Impact of El Niño Southern Oscillation (ENSO), variability on skipjack tuna (Katsuwonus pelamis) catches

by Cek Turnitin

Submission date: 24-May-2023 11:46AM (UTC+0800)
Submission ID: 2100557183
File name: 2021.1685-1694.pdf (890.91K)
Word count: 4389
Character count: 23213

Impact of El Niño Southern Oscillation (ENSO), variability on skipjack tuna (*Katsuwonus pelamis*) catches in the fisheries management area (FMA) 715, Indonesia

[1]Sepri, [2]Agus Hartoko, [2]Suradi W. Saputra, [2]Abdul Ghofar, [3]Erick Nugraha

[1] Doctoral Programe in Coastal Resources Management, Fisheries and Marine Science Faculty, Diponegoro University, Semarang, Central Java, Indonesia; [2] Coastal Resources Management, Fisheries and Marine Science Faculty, Diponegoro University, Semarang, Central Java, Indonesia; [3] Faculty of Fishing Technology, Jakarta Technical University of Fisheries, South Jakarta, Indonesia. Corresponding author: E. Nugraha, nugraha_eriq1@yahoo.co.id

Abstract. Marine and fishery resources have trans-boundary nature and have great potential to be affected by the global climate change. Tuna is one of the main export commodities from Indonesia. Patterns of fish life can not be separated from the environmental conditions, whose fluctuations influence the seasonal fish migration and residence period. This study aimed to determine the tuna catch variability in the peak season, under regional climate change constraints, such as El Niño and La Nina, with the aim to optimize the utilization of *Katsuwonus pelamis*. A descriptive qualitative study was conducted to investigate the direct correlation between *K. pelamis* catches during 2015 to 2019 and regional climate changes that occurred in those periods, i.e., El Niño (2015 to 2019) and La Nina (2015 to 2019). Sampling and measurement sessions were performed at the end of the East season, from September to December 2019. The results of this study show that regional climate change affected inter-monthly variation of the peak seasons of *K. pelamis* fishing in the fisheries management area (FMA) no. 715. During El Niño, the FMA 715 was an ideal place for *K. pelamis* fishing. During the period from September to November, the fishing peak season was in October. The regional climate change originating from the Pacific Ocean caused unsuitable water conditions in the FMA 715, regarding the *K. pelamis* fishing. The variability of the climate changes triggered by La Nina in the Pacific Ocean did not provide a favorable environment for the fish migration to the FMA 715 waters.

Key Words: La Nina, salinity, sea surface temperature, climate change, tuna fishing.

Introduction. Indonesia is an archipelagic country that has a strategic position and its waters are part in the oceanic movement known as the Great Ocean Conveyor Belt. The changes occuring in the pattern of the global water mass movement affect the world's climate (Trenberth 2007). The global warming that hits the world today causes global climate change that is irregular and has an impact on the environment as a whole (Blunden et al 2018). This global change affects life in the territorial area and negatively impacts the potential quality and quantity of the marine and fisheries resources (Yáñez et al 2017). The impact of the global warming increased temperatures with 0.5°C throughout the 20th century (Church & White 2011; Masson-Delmotte et al 2018).

Marine and fisheries resources have a trans-boundary character (Song et al 2017) making them vulnerable to the global climate change (Barange et al 2014; Monnereau & Oxenford 2017). Environmental changes that occur and have an impact on the water resources in a particular area can cause environmental changes in other areas (Duran-Encalada et al 2017). Changes in the global environment emerge due to the climate changes characterized by the atmosphere warming. Tuna is one of Indonesia's main export commodities (Hidayat et al 2019; Ningsih 2018). Fish life patterns cannot be separated from the various environmental conditions.

Fluctuations in the environmental conditions have major influences on the period of seasonal migration (Taylor et al 2013) and the presence of fish in certain places (Enders & Boisclair 2016). The main problems faced in the effort to optimize fish catches, especially *Katsuwonus pelamis*, are the availability of data sources for fishing catches and for site characterization. There is very limited data and information about oceanographic conditions that are closely related to potential fishing areas. The early availability of this information is essential for the *K. pelamis* fishing community, so that fishermen can direct their fishing activities effectively and efficiently.

This study aimed to determine the variability of *K. pelamis* catch season to regional climate changes, i.e. El Niño and La Nina. This study investigated the water sensitivity of FMA 715 towards the regional climate changes that affected the monthly variability of *K. pelamis* catches, with the aim to optimize the *K. pelamis* fishing.

Material and Method

Description of the study site. The position of the each observation station was recorded using the Global Positioning System (GPS) in FMA 715, West Papua. Fishing ground location was located in yellow colour area (Figure 1).

