Highlights

1. Sea Surface Temperature
   - SST was warmer water (26°C to 27°C) above the minimum values of 25°C.
   - SST positivive anomaly approximately 0.7°C was observed.
   - SST in coming months is expected to increase

2. Chlorophyll-a concentration
   - High Chl a values were observed
   - A positivive Chl a anomaly was observed in Zanzibar and Mafia channel and EEZ
   - most part of inshore waters had negative Chl a anomaly

3. Sea Surface Height
   - The eastern open waters of Tanzania experienced anomalously negative SSH.
   - This phenomenon took place during colder waters and higher chlorophylla concentrations.

4. Climate variables and phytoplankton productivity
   - Climate variables have strong relation with fisheries productivity
1.0 Introduction
This monthly bulletin is produced by Tanzania Fisheries Research Institute (TAFIRI). This bulletin provides satellite based general oceanographic observations of the South Western Indian Ocean region and further focus on Tanzanian waters. This issue focuses on remote sensing sea surface temperature, chlorophyll-a concentration sea surface height and an overview of ocean productivity in Tanzania water.

2.0 Sea Surface Temperature

Figure 2.1: SST August 2015

Figure 2.2: Climatological SST Average for August 1992 – 2009
Sea surface temperature (SST) is the temperature of the top millimeter of the ocean’s surface. The map displays the SST variation during the period August 2015. Warmer colours such as yellows and reds represent higher temperatures, while cooler ones such as green and blue represent lower temperatures. A SST anomaly is a departure from average conditions. These maps compare temperatures in a given month to the long-term average temperature of that month from 1992 through 2009. Blue shows temperatures that were cooler than average, white shows near-average temperatures, and red shows where temperatures were warmer than average. Some sea surface temperature anomalies are simply transient events, not part of a specific pattern or trend. Other anomalies are more meaningful.

In general in SWIO, during August 2015, the waters in the northern part (8°S to 8°N) compared to the southern part (8°S to 24°S) appeared to have higher sea surface temperature Fig 2.1. Also a positive SST anomaly (1 °C to 2 °C higher Fig 2.3) was generally observed in the Northern part of the region (3°S to 8°N) and specifically along the coastal waters of Somalia and the northern part of the Kenyan coast. Along the coast of Tanzania, based on 20 years of climatology, the period of July to September corresponds to cooler SST with the minimum values of 25°C F (Figure 2.4). However, much warmer water (26°C to 27°C) were observed during August 2015.

Figure 2.3: SST Anomaly August 2015

Figure 2.4 : Trend of the monthly mean value (2003-2014) of SST in Tanzania
Regarding the coastal region of Tanzania, a positive SST anomaly of approximately 0.7°C was observed in offshore waters beyond the Islands of Pemba, Zanzibar and Mafia (Fig 2.3). This area covers part of the exclusive economic zone (EEZ) of Tanzania. In the coming months SST is expected to increase. The current positive anomaly are likely to persist and might be further influenced by the current El Nino activity, which has been reported by the NOAA Climate Prediction Centre and the Tanzania Metrological Agency.

3.0 Chlorophyll Concentration

Figure 3.1: Average Chlorophyll Concentration-August 2015

Figure 3.2 Climatological Chlorophyll Concentration Estimates for August 2003 – 2010
The chlorophyll-a concentration map showed milligrams of chlorophyll per cubic meter of seawater for the month of August 2015. Places where chlorophyll amounts were very low, indicating very low numbers of phytoplankton are blue. Places where chlorophyll concentrations were high, meaning many phytoplankton were growing, are red. Land is dark gray, and places where satellite could not collect data because of clouds are light gray. The average chlorophyll concentration for the month of August 2015 was lower in the Mascarene region compared to the climatological mean chlorophyll concentration. High Chl-a concentration was observed in the Mozambique shelf areas, Tanzania coast, and Madagascar coastal areas.

In general in SWIO, during August 2015, the waters in the northern (3°S to 10°N) and southern parts (Fig 3.1) beyond 30°S appeared to have higher chlorophyll a (Chl a) values compared to the waters in the central part (3°S to 30°S). Large areas of the Northern part (Equator to 10°N) showed negative Chl a anomaly (less than –0.1 mg.m-3) while waters in the southern part (beyond 30°S) had positive Chl a anomaly Fig 3.3. The observed negative Chl a anomaly in the northern part (3°S to 10°N) could be due to higher temperature (SST anomaly, Fig 2.3), which indicate reduced nutrient availability due to enhanced thermostratification. Thermal stress might also be an additional factor affecting phytoplankton growth and hence contributed to the observed negative Chl a anomaly. Along the coast of Tanzania, based on 20 years of Chl a climatology, the period of July to September Fig 3.4 corresponds to higher Chl a with the maximum values of 0.35mgM⁻³. During August 2015, a positive Chl a anomaly of approximately 0.05 mgM⁻³ was observed in Zanzibar and Mafia channel and parts of Tanzania EEZ.
In contrast, most part of inshore waters had negative Chl $a$ anomaly. A possible explanation for the observed positive Chla anomaly in Zanzibar and Mafia Channel may be related to increased river discharge from the Ruvu and Rufiji respectively.

4.0 Sea Surface Height

Figure 4.4: Trend of the monthly mean value (2003-2014) of Chl $a$ in Tanzania

Figure 4.1 SSH August 2015
The Sea Surface Height map with positive values, indicated by the warmer colours such as yellow and red indicate higher sea surface heights, while blue colour indicate lower sea height. Values are in meters. Sea Surface Height Anomaly map with positive values, indicated by the warmer colours such as red indicate higher than normal sea surface heights, whereas cooler colours, such as blue, corresponding to negative values indicate below normal sea height. Values are in meters.

