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ORIGINAL ARTICLE

Characteristics Fishing Areas of Bigeye Tuna (*Thunnus Obesus*) in Depth of 155m Based on Remotely Sensed Data

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Abstract

Bigeye tuna (*Thunnus obesus*) is one of the commercially important pelagic species that caught mostly in the eastern Indian Ocean. This species prefers to stay close, and is usually below the thermocline layer. Remotely sensed data was used to determine the characteristics of Bigeye tuna fishing areas at a depth of 155 meter. Fishing vessels for Bigeye tuna were obtained from vessel monitoring systems (VMS) from January through December, 2015-2016. Daily data on sub-surface temperature (SST), sub-surface chlorophyll-*a* concentration (SSC), and sub-surface salinity (SSS) were obtained from the INDESO Project website. All oceanographic parameter data were selected at a depth of 155 m. The position of Bigeye tuna and oceanographic data were then grouped into 2 group monsoon, southeast monsoon (April – September) and northwest monsoon (October – March). The results showed that, during the southeast and northwest monsoon, Bigeye tuna mostly found in SSC of 0.03 – 0.05 mg/m^3, SST of 16° - 18°C and salinity of 34 psu. These results showed that at depth of 155 m, Bigeye Tuna prefers to stay in small chl-*a* (0.03 – 0.04 mg/m^3), low SST (16° - 18°C) and salinity of 34 psu. This information was essential and could be used to support fisheries management decisions especially for Bigeye Tuna in the eastern Indian Ocean.

Keywords: Fishing areas, depth of 155 m, eastern Indian Ocean, Bigeye tuna, remotely sensed data

Introduction

Indonesian waters have a high diversity of pelagic fish resources, unique and dynamic oceanographic characteristics (Susanto et al., 2001; Hendiarti et al., 2004; and Susanto et al., 2006). Indonesian waters are also mainly influenced by the phenomenon of Asia-Australian Monsoon (Tomczak and Godfrey, 2001; Hendiarti et al., 2004; Qu et al., 2005; and Longhurst, 2007), the Indonesian Through flow (Sprintal et al., 2003 and Wijffels et al., 2008) and El Nino Southern Oscillation (ENSO) (Susanto et al., 2001; and Hendiarti et al., 2004). One of Indonesia's waters which famous as a fishing area is southern waters of Java - the Nusa Tenggara archipelago Sumatera (Ukolseja, 1996; Davis and Farley, 2001; Merta et al., 2004; and Hendiarti et al., 2005). This region is famous as fishing areas for an economically important fish such as Bigeye tuna (Thunnus obesus).

Bigeye tuna (Thunnus obesus) is one of the important pelagic fisheries resources with high economic value. In the early 80s, Bigeye tuna production was about 20.000 tons per year and reached about 140.000 tons in the 90s. During 2000 – 2013, the production of Bigeye tuna unexpected drop, especially in 2010 which only reached 87.926 tons (IOTC 2014) following a period of high export value reach USD 89.41 million (KKP 2015) indicate that the number, size and location of fishing ground for Bigeye tuna are largely affected by oceanographic conditions.

Bigeye tuna is a highly migratory pelagic species inhabiting all tropical and sub-tropical waters of the world's ocean, except in the southwestern sector of the Atlantic (Hanamoto, 1987). Bigeye tuna prefers water temperatures between 17°C and 22°C. Pepperell (2010) reported that Bigeye tuna prefers to stay near and usually below the thermocline layer and can make vertical movement periodically.

The main depth range of fishing for Bigeye Tuna in the Indian Ocean is 161–280 m (Mohri and Nishida, 1999). However, they can come to the surface at depth of 0 – 100 m during the night (Howell et al., 2010). In addition, Sukresno et al., (2015) and Hartoko (2010) pointed out that Bigeye tuna prefer to stay in depth around 150 m. Therefore, in this study, we focus on the ways in which characteristic of fishing areas for Bigeye tuna at depth of 155 m.