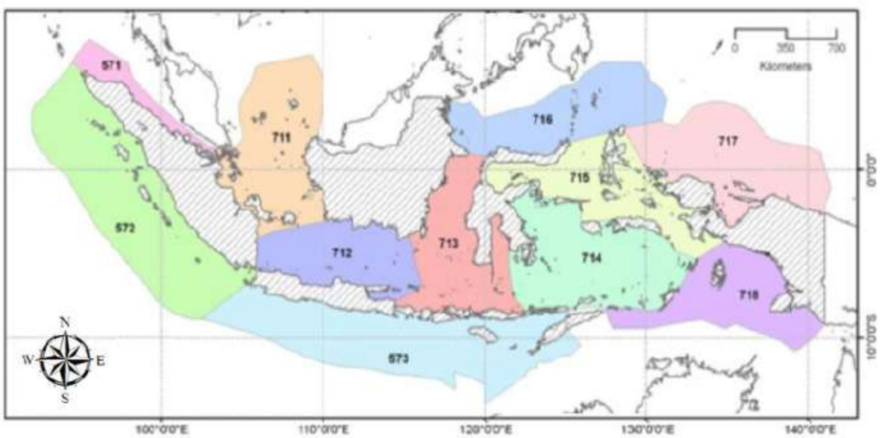

Figure 1. Map of sampling site (MMAF 2018).

Data collection. Observations and data collection on oceanographic variable factors (SST and salinity) in the FMA 715 area were carried out using satellite data and in situ data from September to December 2019, where the West Papua Province was still in the transition season from the East season (Figure 2). The study was conducted using qualitative and descriptive methods by investigating the direct correlation between *K. pelamis* catches during 2014 to 2019 and the regional climate change events that occurred during those periods, i.e., El Niño (2014 to 2019) and La Nina (2004 to 2019) using data from the Indonesian Meteorology, Climatology and Geophysical Agency, Jefman Sorong Station.

Sampling and measurement sessions were carried out at the end of the East season, which was between September and November 2019. Simultaneous measurement methods of the Sea Surface Temperature (SST) in the FMA 715 waters area were performed using satellite imagery and Triton buoy data.

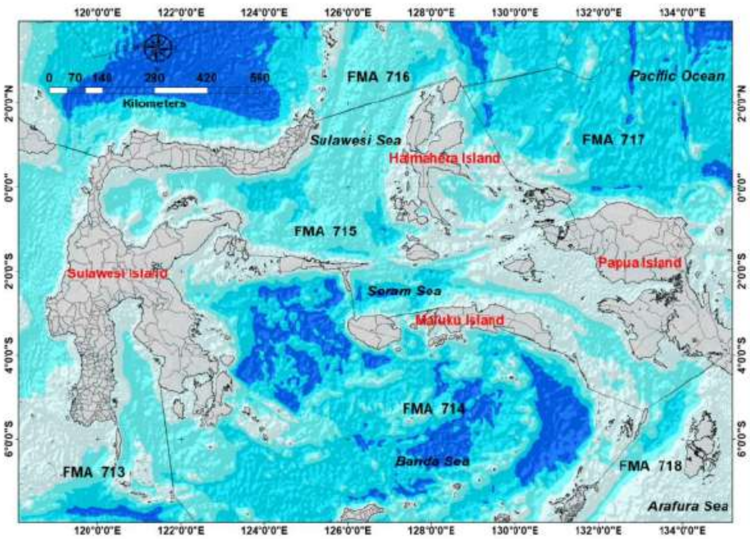

Figure 2. Indonesia Fisheries Management Area (FMA) 715 (MMAF 2018).

Data analysis. Data analysis using descriptive qualitative analysis was conducted to investigate the direct correlation between *K. pelamis* catches during 2014 to 2019 and the regional climate changes that occurred in those periods, i.e., El Niño (2015 to 2019) and La Nina (2015 to 2019).

Results and Discussion

Resources. West Papua is one of the Provinces in the Papua Island that has a considerable fish resource potential and has good prospects for capture fishery activities, especially pelagic species, among which fishery commodities with important economic value such as tuna, *K. pelamis* and small fish groups. It was recorded in 2019 that 15,825 tons of tuna were caught (MMAF 2012). Fishing season occurs throughout the year and moves according to food availability and temperature that can be tolerated by the fish body (Brucet et al 2012; O'Gorman et al 2016).

K. pelamis in eastern Indonesia waters are available throughout the year, especially in the Maluku Sea, Halmahera Sea, Banda Sea, Seram Sea and Sulawesi Sea (Tadjuddah et al 2017; Hidayat et al 2019). The abundance of *K. pelamis* is very dependent on the oceanographic conditions of waters, especially on the water temperature (in accordance with the tolerance of body temperature of *K. pelamis*) and abundance of food. The potential fishing catch zone is strongly influenced by oceanographic physical, chemical and aquatic biology factors, including the SST (Zainuddin 2011), distribution of horizontal (Zainuddin et al 2017) and vertical temperature, salinity, chlorophyll-a concentration and front or up welling phenomena (Putri et al 2018).

