The Dynamic of Convergence Zone Displacement in Western Pacific Ocean on 2015 Super El Niño Event

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Abstract. Warm pool and the existence of equatorial processes in the Pacific Ocean have an important role on El Niño Southern Oscillation (ENSO). The eastward advection of warm and less saline water from the western Pacific together with the westward advection of cold and more saline water from the central-eastern Pacific induces a convergence of water masses at the eastern edge of the warm pool. The aim of this study is to determine convergence zone displacement in Western Pacific Ocean based on oceanography parameters such as temperature, salinity and surface current from in situ Argo Float, satellite and model data. The convergence zone displacement was characterized by proxies variable of isotherm 28.5 °C and isohaline 34.6 psu. The convergence zone is zonally displaced in association with El Niño-La Niña and wind-driven surface current variations. The displacement of the convergence zone moved as far east as 136 °W in the eastern Pacific during the 2015 Super El Niño. Otherwise, convergence zone moved westward near 154 °E in the western Pacific, during La Niña periods. During Super El Niño, the stronger than-normal speed of the North Equatorial Counter Current (NECC) was increased by 0.8 m/s and appears to have been a major factor in convergence zone reaching the far eastern Pacific. A strong significant positive correlation (R= 0.88, 0.82 and 0.84) between SST and skipjack tuna catch on Super El Niño, La Niña and Normal respectively suggested that changes in skipjack CPUE occurred in phase with movement of convergence zone.

1. Introduction

The forms controlling the warm ocean surface temperatures (SST) forever found within the western central Pacific and known as the warm pool are central to characterizing climate and deciding the character of expansive scale and profound air convection. The western tropical Pacific warm pool is subject to solid east-west movements on interannual time scales in stage with the Southern Wavering Record. Interannual developments of the warm pool are overwhelmed by zonal advection. The eastbound advection of warm and less saline water from the western Pacific in conjunction with the westbound advection of cold and more saline water from the central-eastern Pacific actuates a merging of water masses at the eastern edge of the warm pool [1].

The central Pacific surface waters are characterized by a continuous increment of ocean surface temperature (SST) from low SST called the cold tongue at the Eastern Pacific to approach the international date line and after that a about steady with tall SST (>28 °C) all the way to the warm pool in Western Pacific. On contrary, the surface saltiness of these waters varies, Within the central Pacific,
the waters are characterized by tall saltiness (i.e., bigger than 35 psu) and less saline water within the western tropical Pacific. The division between the cold tongue and the warm pool characterizes as a lasting meeting of surface-layer water masses. The convergence zone is recognized by a well-marked saltiness front isohaline 34.6 psu and isotherm 28.5 °C [2]. Fabulous zonal relocations of the convergence zone over Pacific Sea happen in stage with the warm and cold stages of the ENSO cycle [3]. Amid El Niño stage a intermittent eastbound advection of warm, low-salinity water from the western tropical Pacific, created by westerly wind bursts. When the development of the warm pool is eastbound the convergence zone moreover moves eastbound and the coming about expansion of warm SSTs supports barometrical convection and precipitation. On the other hand, amid La Niña periods, the development of the warm pool is westbound and the convergence zone can pass through the eastern edge of the warm pool. It is initiated by westbound advection of cold, saline water from the central-eastern Pacific experiencing Western Pacific. The development of convergence zone within the eastern edge of the warm pool is in this way vital to get it and to screen inside the setting of seasonal-to-interannual climate varieties.

In recent years, a few considers have proposed that ENSO behaviors are getting to be increasingly complex, counting their spatial conveyance and concentrated. The advancement of the 2015/2016 El Niño appeared bizarre complexity, and its execution may have included the interaction of decadal inconstancy and worldwide warming [4]. The El Niño in 2015–2016 was without a doubt a solid occasion, with sensational impacts on a worldwide scale. The warm ocean surface temperature peculiarity (SSTA) began to fortify within the early summer of 2015, and the most grounded El Niño event at long last materialized within the winter of 2015–2016. Zhi et al, 2019 appeared not as it were the highlights of all solid El Niño, but moreover a few unmistakable characteristics diverse from past extraordinary El Niño.