Materials and Methods

Detection of Fishing Vessel from Vessel Monitoring System

Daily vessel monitoring system (VMS) data were provided and distributed by Ministry of Maritime Affairs and Fisheries Indonesia (http://integrasi.djpt.kkp.go.id). We collected 707 data from August through December 2015 – 2016 (Table 1). The data was chosen for analysis based on the speed of fishing vessels and type of fishing gear. The speed of fishing vessels less 3 knots were considered conducting fishing activities while vessels velocities more than 3 knots were assumed not to be conducting fishing activities.

In addition, longline is a common fishing gear used to catch Bigeye tuna in EIO (Hartoko, 2010; Syamsudin et al., 2013; and Barata et al., 2011). Therefore, in this study, we selected vessels equipped with longline tuna fishing gear and speed of vessels less than 3 knots as the fishing vessels for Bigeye tuna in the EIO. The location of the fishing vessels then was assumed to represent the Bigeye tuna fishing location in the EIO.

Table 1: Number of fishing vessels from Vessel Monitoring System for the period 2015 – 2016

Year	Jan	Feb	Mar	Apr	Mei	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	12	13	24	27	31	21	19	11	29	26	26	27
2016	8	18	33	31	51	54	26	41	46	59	28	46

Satellite-derived Environment Variable

Sub-surface chlorophyll-*a* (SSC), sub-surface temperature (SST), and sub-surface salinity (SSS) data at depth of 155 meter from 2015 through 2016 were used in this study. Daily SSC, SST and SSS data with 9 spatial resolutions were downloaded from Infrastructure Development of Space Oceanography website (www.indeso.web.id.).

To undersatand the cahárateristic of Bigeye tuna fishing areas, the data were then overlaid with fishing location from VMS.

Results and Discussion

A fishing vessel monitoring system (VMS) were used to identify the location of fishing vessel for Bigeye tuna in the eastern Indian Ocean. Vessel monitoring system is a radar satellite-based ship monitoring system. This system can be used to generate the position of fishing vessel for Bigeye tuna. Analyses of VMS allowed us to locate fishing vessel lights across space and time, and we assumed that Bigeye Tuna were caught in areas where fishing vessels were identified.

On the basis of the derived fishing vessel locations, we were able to estimate the spatial and temporal distribution of potential fishing zones for Bigeye tuna. Figure 1 showed the distribution of fishing vessels for Bigeye tuna in 2015 and 2016.

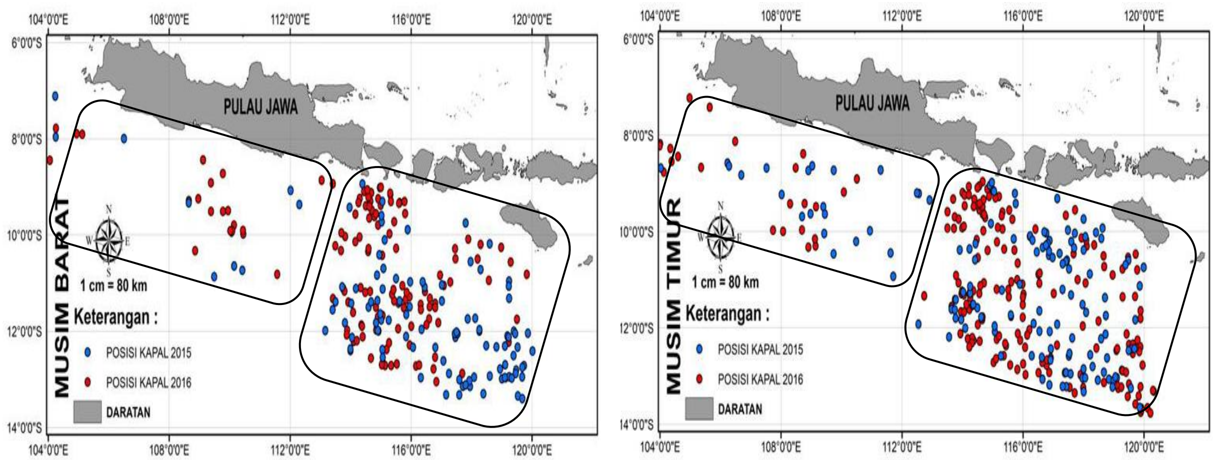


Figure 1: Spatial distribution of fishing locations for Bigeye tuna (Thunnus obesus) during (a) southeast (April – September) and (b) northeast (October – March) monsoon in 2015 (blue dot) and 2016 (red dot) and 2 hot spot of fishing locations.