Climate conditions. The waters of FMA 715 are areas of a tropical zone, in a region with rainfalls above 3,000 mm year^{-1}, located to the west of Irian and Mindanao. It is the center of a warm water pool, which results in intensive convection accompanied by high velocity currents (Wyrtki 1961). During the period of 2019 in September-November, data collected from Jefman station, Sorong, showed the average rainfall decrease, both in number of rainy days and in rain intensity. This indicates the occurrence of the seasonal transition process in the FMA 715 waters, from the rainy season to the summer (transition season).

Oceanographic conditions. In the eastern part of the Indonesian archipelago flow 7nportant ocean currents, known as Arus Lintas Indonesia (Arlindo). This current flows from the Pacific Ocean to the Indian Ocean and falls on the surface and the thermocline zone. In general, the waters of the West Papua Sea and FMA 715 are directly influenced 10 the Pacific water mass, from the entrance of the main area consisting of the Indonesian waters to the Indian Ocean. The effect of oceanic water mass from the Pacific Ocean is dominant in the East season.

The upwelling process in the waters of North Papua is generally caused by the flow of westward water mass from the Pacific, in the form of warm water mass towards the Halmahera Island, which spreads in many directions, including towards the equator and Indonesian waters, through the waters gate between the Halmahera and the Papua Islands (Hartoko 2007). Pelagic fish are organisms that have the ability to move, so that they do not depend on ocean currents or the water movements caused by wind. However, the ocean currents form areas known as upwelling and fronts. The horizontal surface temperature pattern in North Papua comes from the mass flow temperature of the water originating from the Northwest. Th12 event is known as the lower current in New Guinea Coastal under Current (NGCUC). The transfer of water mass from the Pacific (inflow) into the Eastern islands such as Papua occurs along the Northwest monsoon and outflows to the Indian Ocean, during the Southeast monsoon wind (Hartoko 2007). The NGCUC water mass flows from a depth of 100 m in the North Papua, then continues to the surface of the water in the South Halmahera and becomes upwelling as shown in Figure 3. Upwelling brings nutrients from deeper water to the surface, causing nitrification and phytoplankton bloom (Kämpf & Chapman 2016).

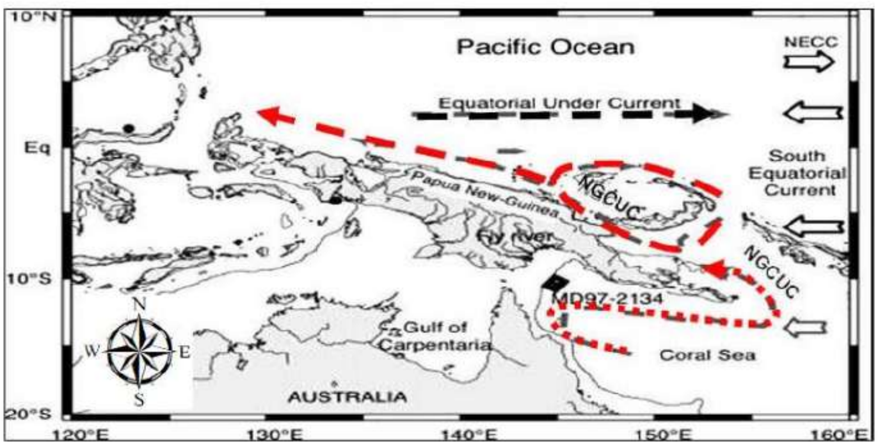

Figure 3. Current flow patterns in North Papua (Hartoko 2007).

Water temperature. The temperature of the FMA 715 waters is directly affected the Pacific Ocean. Water temperature based on vertical sea temperature data from Triton buoy was obtained at various depths 1.5 m. Temperature data from Triton show an average of the SST variations ranging from 28.4 to 30.6°C (Figure 4). The largest catch of *K. pelamis* occured in the SST range of 29 to 30°C (Nugraha et al 2020).