In any case, the current investigate on the 2015/2016 EN, counting the forms related with convergence zone engendering eastwards from the warm pool locale of the west Pacific over to the South American coastline amid 2015-2016 are still not caught on well. Subsequently, this has driven researchers to examine the later ENSO occasions. In this think about, A few significant questions ought to be replied: What’s the impact of Super El Niño (2015-2016) on zonal convergence zone’s displacement mechanism. If the warming of ocean surface temperature (SST) within the eastern Pacific signals the entry of El Niño conditions, at that point the synchronous zonal relocations of the convergence zone and climatic convection ended up fundamental forerunners of this conditions. Since zonal displacement of the convergence zone is critical for setting up the air-sea intuitive within the central-western Pacific that are related with the onset of the El Niño Southern Oscillation (ENSO) phenomenon [5]. Thus, this study is of great importance for improving ENSO prediction and obtaining a better understanding of the nature and dynamic mechanisms of the ENSO.

A few considers have endeavored to discover a straightforward way to distinguish merging zone within the eastern edge of the warm pool. [5] utilized speculative strays with tremendous drogues as a way to highlight the meeting of waters at the eastern edge of the warm pool. Within the taking after, the convergence zone will be essentially characterized as the locale where the speculative vagabonds focalize. One ought to note that these past thinks about utilizing in-situ streams were restricted to the central Pacific and subsurface perceptions are as well inadequate to archive the long term inconstancy of subsurface saltiness stratification with this instrument. The truth that [6] were moreover unable to recognize a signature in saltiness front that's known as the boundary layer is especially critical in determining convergence zone. In any case, the convergence zone along the equator isn't legitimately characterized as it were by a front since it has particular hydrological highlights and environment flow. The issue has been that in spite of the fact that the convergence. The issue has been that in spite of the fact that the convergence zone within the eastern edge of the warm pool may be well characterized by a contrast between warm, precipitation initiated low salinity, oligotrophic waters within the west and the cold tongue by cold, high-salinity, mesotrophic waters within the east. This assignment has demonstrated more troublesome than anticipated, it cannot be dependably recognized by more promptly perceptible marvels such as SST or indeed ocean surface saltiness (SSS) front only.

In this study, we expected to archive the plausibility of utilizing satellite-based perceptions of SST, SSS and surface streams and to distinguish, precisely and reliably, convergence zone within the eastern
edge of the warm pool. Investigations on the different atmospheric processes before and after 29.5°C
Before 29.5°C, the deep convection represented by the highly reflective cloud (HRC) increase following
SST [7]. This plausibility emerges since of the average zonal streams within the tropical waveguide can
be utilized to take after the zonal relocation of the warm pool in connection to El Niño. This last
mentioned point will be confirmed to begin with with in situ information from Agro Floats collected
vertical dissemination of SST and SSS. With the utilize of four information sets and three classes of sea
models, we illustrate the zonal and vertical displacement of the convergence zone. More importantly,
The accessibility of extra new current estimations within the far western equatorial Pacific, such as that
from marine Copernicus modeling data, implies that it is now possible to consider the uprooting of the
oceanic zone of convergence within the distant western Pacific.

2. Data And Method

2.1 Data
Daily Sea Surface Temperature (SST) data is obtained from microwave satellite imagery (MW)
combined with TMI, AMSR-E, AMSR-2, Windsat and GMI sensors with a resolution of 0.25 degrees
or 25 km. Sea Surface temperature data for 2015-2017 are downloaded from the website
http://www.remss.com. Daily Sea Surface Salinity (SSS) data is obtained from SMAP (Soil Moisture
Active Passive) satellite images with a resolution of 0.25 degrees or 25 km. The temperature and salinity
depth data uses Argo float data which can be downloaded through the portal
https://www.jcommops.org/.

Sea Surface current used numerical modeling data from Marine Copernicus with a spatial resolution
of 25 km. Marine Copernicus is one of project under European Comission which observe oceanographic
parameters using remote sensing technology or using numerical model. In this research, we used the
dataset called global-reanalysis-phy-001-025-monthly with the same timeframe and coordinate as Sea
Surface Temperature and Sea Surface Salinity.

Catch per unit effort (CPUE) data obtained from data from the Western Central Pacific Fisheries
Commission (WCPFC) used to measure the relative abundance of skipjack tuna stocks and can be
downloaded on the website: http://www.wcpfc.int/doc. Average global CPUE for the Pacific Equatorial
purse seine fleet contains the coordinate of skipjack fishing ground during 2015-2017.