Fishing locations for Bigeye tuna and oceanographic parameters at depth of 155 m were used understand the characteristic of fishing areas for Bigeye tuna in the eastern Indian Ocean. Depth of 155 m was chosen since Bigeye tuna was generally found at the depth around 150 m (Hartoko, 2010 and Sukresno et al., 2015).

Bigeye tuna are very sensitive to changes in SST (Syamsudin et al., 2013). Brill et al., (2005) reported that SST is the most important variable to the distribution for Bigeye tuna in the eastern Indian Ocean. Analysis of SST indicates that remote forcing from the Pacific Ocean has a large effect on HR during an El Niño because of the reduction in heat transported from the Pacific to the Indian Ocean by the Indonesian Through flow during El Niño events (Ffield et al., 2000 and Gordon et al., 2010).

Figure 2 showed seasonal SST in 2015 and 2016. In general, the SST has a range between 11° – 25°C. At depth of 155 m, Bigeye tuna mostly found at SST of 16 – 18°C (Figure 3). Sukresno et al., (2015) reported that Bigeye tuna were found to be more favour in the depth around 150 m with optimum temperature between 16° – 21°C.

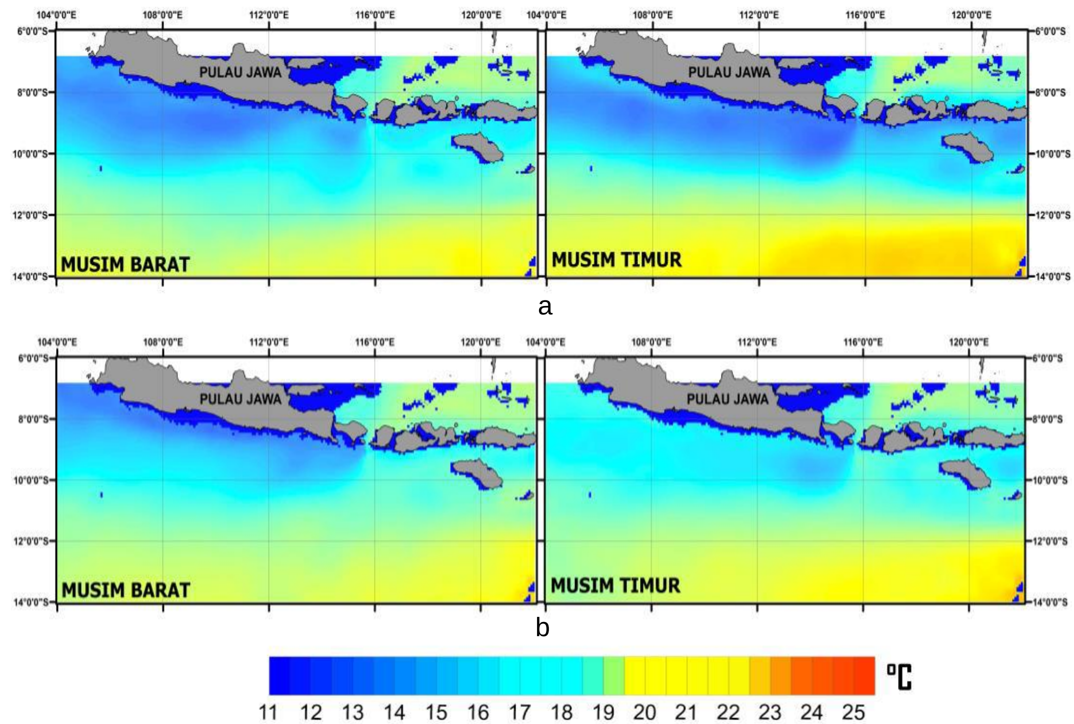


Figure 2: Seasonal sub-surface temperature in (a) 2015 and (b) 2016

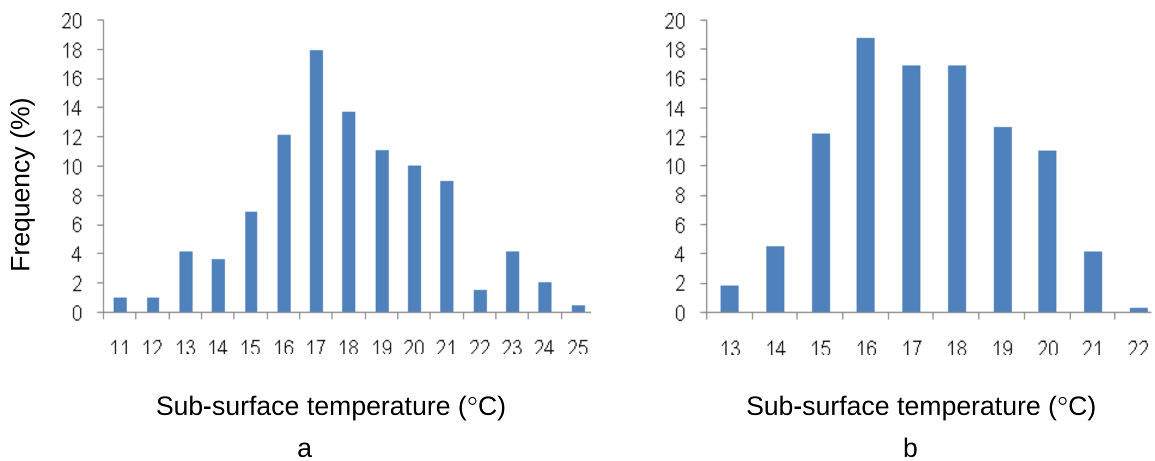
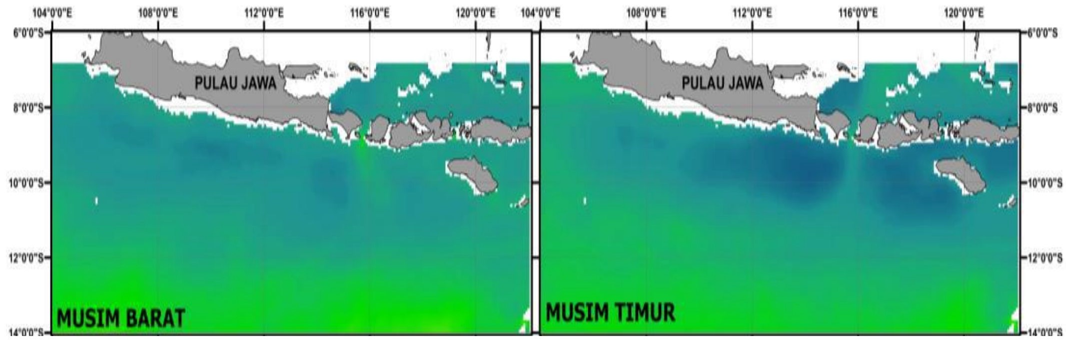
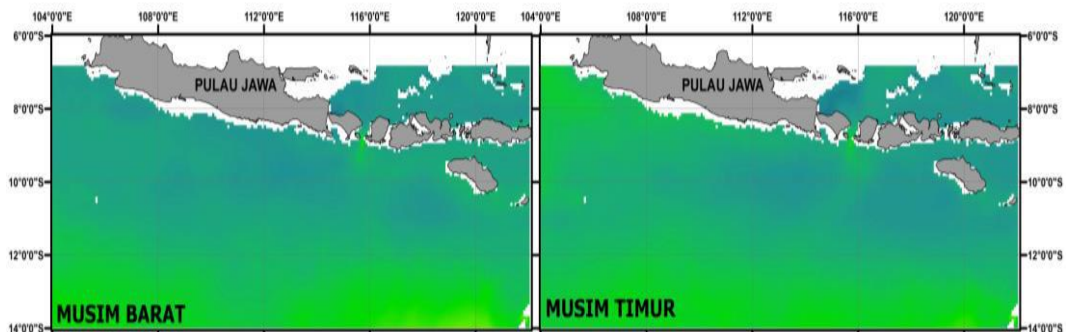