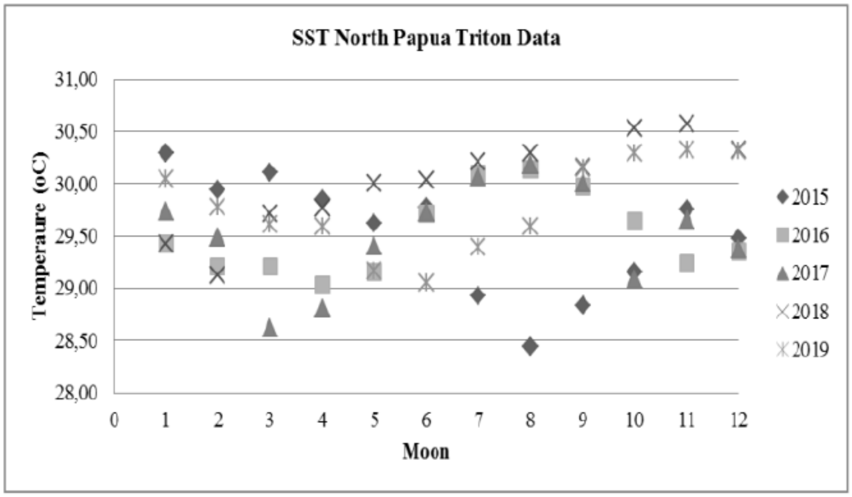

Figure 4. Sea Surface Temperature (SST) in the FMA 715 waters.

Salinity. The water surface layer's salinity is influenced by wind and monsoon current. In the east monsoon, a high salinity value occurs due to Arlindo currents, which transfer water masses from the Pacific Ocean into Eastern Indonesian (Bahiyah et al 2019). The vertical salinity data of the TRITON buoy shows the temperature data obtained at each depth of 1.5 m. During the period from 2015 to 2019, the salinity profiles at certain coordinate points in North Papua show values ranging from 33.3 to 34.6 psu (Figure 5).

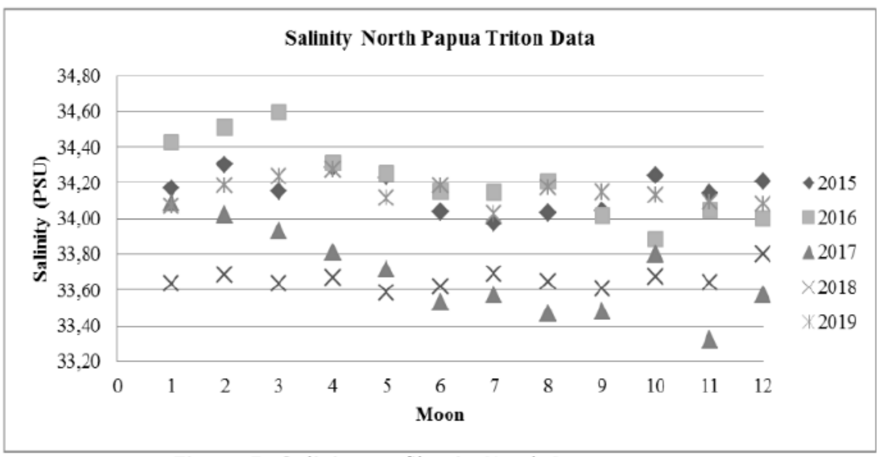

Figure 5. Salinity profiles in North Papua waters.

Catches of K. pelamis. January, May to June and September to December are not the appropriate seasons for *K. pelamis* fishing in the area of Papua. The five years catches of *K. pelamis* originating from the headwaters of Papua and landing at Radios Apirja Co. Ltd. reached their highest levels in March. It can be assumed that in March, the waters to the north of Papua (FMA 715) were in a suitable condition, with food available in abundance, and it was convenient for *K. pelamis* to migrate into (Mugo et al 2010).

The graph from Figure 6 of *K. pelamis* catches shows decreasing trends in the fishing periods of February to May and September to December and increasing catches in June to August, November and January, without considering other factors that affect production, such as fishing fleet, size and number of catches.

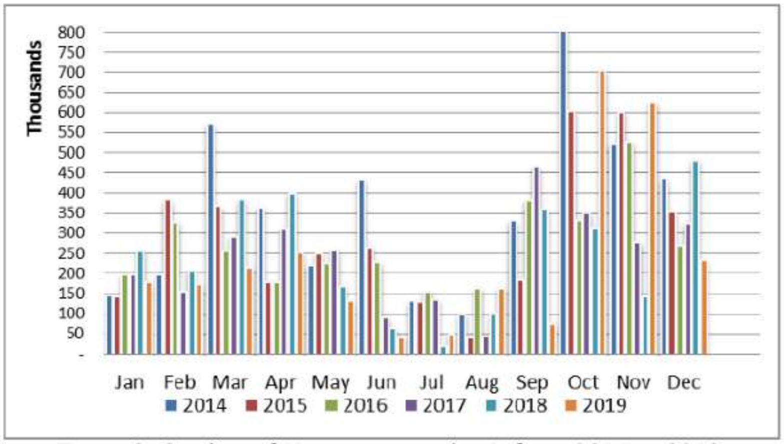

Figure 6. Catches of *Katsuwonus pelamis* from 2014 to 2019.