The data of climate variability used in this study is the El Niño Southern Oscillation (ENSO) data.
ONI index Data is obtained based on the SST anomaly difference in the western Pacific Ocean and the
East Pacific Ocean in the Nino 3.4 region (5°N - 5°S, 120° - 170°W) obtained from the
http://www.cpc.noaa.gov/products/analysis_monitoring page.

2.2 Method
Horizontal distribution of temperature and salinity is carried out by extracting compile daily data with a
data format (*. sav) into monthly data using Interactive Data Language (IDL) software Processing of
temperature and salinity vertically is done by extracting the NetCDF format data using Ocean Data View
software and real time tracking float, temperature data which was acquired from several Argo Floats
that have been deployed at the same latitude, longitude and depth positions each year during 2015-2017
period using Excel software.

Convergence zone identified by a proxy isotherm 28.5 0C and isohaline 34.6 psu. The horizontal
movement of the convergence zone uses a hovmoller diagram showing longitudinal cross-sections of
temperature and salinity. The limitations of the depiction of the hovmoller diagram include the area
between latitude 5 °N-5 °S.

The mechanism of movement of the convergence zone used spatial distribution and temporal velocity
and direction of surface currents. Surface flow data processing in the form of NetCDF (Network
Common Data Form) is carried out by extracting data, compiling daily data into monthly data and
displaying temperature movement patterns during the ENSO phase using Interactive Data Language
(IDL) software.

Analysis of the effect of the movement of the convergence zone on the production volume of skipjack
tuna through CPUE data of skipjack tuna in the West Pacific Ocean. The skipjack tuna catch data used
is the accumulated data per longitude and month from 2015-2017. ONI Index data which is a sea-level anomalous data in the region Niño3.4. If the ONI Index > 0.5°C then classed as an El Niño condition, and when the ONI Index of < -0.5°C is La Niña.

3. Result And Discussion

3.1 Variations of Sea surface temperature (SST) and Sea surface Salinity (SSS) in ENSO and Normal Conditions

Indications of the relationship between ENSO and the variability of surface temperature and salinity in the Pacific Ocean have been described in previous studies. This study shows differences in temperature and salinity variations in the West Pacific (I) Central Pacific (II) and East Pacific (III) regions and their changes to ENSO intensity during 2015-2017 and possible mechanisms are explained.

The temperature in the West Pacific (Figure 1c) decreased by 0.2 °C During strong El Niño to Super El Niño events (June 2015-February 2016) indicating a decrease in warm water mass caused by the movement of warm pools towards the East Pacific. The contrasting pattern is shown by the increase in salinity in the Western Pacific due to the increase in mass of high salinity water replacing the mass of fresh water brought along with the zonal movement of warm ponds. The same thing happened in the Central Pacific (Figure 1d) the temperature value of 29.6 °C decreased significantly with a change of 0.5 °C. Meanwhile, the salinity value in this region decreased by 0.35 psu due to advection of low salinity water masses brought in by warm ponds. This pattern of salinity reduction is also evident in the East Pacific region (Figure 1e) with a larger decline rate of 0.5 psu. In contrast to the West Pacific and the central Pacific, the temperature in the East Pacific increased by 0.2. This shows the accumulation of water masses from warm pools, thus pressing the cold water masses in the East Pacific to form a vertical temperature stratification.

Figure 1. Horizontal distribution of temperature (a) and salinity (b) in regions I, II and III illustrates the variations in temperature and salinity in the Western Pacific Region (c) the Central Pacific (d) and the East Pacific Region (e) in the El Niño Phase (January 2015- April 2016). The black graph depicts the temperature value and red represents the salinity value.
During the Super E1 Nino event the warm pool shifted significantly to the eastern Pacific (Figure 2a) generating a decrease in temperature in the Western Pacific and an increase in temperature in the eastern Pacific. Changes in temperature in these two regions cannot be separated from their association with intense rainfall and evaporation that follows the movement of warm pools. According to [1], the convection zone above the warm pool and rainfall follows the migration of the zone of the eastern edge of the warm pool, as indicated by the movement of high reflective clouds. Heavy rainfall significantly reduces the salinity of the top layer of warm ponds. So that the movement of warm ponds to the Central and East Pacific at the time causes a decrease in salinity in the two waters. This is supported by research by [4] who calculated the anomaly value of FWF (fresh water flux) along the Pacific equator during 2014-2016. FWF anomaly is obtained from evaporation (E) minus rainfall (P). In the El Niño phase, a positive anomaly was found in the Western Pacific, which means that high evaporation values allow an increase in salinity in the West Pacific. On the other hand, a negative anomaly in the East Pacific shows that high precipitation is the key to a rapid decrease in salinity in high salinity areas.

