climatic variability. From Last year 2015 Earth Observation (EO) satellite revealed SST anomalies which influenced ocean productivity in Tanzanian coastal waters (see TAFIRI bulletin).
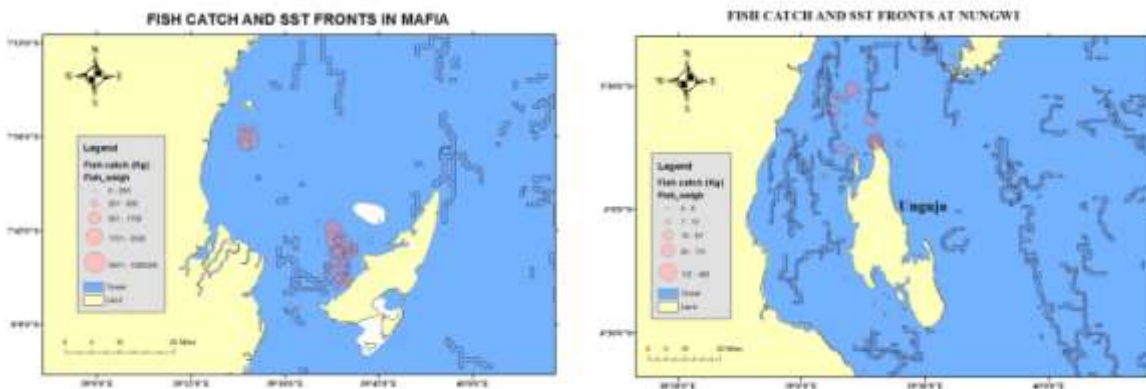
Fig 8a: Fish catch data matched with PFZ line in Mafia.

Fig 8b : Fish catch data matched with PFZ line in Nungwi.

3.5 Validation of Satellite Remote sensing SST to *insitu* SST

Remote sensing collected SST matched perfectly with field data of SST collected with a temperature logger data deployed at Chumbe Island at 3 m depth (Fig. 8). Five year data (2009-2014) of monthly mean SST values from EO satellite with the correspondence *insitu* temperature loggers monthly mean SST had the same pattern. This finding suggests that EO SST values can be used to understand how ocean warming can influence the productivity in Larger areas of marine ecosystem (Worm et 2005)
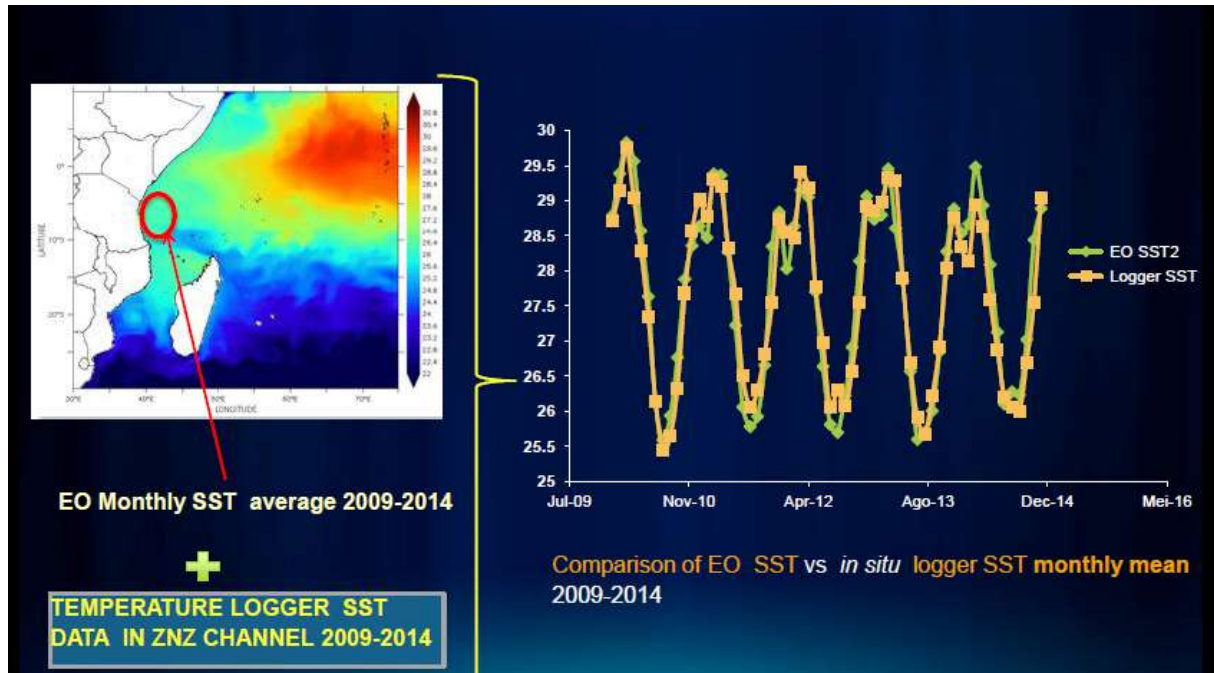
Figure 9: Remote sensing collected SST matched perfectly with field data of SST collected with a temperature logger data deployed at Chumbe Island at 3 m depth.