Correlation analysis of K. pelamis catches and regional climate change. The conditions of Indonesia's oceanography are influenced by global climate change factors, for example by the condition of rainfall on land and at sea, the sea surface temperature (SST) and the sea level height. Rainfall is influenced by the El Niño phenomenon which is predicted to affect sea surface temperature. Global warming will increase sea level (Mimura 2013) and water temperature (Brown et al 2019). The impact of the ozone layer is expected to affect the performance of chlorophyll synthesis.

El Niño. El Niño is characterized by a SST decrease in the Indonesian waters and increase (of more than 0.5°C) in the eastern tropical Pacific Ocean (Sofian et al 2011). From March 2014 until April 2016, the regional climate experienced one of the longest dry seasons in History, due to El Niño. The year and intensity of El Niño can be seen in Figure 7 (NOAA-NWS 2019).

Running 3-Month Mean ONI values

https://origin.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ONI_v5.php

WE=Weak El Niño, ME=Moderate El Niño, SE=Strong El Niño, VSE=Very Strong El Niño

WL=Weak La Niña, ML=Moderate La Niña, SL=Strong La Niña

ENSO Type	Season			JJA	JAS	ASO	SON	OND	NDJ	DJF	JFM	FMA	MAM	AMJ	MJJ
	2013	-	2014	-0.4	-0.4	-0.3	-0.2	-0.2	-0.3	-0.4	-0.4	-0.2	0.1	0.3	0.2
WE	2014	-	2015	0.1	0.0	0.2	0.4	0.6	0.7	0.6	0.6	0.6	0.8	1.0	1.2
VSE	2015	-	2016	1.5	1.8	2.1	2.4	2.5	2.6	2.5	2.2	1.7	1.0	0.5	0.0
WL	2016	-	2017	-0.3	-0.6	-0.7	-0.7	-0.7	-0.6	-0.3	-0.1	0.1	0.3	0.4	0.4
WL	2017	-	2018	0.2	-0.1	-0.4	-0.7	-0.9	-1.0	-0.9	-0.8	-0.6	-0.4	-0.1	0.1
WE	2018	-	2019	0.1	0.1	0.4	0.7	0.9	0.8	0.8	0.8	0.8	0.8	0.6	0.5
WE	2019	-	2020	0.3	0.1	0.1	0.3	0.5	0.6	0.5	0.6	0.5	0.3	0.0	-0.3

Figure 7. El Niño years and intensities (NOAA-NWS 2019).

El Niño began to be felt in October 2014, with a moderate intensity, when the western Pacific equatorial hot pool moved from the west to the central Pacific. This caused Indonesia's internal waters to obtain a mass supply of water that is relatively cooler than the The Indonesia through Flow (Arlindo) coming from the western Pacific Ocean. This condition continued to grow with the strengthening of El Niño signals, which became extreme in November 2015 and returned to normal conditions in May 2016 (Figure 7). From August 2015 to April 2016, El Niño was a stronger category, even reaching its peak in January 2016 (Figure 7), and during this phase, *K. pelamis* catches increased (Figure 6).

Normal phase. The oceanographic conditions of FMA 715 returned to normal and upwellings began to form. The formation of warm water masses in the internal waters of

FMA 715 is an ideal condition for the *K. pelamis* environment. The normal phase can be observed from March to September 2014 and from March to August 2018, with increasing yield catchment, but not as significant as in the El Niño phase.

La Nina phase. During La Nina (from June 2016 to January 2017 and from June 2017 to April 2018), *K. pelamis* catches were decreased when observed in the fishing area of the western Pacific, compared to the eastern and central Pacific regions. Correlations between *K. pelamis* catches in FMA 715 waters and regional climate change could be observed, using SST and depth temperature data from the Triton buoy. Within the transition season (September to November), the *K. pelamis* catches showed a decrease.

K. pelamis migrated in the La Nina period, moving from the Pacific to the East (including Indonesia). These conclusions proved the observation of a shift in the fishing season, caused by climate change, reported by the fishing communities active in the FMA 715. This weather deviations can have a positive impact on the fisheries sector, triggering migrations of tuna to the territorial waters of Indonesia. Turkington (2019) reported that El Niño and La Niña have the potential to occur periodically, every 2 to 3 years.

A possible impact of the climate change on fisheries is a decrease in the catch results, which can occur due to the migration of the targeted fish species. The migration from temperate (sub-tropical) to tropical climate regions (and not vice versa), due to the climate change, will decrease the fish stocks. Climate change will greatly affects the physiology and behavior of individuals, populations and communities (Walther 2010; Butler 2019). Extreme conditions with rising water temperatures, low dissolved oxygen concentrations and water pH can result in fish death. Environmental conditions that are not optimal can reduce metabolic rate, growth and ability of fish to lay eggs, and can also change metamorphosis, endocrine systems and patterns of the fish skin (Roessig et al 2004).