Figure 2. Horizontal distribution of temperature (a) and salinity (b) in regions I, II and III illustrates variations in temperature and salinity in the Western Pacific Region (c) the Central Pacific (d) and the East Pacific Region (e) in the La Niña Phase (August- November 2016). The black graph depicts the temperature value and red represents the salinity value.
On the La Niña phase the temperature increases by 0.2 °C in the West Pacific (Figure 2c) as the warm pool slowly moves towards the West Pacific. Meanwhile, the decreasing salinity value indicates the mass transport of low salinity water moving along the warm pool back to the West Pacific. The Central Pacific (Figure 2d) temperature is spatially lower than the West Pacific with the interval 28.80-28.85 °C 0.12 psu. Meanwhile, the temperature value in the East Pacific decreased by 0.4 °C and the salinity increased by 0.1 psu which was caused by the vacuum of water mass on the surface along with the movement of the warm pool to the West Pacific. This results in the coordination of evaporation and the presence of equatorial upwelling, which carries high salinity water from below, so that surface water from the East Pacific is characterized by relatively cold temperatures and high salinity.

Figure 3. Horizontal distribution of temperature (a) and salinity (b) in regions I, II and III illustrates variations in temperature and salinity in the Western Pacific (c) Central Pacific (d) and East Pacific (e) in the Normal Phase (January-August 2017). The black graph depicts the temperature value and red represents the salinity value.

Normal Phase showed the position of warm ponds concentrated in the Western Pacific. The temperature increase is not high by 0.02 °C and the decrease in salinity is quite large, namely 0.2 psu in the West Pacific (Figure 3c) due to the warm ponds that have moved to the West Pacific since the La Niña phase. Salinity increases in the Central Pacific region by 0.1 psu due to the high salinity water mass being carried by the South Equatorial Current (SEC) from the East Pacific to the west. The higher
salinity in the East Pacific indicates equatorial upwelling in the form of an increase in the mass of cold water with high salinity from the depth that has occurred since the La Niña phase. So that the patterns of changes in temperature and salinity do not differ in La Niña conditions.

In normal conditions, the temperature in the western tropical Pacific is marked with a value > 28.5 °C and a low salinity < 34.6 psu (Figure 4a). Warm temperatures cause wet air masses to descend over the Western Pacific and result in a process of precipitation. At the same time, high precipitation affects low salinity in the Western Pacific. This is in line with the opinion of [8], which states that the SST value of 28 °C is the threshold for the formation of atmospheric convection integrated with surface wind movement and rainfall. According to [3], rainfall through its salinity effect can reach up to 30% of the reduction in sea surface salinity over warm ponds.

3.2 Horizontal Displacement of Convergence Zone
During the weak to strong El Niño period (January - August 2015), the convergence zone moves towards the Middle and East Pacific from a boundary of longitude 177 °E to 160 °W. Entering September 2015 to February 2016 the convergence zone moved up to 136 °W longitude. In this period the movement of the most massive convergence zone towards the East Pacific was caused by the Super El Niño phenomenon with temperature anomalies reaching 2.67 °C in a row over a span of 6 months. During the final El Niño period March - April 2016 the isotherm 28.5 °C began to move towards the West Pacific from 140 °W - 178 °E. The convergence zone reaches the westernmost boundary in weak La Niña conditions (July - October 2016) with a longitude limit of 154°E. Meanwhile, during the transition from La Niña to normal (October 2016 - January 2017) the convergence zone moves back to the east with a longitude of 164 °E. This indicates that the La Niña phase is an amplified normal phase where the South Equatorial Current (SEC) is moving to push the warm pool to the West Pacific stronger than normal conditions.

During the strong El Niño (Figure 5c) the easternmost longitude boundary of the convergence zone is at longitude 145 °W, while during normal times (Figure 5f) the westernmost boundary of the convergence zone is at longitude 157 °E. In addition, during a strong El Niño the convergence zone extends to the East Pacific while in normal conditions the convergence zone moves to the West Pacific with an area smaller than during a Strong El Niño condition. The zonal movement of the convergence zone was detected in the equatorial region at intervals of latitude 5 °N - 5 °S. This indicates that the current mechanism in the Equatorial Pacific is responsible for moving the convergence zone.