3.6 Bulletin production

The project is producing a bulletin (Fig. 10) which reveals the status of climatic condition within a month, specifically sea surface temperature and chlorophyll anomalies which reflects the ocean primary productivity (see TAFIRI website, www.tafiri.go.tz). The bulletin outputs provide essential tools to help policy makers and policy advisers in shaping policies in the fields of climate studies and climate change assessment and mitigation, as well as in fisheries management. SST* and CHLα* are essential in fisheries management since they help in identifying areas of high or low productivity, hence fish stock health, as well as their extension in time and surface (see annex 1)**.**
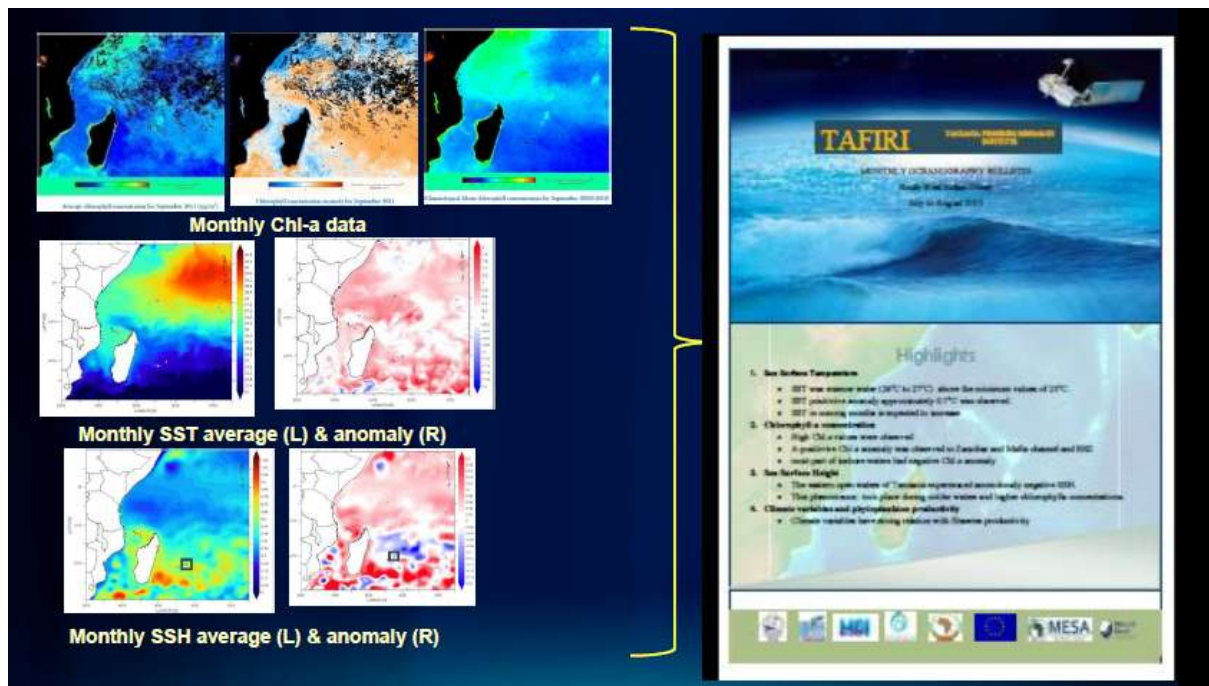
Fig 10: Monthly SST and Chl *a* information used for production of TAFIRI bulletin

4. Way forward

1. As a result of current work, a further study is proposed for more clarity and validation of PFZ to fish catch data for Nungwi and Mafia. This time fishers will be given PFZ fishing point and they will be sending information of geo-reference fish catch data through a mobile fish collection system to TAFIRI

2. A new study area is proposed in Pemba Channel (Tanga and Pemba Island), this is the area was observed to have more PFZ lines (Figure 5).

3. Currently there is an initiative of upgrading e-station at TAFIRI; equipments are expected to arrive on 7th July 2016. Upgrading of e-station will increase efficiency and capacity to implement the project by production of higher quality resolution images within a relatively short time (1 day compared 2 weeks).

4. Earth Observation Remote sensing technology plays a vital role in the development of validated, global, interactive Earth system models able to predict global change accurately enough to assist policy makers in making sound decisions concerning the protection of our environment.

5. The project will use catch data for tuna collected by DSFA from distant nation fishing vessels in Tanzania EEZ for ground thuthing with satellite observed fishing habitats in our e-station (after Miller and Christodoulou 2014) . The result from this exercise will help Fisheries managers to understand hot spot of tuna fishery and also encourage investors on accessibility of Tuna in our EEZ.

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Annex 1