Conclusions. This study suggests that the peak season of *K. pelamis* fishing in the waters of FMA 715 can be predicted based on information on the area's climate conditions. The study also shows that regional climate change greatly affects the inter-monthly variation and the peak of the *K. pelamis* fishing season, in the FMA 715 waters. During El Niño, these waters are an ideal place for catching *K. pelamis*. In normal climatic conditions, the peak of the fishing season occurs from October to November. Regional climate change triggered from the Pacific Ocean does not provide a suitable environment for *K. pelamis* migration to the FMA 715 waters. Therefore, the regional climate change triggered from the Pacific Ocean can also make these waters unfavorable for the *K. pelamis* environment.

Acknowledgements. This research was funded by the Marine and Fisheries Education Centre - Ministry of Marine Affairs and Fisheries Republic of Indonesia. Thanks also to Marine and Fisheries Resources Surveillance Sorong, Citra Raja Ampat Canning Co. Ltd Sorong and MV. Cinta Bahari 09 crews for enabling us to carry out this research.

Conflict of interest. The authors declare no conflict of interest.

References

Bahiyah A., Wirasatriya A., Marwoto J., Handoyo G., Anugrah A. D. S. P., 2019 Study of seasonal variation of sea surface salinity in Java Sea and its surrounding seas using SMAP Satellite. IOP Conference Series: Earth and Environmental Science 246(1):1-12.

Barange M., Merino G., Blanchard J. L., Scholtens J., Harle J., Allison E. H., 2014 Impacts of climate change on marine ecosystem production in societies dependent on fisheries. Provisional. Nature Climate Change 4(3):211-216.

Blunden J., Ardnt D., Hardfield G., 2018 State of the climate in 2011: State of the climate in 2011. Special Supplement to The Bulletin of The American Meteorological Society 93(7):1-310.
Brown B. E., Dunne R. P., Somerfield P. J., Edwards A. J., Simons W. J. F., Phongsuwan N., Putchim L., Anderson L., Naeije M. C., 2019 Long-term impacts of rising sea temperature and sea level on shallow water coral communities over A ~40 year period. Scientific Report 9(1):1-12.
Brucet S., Boix D., Nathansen L. W., Quintana X. D., Jensen E., Balayla D., Meerhoff M., Jeppesen E., 2012 Effects of temperature, salinity and fish in structuring the macroinvertebrate community in shallow lakes: Implications for effects of climate change. PLoS ONE 7(2):1-11.
Butler C. J., 2019 A Review of the effects of climate change on Chelonians. MDPI, Diversity 11(138):1-22.
Church J. A., White N. J., 2011 Sea-level rise from the Late 19th to the Early 21st Century. Survey in Geophysics 32:585-602.
Duran-Encalada J. A., Paucar-Caceres A., Bandala E. R., Wright G. H., 2017 The impact of global climate change on water quantity and quality: A system dynamics approach to the US–Mexican transborder region. European Journal of Operational Research 256(2):567-581.
Enders E. C., Boisclair D., 2016 Effects of environmental fluctuations on fish metabolism: Atlantic salmon *Salmo salar* as a case study. Journal Fish Biology 88(1):344–358.
Hartoko A., 2007 Vertical temperature, the fate of up welling and spatial distribution of fish biomass of North. Journal Coastal Development 10(3):181–187.
Hartoko A., 2009 Ocean observation on SST variability and sub-surface sea water temperature of the North Papua the fate of El Niño 1997 & 2007 and La Nina 2002: Field Measurement and Triton Buoy Data. Journal of Coastal Development 13(1):28–35.
Hidayat R., Zainuddin M., Putri A. R. S., Safruddin, 2019 Skipjack tuna (*Katsuwonus pelamis*) catches in relation to chlorophyll-a front in Bone Gulf during the southeast Monsoon. AACL Bioflux 12(1):209-218.
Kämpf J., Chapman P., 2016 Upwelling systems of the world: A scientific journey to the most productive marine ecosystems. Springer International Publishing, 433 p.
Masson-Delmotte V., Zhai P., Pörtner H.-O., Roberts D., Skea J., Shukla P. R., Pirani A., Moufouma-Okia W., Péan C., Pidcock R., Connors S., Matthews J. B. R., Chen Y., Zhou X., Gomis M. I., Lonnoy E., Maycock T., Tignor M., Waterfield T., 2018 Global warming of 1.5°C. An IPCC special report on the impacts of global warming of 1.5°c above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. IPCC, 616 p.
Mimura N., 2013 Sea-level rise caused by climate change and its implications for society. Proceedings of the Japan Academy, Series B 89(7):281-301.
Monnereau I., Oxenford H. A., 2017 Impacts of climate change on fisheries in the coastal and marine environments of Caribbean Small Island Developing States (SIDS). Science Review, pp. 124-154.
Mugo R., Saitoh S. I., Nihira A., Kuroyama T., 2010 Habitat characteristics of skipjack tuna (*Katsuwonus pelamis*) in the Western North Pacific: A remote sensing perspective. Fisheries Oceanographic 19(5):382-396.
Ningsih R., 2018 Strengthening Indonesia's exports of fish and processed fish products to Canada. TPSA, Canada–Indonesia Trade and Private Sector Assistance Project, 38 p.
Nugraha E., Gunawan R., Danapraja S., Yusrizal, Kusdinar A., Waluyo A. S., Hutajulu J., Prayitno H., Halim S., Sutisna D. H., 2020 The sea surface temperature effect on the length and size of skipjack tuna (*Katsuwonus pelamis*) catches in the Banda Sea, Indonesia. AACL Bioflux 13(1):1-18.
O'Gorman E. J., Ólafsson O. P., Demars B. O. L., Friberg N., Guðbergsson G., Hannesdóttir E. R., Jackson M. C., Johansson L. S., McLaughlin O. B., Ólafsson J. S., Woodward G., Gíslason G. M., 2016 Temperature effects on fish production across a natural thermal gradient. Global Change Biology 22(9):3206–3220.