The area of the convergence zone observed changes every year based on longitude and the movement is in phase with ENSO. The zonal movement of the convergence zone represents the movement of a warm pool which is influenced by the force of the trade wind. In normal conditions and La Niña trade winds blow from the East and Southeast pushing the warm pool towards the western Pacific Ocean. On the other hand, in El Niño conditions, the warm pool moves from the west pacific to the east pacific due to the weakening of the east trade winds accompanied by an anomaly of increasing the intensity of the westerly wind burst.

The movement of the convergence zone during La Niña and Super El-Nino has a limit on longitude at 154 °E-136 °W, respectively. These results are close to the results of research conducted by [6] observed the movement of this convergence zone by installing a buoy-drifter with a location 4 °S-4 °N mid-1988-1993 which occurred sequentially strong El Niño events (1986-1987) with the highest ONI index of 1.77 °C and La Strong Nina (1988-1989) with the lowest ONI index of -1.87 °C and an extension of the 1991-1993 El Niño heating period. The results reveal that the buoy drifter trajectory follows the movement of the eastern edge of the warm pool, especially at a temperature of 28.5 °C and a salinity of 34.6 psu. Drift is found at coordinates 140 °E - 140 °W. The difference in the results of the study was caused by the different intensity of ENSO.
Figure 4. Longitude-time distribution at 5°N-5°S of a) averaged SST and b) averaged SSS compared to NINO 3.4 Index. Weak La Niña (LL); Normal (N); Weak El Niño (EL); Strong El Niño (ES); Moderate El Niño (ES); Super El Niño (SO).
3.3 Vertical Displacement of Convergence Zone

At the time of Super El-Nino the boundary of the warm water column was marked (isotherm 28.5 °C) and the salinity front (isotherm 34.6 psu) moved eastward to longitude 145 °W. The convergence zone in the Western Pacific reaches a depth of 90 m. During normal conditions, the boundary of the convergence zone moves westward to longitude 180° at a depth of 100 m. Meanwhile, during moderate La Niña conditions, the convergence zone boundary moves further west to 170 °W longitude at a depth of 125 m.

This implies the vertical movement of the convergence zone due to changes in the depth of the warm pool. The effect of El Niño on reducing the depth of warm pools is due to the expansion of the warm pool area to the East Pacific. This is due to the movement of warm low salinity water masses from warm pools in the West Pacific towards the East Pacific pressing down on high salinity cold water masses in the East Pacific resulting in a decrease in temperature gradient. Meanwhile, at La Niña the depth of the convergence zone is deeper indicated by the very steep temperature gradient in the East Pacific. There is a divergence process in the form of upwelling where the cold water mass rises to the surface to fill the void of warm water mass which returns to the West Pacific during the cooling phase in the East Pacific. The climate variability (Normal, El Niño, dan La Niña) are supposed to causes the upwelling characteristic changes, both temporally (upwelling periodic) and spatially (horizontal distribution) and also upwelling intensity [11].
Figure 6. Vertical Distribution of SST (upper panel) and SSS (lower panel) on Super El Niño (December 2015), Normal (December 2016) and La Niña (December 2017).
3.4 The Influence of Super El Niño On Convergence Zone’s Displacement

Interannual changes in surface currents near the equator are mainly due to ENSO signals. (Figure 7) shows during the El Niño period (January 2015 - April 2016) the dominant surface currents to the east. The current which has the greatest speed of 5 m / s is shown in the range July-October 2015 moving to reach longitude 165 °W. While in La Niña and Normal conditions the dominance of the current moves to the west. The current moving west at a velocity (-5 m / s) reaches longitude 130 °E.

![Figure 7](image_url)

**Figure 7.** Time/longitude sections of surface zonal currents and ENSO for the 5°N- 5°S band during 2015–2017 period.

The program results well reproduce the presence of a permanent mainstream in the equatorial Pacific. (Image) shows the main components of currents moving westward from the equatorial current system, namely the North Equatorial Current (NEC) and South Equatorial Current (SEC). NEC is in the 7-10 °N latitude interval while SEC is found at 0-20 °S latitude. New Guinea Coastal Current (NGCC) water masses drained from SEC currents were also found along the Papua New Guinea coastline which then rotated to form Halmahera Eddy over Papua Island. The simulation also shows the most important eastward flow in the zonal movement of warm ponds, namely the North Equatorial Counter Current (NECC). NECC is transported from a branch of the SEC stream, flowing between 2-7 °N.