Figure 3: sea-subsurface temperature and freqeuncy (%) of Bigeye tuna during (a) northeast and (b) southeast monsoon

Although chlorophyll-*a* concentrations exhibited lowest contribution to the model prediction, this oceanographic parameter was statistically significant to distribution of Bigeye tuna (Syamsudin et al., 2013). In this study, the distribution of SSC in 2015 and 2016 are shown in Figure 4. In general, the SSC has a range between 0.022° – 0.099°C. Chlorophyll-*a* data is a valuable proxy for water mass boundaries and upwelling events. Bigeye tuna fishing sets were located in waters with relatively low-to-moderate chlorophyll values. At depth of 155 m, Bigeye tuna mostly found at SSC of 0.03 – 0.05 mg/m^3 (Figure 5).



a



b

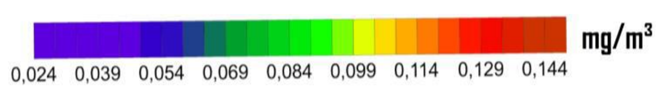
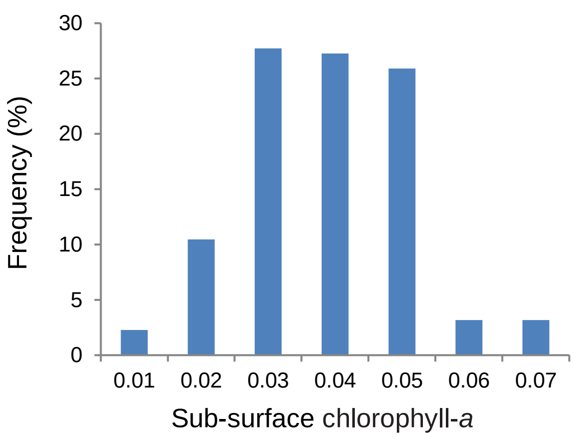
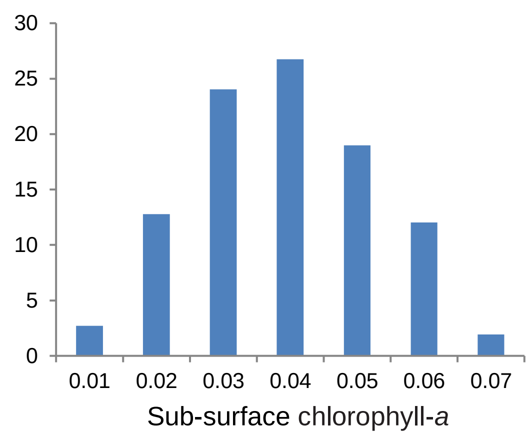


Figure 4: Seasonal sub-surface chlorophyll-*a* in (a) 2015 and (b) 2016



a



b

Figure 5: Sea-subsurface chlorophyll-*a* and freqeuncy (%) of Bigeye tuna during (a) northeast and (b) southeast monsoon

In this study, we also used sub-surface salinity to understand the characteristic fishing areas of Bigeye tuna. Salinity is one of physical environment of the sea water which plays a role in the survival of marine organisms. Fish needs for salinity are mainly for diffusion and osmosis. Changes in extreme levels of salinity will cause the process to be disrupted which can cause death. Salinity can also act as an indicator of the mechanism of enrichment of water masses (Tangke et al., 2016). In addition, salinity variations in offshore areas are smaller than coastal areas. This is because a run-off effect from the land (Laevestu and Hela 1970). Figure 6 showed the seasonal SSS in 2015 and 2016. In general, in general the SSS has a range between 33 – 35 psu.