Putri A. R. S., Zainuddin M., Putri R. S., 2018 Effect of climate change on the distribution of skipjack tuna *Katsuwonus pelamis* catch in the Bone Gulf, Indonesia, during the southeast monsoon. AACL Bioflux 11(2):439–451.

Roessig J. M., Woodley C. M., Cech J. J., Hansen L. J., 2004 Effects of global climate change on marine and estuarine fishes and fisheries. Reviews in Fish Biology and Fisheries 14(2):251–275.

Sofian I., Supangat A., Fitriyanto M. S., Kurniawan R., 2011 Understanding and anticipating the impact of climate change on coasts and seas in eastern Indonesia. Journal Meteorology and Geophysics 12(1):53–64.

Song A. M., Scholtens J., Stephen J., Bavinck M., Chuenpagdee R., 2017 Transboundary research in fisheries. Marine Policy 76:8–18.

Tadjuddah M., Anadi L., Mustafa A., Arami H., Abdullah, Kamri S., Wianti N. I., 2017 Growth pattern and size structure of skipjack tuna caught in Banda Sea, Indonesia. AACL Bioflux 10(2):227-233.

Taylor R. A., White A., Sherratt J. A., 2013 How do variations in seasonality affect population cycles? Proceedings of the Royal Society B 280(1754):20122714.

Trenberth K. E., 2007 Observations: Surface and atmospheric climate change. Changes 164:236–336.

Turkington T., Timbal B., Rahmat R., 2019 The impact of global warming on sea surface temperature based El Niño–southern oscillation monitoring indices. International Journal of Climatology 39(2):1092–1103.

Walther G. R., 2010 Community and ecosystem responses to recent climate change. Philosophical Transactions of the Royal Society B: Biological Sciences 365(1549): 2019–2024.

Wyrtki K., 1961 Physical oceanography of the southeast asian waters. NAGA Report. Vol. 2. The University of California Scripps Institution Of Oceanography La Jolla, California, 226 p.

Yáñez E., Lagos N. A., Norambuena R., Silva C., Letelier J., Muck K. P., Martin G. S., Benítez S., Broitman B. R., Contreras H., Duarte C., Gelcich S., Labra F. A., Lardies M. A., Manríquez P. H., Quijón P. A., Ramajo L., González E., Molina R., Gómez A., Soto L., Montecino A., Barbieri M. A., Plaza F., Sánchez F., Aranis A., Bernal C., Böhm G., 2017 Impacts of climate change on marine fisheries and aquaculture in Chile. Climate Change Impacts on Fisheries and Aquaculture: A Global Analysis I 1:239-332.

Zainuddin M., 2011 Skipjack tuna in relation to sea surface temperature and chlorophyll-a concentration of Bone Bay using remotely sensed satellite data. Scientific of Tropical Marine Science And Technology Journal 3(1):82–90.

Zainuddin M., Farhum A., Safruddin, Selamat M. B., Sudirman, Nurdin N., Syamsuddin M., Ridwan M., Saitoh S., 2017 Detection of pelagic habitat hotspots for skipjack tuna in the Gulf of Bone-Flores Sea, Southwestern Coral Triangle tuna, Indonesia. PLoS One 12(10):1-19.

*** Ministry of Marine Affair and Fisheries, MMAF, 2012 Marine and fisheries statistics Book, 291 p.

*** Ministry of Marine Affairs and Fisheries, MMAF, 2018 Fisheries management area 711 training. Economic Tools Oceans + Fish, Tanjung Pinang, Indonesia, www.conservation-strategy.org.