In the Super El Niño (a) condition, the NECC speed reaches its greatest strength with a speed of 0.8 m / s so that it is able to push the warm pool into the East Pacific. In La Niña (c) conditions, the velocity of the current moving from east to west in this case the South Equatorial Current (SEC) is up to 0.8 m / s. The current component that acts on the La Niña phase is stronger than the normal phase. So the La Niña phase is an amplified normal phase. The current with a faster speed causes the warm pool that is formed to expand westward into Indonesian waters and hold the warm pool to remain the West Pacific. In contrast to La Niña conditions, under normal conditions the speed of the South Equatorial Current (SEC) is the largest in the East Pacific region and decreases towards the West Pacific to be 0.3 m / s.
Figure 8. Monthly mean of sea surface current on Super El Niño August 2015 (a), La Niña August 2016 (b) dan normal August 2017 (c).

During Super El Niño, a large sea surface temperature gradient between the warm pool in the West Pacific and the cold tongue in the Central-East Pacific caused the strength of the westerly winds to increase and induced zonal current movement in pushing the warm pool further east. In this condition, zonal advection is driven by large-scale surface currents around the equator which are identified as the North Equatorial Counter Current (NECC).

The magnitude of the temperature gradient integrated with the NECC velocity described by [9] in the results of his research analyzed when the El Niño wind pressure anomaly resulted in an increase in positive Wind Stress Curl (WSC) moving synclonically over the West Pacific which then induced ekmn pumping to form a temperature gradient the steep and meridional gradients of sea level. Simultaneously a positive WSC also increases the strength of the northern subtropical gyre while the southern subtropical gyre is weak, this causes a large temperature difference across the counter current region so that the counter current speed becomes stronger. This situation implies the ability of the NECC to flow warm water from the West Pacific to the East Pacific and cause warm pools to lose mass in the Western Pacific.

On contrary, when the negative WSC moving anticyclonic speed increases and causes the southern subtropical gyre to be strong, while the northern subtropical gyre is weak, the temperature difference is small, and the counter current will not strengthen but the SEC (South Equatorial Current) which moves...
west is stronger. This situation will result in the discharge of water from the warm pond a little, but there is a strong accumulation of warm water in the pool by the intensive Southern Equatorial Current. This occurs in the La Niña and Normal phases. As stated by [10], during an El Niño event, the sea level difference between the two gyres increases, and falls, rapidly. This confirms the notion that El Niño events involve the periodic discharge of warm water from the Western Equatorial Pacific.

3.5 The Effect of Convergence Zone’s Displacement on Skipjack Tuna Catch

The pattern of increase in Skipjack tuna CPUE is clearly described as having a positive association with temperature changes. During the El Niño period, the number of CPUE increased significantly during (June-September 2016) which peaked in September with a value of 15000 tons. This finding is similar with Kunarso et al [11, 12] who found that El Niño tend to increase tuna catches along the southern coast of Java to Lesser Sunda Islands. Meanwhile the temperature reached its warmest value in December 2015 during the El Niño period three months after the peak catch of Skipjack tuna. This shows the high responsiveness of Skipjack fish to changes in temperature. A decrease in skipjack is also followed by a decrease in temperature with a change of 0.1 °C the amount of CPUE can experience a large decline. After the El Niño phase, the increasing CPUE pattern follows the seasonal pattern of periodically high CPUE in the east monsoon (June-August). The easterly monsoon winds move from east to west causing warm pools to be concentrated in the western Pacific. This is consistent with the CPUE plotting of skipjack tuna, which is dominant in the Western Pacific. The difference in the amount of fish catch can be seen in the 2016 eastern season getting a CPUE value of 10000 tons, which is higher than the CPUE in the 2017 eastern season which is only perched at 7000 tons. This is inseparable from the temperature value in the 2016 east monsoon which was higher than the temperature in the 2017 east monsoon.

Figure 9. Correlation of Skipjack Tuna CPUE temporal distribution in 2015-2017 (black graph) with the average monthly temperature (red graph).