The eastern open waters of Tanzania are experiencing an anomalously negative SSH (Fig 4.2). This phenomenon takes place during colder waters with higher chlorophylla concentrations. The driving force behind this phenomenon may be the south East Monsoon winds. All these are indicative of productive waters in this area.

5.0 Phytoplankton productivity

Chlorophyll a (Chl a) biomass is a signature of Phytoplankton productivity. Along the coast of Tanzania Phytoplankton productivity is limited by environmental factors such as nutrients, irradiance, SST, wind and river discharge. Phytoplankotons are primary producer in food chain and are linked with coastal ecosystem, coral reef ecosystem and oceanic ecosystem fisheries productivity. Climate variables information measured by Earth Observation Setellite in oceanic waters of Tanzania show that SST have negative relation with chl a (Figure 5.1), this is could be seen in (Fig 5.2) where by higher values of Chl a in August coincides with low values of SST. The higher fish catch values during NE monsoon may be linked with the presence of phytoplankton which supports lives of fish larvae at the beginning the season (Reference). Time series of maximum values of phytoplankton and SST (Fig 5.3) shows that between 2003 to 2007 there was a decrease in values of Chl a which considers with low values of Chl a anomaly in the same period. The observed higher temperature (Fig 5.3) during this period (2003 to 2007) may have contributed to the observed decrease in prawn catch within the same period (Fig 5.5).
Figure 5.1: Relationship between Chl $a$ and SST anomalies value (2003-2014) along the coast of Tanzania.

Figure 5.2: Monthly mean values of SST and Chl $a$ (2003-2014) in Tanzania coast waters.
Figure 5.3: Time series monthly values of SST and Chl \( \alpha \) (2003-2014) along the coast of Tanzania

Figure 5.4: Trend of Chl \( \alpha \) and SST anomalies value (2003-2014) in Tanzanian waters

Figure 5.5: Annual Fishing effort and catch trend of the commercial prawn trawler fishery along the coast of Tanzania
6.0 Annex

Description of Environmental Indicators

*Sea Surface Temperature (SST)* reflects the storage of thermal energy in the upper mixed layer of the oceans. Sea surface temperature anomalies have practical applications to fisheries and coastal waters management, including coral reef monitoring and prediction of red tides or other harmful algal blooms.

*Sea Surface Temperature Anomaly (SST Anomaly)* means a departure from a reference value or long-term average. A positive anomaly indicates that the observed temperature was warmer than the reference value, while a negative anomaly indicates that the observed temperature was cooler than the reference value.

*Sea Surface Height (SSH)* is defined as the distance of the sea surface above a known reference surface, such as the earth's ellipsoid or the marine geoid.

*Sea Surface Height Anomaly* is the difference between the best estimate of the satellite-observed sea surface height and a mean sea surface.

*Sea Surface Chlorophyll-a*: Chlorophyll-a is the light-harvesting pigment found in marine microscopic photosynthetic plants, known as phytoplankton. Its concentration is widely used as an index of phytoplankton biomass and is also used as a proxy for primary production. Chlorophyll absorbs most visible light but reflects some green and near-infrared light. By measuring what kind of light is absorbed and reflected, satellite can measure chlorophyll concentrations in the ocean, thus providing valuable insights on the health of the ocean.

*Sea Surface Chlorophyll Anomaly* is a variation from the mean chlorophyll-a concentration.

*Significant wave height (Hs)* is defined as the average height of the highest one-third waves in a wave spectrum.

Datasets

For SST, SSH and H₃, a climatological reference was derived from the GLORYS2 model reanalysis from Mercator Ocean over the period 1992-2009. For the current month, daily model hindcasts, also from Mercator Ocean, have been used, with a spatial resolution of about 27 km. The main advantages of reanalysis datasets are the completeness with respect to observations (remote sensing and in-situ data) and the performance of the interpolation method (assimilation). These provide a spatially and temporally continuous field which can be viewed as the “best estimate” of the ocean state for the given period.
Chlorophyll Level 3 Standard Mapped Image (SMI) dataset was used from the Moderate-resolution Imaging Spectrometer (MODIS) data, with spatial resolution of 4 km. The Level 3 SMI products are image representations of binned data products.

Indicator Calculation

The SST anomalies are calculated from daily operational model outputs relative to a climatological seasonal cycle based on the interval 1992 to 2009. The daily series were used to calculate monthly averages and spatial averaging was carried out for the SST and SSH time series.

Monthly chlorophyll anomaly images were created using the processed monthly satellite data and the monthly climatology data. The monthly anomalies were calculated relative to the respective monthly mean. The chlorophyll climatology was obtained from 9 years of MODIS data (2002-2010). The nominal pixel resolution is 4 km. The chlorophyll anomalies were calculated from a ratio of a monthly composite to the respective monthly mean.

Abbreviations

Chl-a Chlorophyll a
Dipole A local pair of anomalies, one positive and the other negative
DSFA Deep Sea Fishing Authority
EEZ Exclusive Economic Zone
Geoid A reference surface corresponding to the equilibrium water level of the stationary ocean
GLORYS Global Ocean ReanalYsis and Simulations
Hs Significant wave height
JRC Joint Research Centre
MESA Monitoring for Environment and Security for Africa
MODIS Moderate-resolution Imaging Spectrometer
MOI Mauritius Oceanography Institute
SMI Standard Mapped Image
SSH Sea Surface Height above the geoid
SST Sea Surface Temperature
SWIO South West Indian Ocean

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