*** NOAA-NWS Climate Prediction Center, 2019 http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml

Received: 06 March 2021. Accepted: 11 June 2021. Published online: 21 June 2021.
Authors:
Sepri, Diponegoro University, Doctoral Programe in Coastal Resources Management, Fisheries and Marine Science Faculty, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia, e-mail: sepri.papua31@gmail.com
Agus Hartoko, Diponegoro University, Coastal Resources Management, Fisheries and Marine Science Faculty, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia, e-mail: agushartoko.undip@gmail.com
Suradi Wijaya Saputra, Diponegoro University,Coastal Resources Management, Fisheries and Marine Science Faculty, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia, e-mail: suradiwsaputra@yahoo.co.id
Abdul Ghofar, Diponegoro University, Coastal Resources Management, Fisheries and Marine Science Faculty, Prof. Sudarto Street, Semarang 50275, Central Java, Indonesia, e-mail: aghofar099@gmail.com
Erick Nugraha, Jakarta Technical University of Fisheries, Faculty of Fishing Technology, AUP Pasar Minggu street 12520, South Jakarta, Indonesia, e-mail: nugraha_eriq1@yahoo.co.id
This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.
How to cite this article:
Sepri, Hartoko A., Saputra S. W., Ghofar A., Nugraha E., 2021 Impact of El Niño Southern Oscillation (ENSO), variability on skipjack tuna *(Katsuwonus pelamis)* catches in the fisheries management area (FMA) 715, Indonesia. AACL Bioflux 14(3):1685-1694.

Impact of El Niño Southern Oscillation (ENSO), variability on skipjack tuna (Katsuwonus pelamis) catches

ORIGINALITY REPORT

9%	6%	6%	3%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to SDM Universitas Gadjah Mada Student Paper	2%
2	www.ingentaconnect.com Internet Source	1%
3	D. S. Arndt. "State of the Climate in 2009", Bulletin of the American Meteorological Society, 07/2010 Publication	1%
4	T. C. Peterson. "State of the Climate in 2008", Bulletin of the American Meteorological Society, 08/2009 Publication	1%
5	www.scielo.br Internet Source	1%
6	Submitted to Universitas Muhammadiyah Surakarta Student Paper	<1%
7	Paul H. Barber. "COMPARATIVE PHYLOGEOGRAPHY OF THREE	<1%

CODISTRIBUTED STOMATOPODS: ORIGINS AND TIMING OF REGIONAL LINEAGE DIVERSIFICATION IN THE CORAL TRIANGLE", Evolution, 9/2006
Publication

---

8 Safruddin, Rachmat Hidayat, Baso Aswar, St. Aisjah Farhum, Mukti Zainuddin. "The use remote sensing technology to determine the distribution of small pelagic fish in IFMA 713", IOP Conference Series: Earth and Environmental Science, 2021 <1%
Publication

---

9 journal.unhas.ac.id <1%
Internet Source

---

10 A Selao, A A Malik, F I Yani, A Mallawa, Safruddin. "Remote Chlorophyll-a and SST to Determination of Fish Potential Area in Makassar Strait Waters Using MODIS Satellite Data", IOP Conference Series: Earth and Environmental Science, 2019 <1%
Publication

---

11 S. M. Verbout, D. M. Schultz, L. M. Leslie, H. E. Brooks, D. J. Karoly, K. L. Elmore. "Tornado outbreaks associated with landfalling hurricanes in the North Atlantic Basin: 1954–2004", Meteorology and Atmospheric Physics, 2007 <1%
Publication

12	doczz.net Internet Source	<1 %
13	pure.port.ac.uk Internet Source	<1 %
14	trjfas.org Internet Source	<1 %
15	ueaeprints.uea.ac.uk Internet Source	<1 %
16	www.cpc.ncep.noaa.gov Internet Source	<1 %
17	www.un.org Internet Source	<1 %
18	Alexandra Langford, Scott Waldron, Sulfahri, Hasnawati Saleh. "Monitoring the COVID-19-affected Indonesian seaweed industry using remote sensing data", Marine Policy, 2021 Publication	<1 %
19	J. Blunden. "State of the Climate in 2010", Bulletin of the American Meteorological Society, 06/2011 Publication	<1 %
20	"Abstracts for the 37th Human Genetics Society of Australasia Annual Scientific Meeting Queenstown, New Zealand: August 4–7, 2013", Twin Research and Human Genetics, 2013	<1 %

Publication

21	"Copernicus Ocean State Report, issue 6", Journal of Operational Oceanography, 2022 Publication	<1 %
22	Vincent Fugère, Thomas Mehner, Lauren J. Chapman. "Impacts of deforestation - induced warming on the metabolism, growth and trophic interactions of an afrotropical stream fish", Functional Ecology, 2018 Publication	<1 %

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		