Temporal distribution also explains the effect of ENSO on the catch of skipjack tuna. Based on the ONI index, the east season, both 2016 and 2017, were classified as normal ENSO periods. This indicates that the increase in the number of Skipjack fish catches in September 2015 when compared to normal conditions is an implication of the Super El Niño phenomenon which is characterized by a longer warming period and a large temperature anomaly on the surface of the Pacific Ocean. The trend of changes in the catch volume of Skipjack tuna according to changes in temperature, season and ENSO
values is a starting point that can explain the effect of movement of the convergence zone on Skipjack fish migration.

Figure 10. Horizontal Distribution of Skipjack Tuna CPUE 2015-2017 (a) and Convergence zone (b).

Figure 10 illustrates the accumulation of Skipjack tuna CPUE at each longitude in the catchment area during the 2015-2017 study year. The peak catch of Skipjack tuna is at longitude 155 °E- 175 °E with a catchment range of 16,000 tons to 25,000 tons. The horizontal distribution of the skipjack CPUE shows the same location as the convergence zone. The convergence zone shown in Figure (10b) is in the Equatorial Pacific with a longitude limit of 150 °E - 170 °W covering an abundance area of Skipjack tuna.

Figure 11. Skipjack Tuna Catches (a) and Time/longitude sections of Sea Surface Temperature and ENSO for the 10°N- 10°S band (b).
The indication of The Effect of Convergence Zone’s Displacement on the skipjack tuna migration is evidenced in (Figure 11). Broadly speaking, the amount of catch follows the movement pattern of the 28.5 °C isotherm in the ENSO phase. During the Super El Niño (August 2015 - February 2016) the isotherm 28.5 °C moved further east along with the zonal movement of the warm pond and the abundance of fish increased to 150,000 tons. In contrast, during normal times and La Niña (2017) isotherm 28.5 °C moves to the west and the amount of fish abundance decreases to 50,000 tons. Interestingly, most of the skipjack tuna catches occurred in the interval 10 °N-10°S latitude, at this latitude interval is also found movement of isotherm 28.5 °C such as (Figure 11). This supports the possible role of convergence zone dynamics on the mechanism of movement and aggregation of Skipjack tuna on the surface. Figure 10 illustrates the accumulation of Skipjack tuna CPUE at each longitude in the catchment area during the 2015-2017 study year. The peak catch of Skipjack tuna is at longitude 155 °E- 175 °E with a catchment range of 16,000 tons to 25,000 tons. The horizontal distribution of the skipjack CPUE shows the same location as the convergence zone. The convergence zone shown in Figure (10b) is in the Equatorial Pacific with a longitude limit of 150 °E- 170 °W covering an abundance area of Skipjack tuna.

The same results were obtained in the study of [2], the results showed that during La Niña 1988-1989, the catch of purse seine fleets concentrated in warm ponds decreased to the west of 160°E. In contrast, during the three weak El Niño series of events during the 1991-1995 period, skipjack tuna was caught in an area stretching eastward with warm pool. Analysis of the correlation between the longitudinal center of gravity of the CPUE with the SOI index of 0.75 and the correlation of the movement of the isotherm 29 °C with SOI of 0.89.

4. Conclusion
The study of the dynamic of convergence zone displacement in Western Pacific Ocean in 2015 Super El Niño event has been revealed using satellite, reanalysis and observation data. The convergence zone moves eastward reaches by 136 °W in the eastern Pacific and moves to a depth of 90 m during Super El Niño 2015. Conversely, when La Niña the convergence zone moves west as far as 154 °E in the Western Pacific at a depth of 125 m. At the beginning of Super El Niño, a large sea surface temperatures gradient between warm pools in the West Pacific and cold tongue in the Central-East Pacific increases the strength of westerly wind burst and induces the movement of zonal currents in pushing warm pools further east. In this condition zonal advection is driven by large-scale surface currents and identified as North Equatorial Counter Current (NECC). NECC has the greatest speed during the Super El Niño phase of 0.8 m/s. Changes in the number of skipjack catches following the isotherm 28.5 °C movement pattern during the ENSO phase. During the Super El Niño (August 2015 - February 2016) the isotherm 28.5 °C moved further east and the abundance of fish increased to 150,000 tonnes. In contrast, during normal times and La Niña (2017) isotherm 28.5 moves to the west and the amount of fish abundance decreases to 50,000 tons.

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