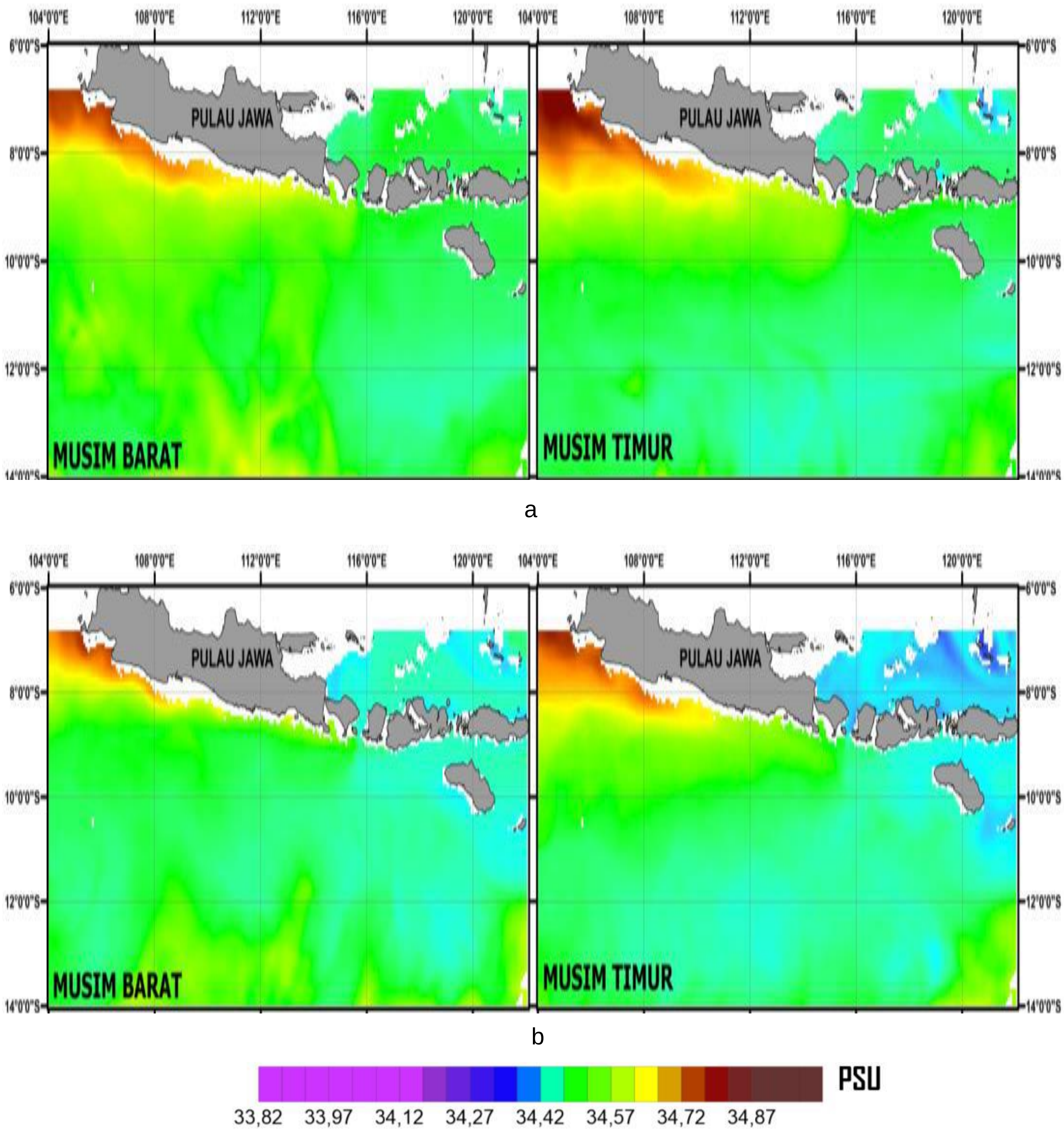


Figure 6: Seasonal sub-surface salinity in (a) 2015 and (b) 2016

At depth of 155 m, Bigeye tuna mostly found at SSS around 34 psu (Figure 7). Arrizabalaga et al., (2015) reported that salinity for tunas (albacore, skipjack and bigeye) in range salinity value of 36 – 37 ‰ meanwhile yellowfin tuna in salinity value around 33 ‰.

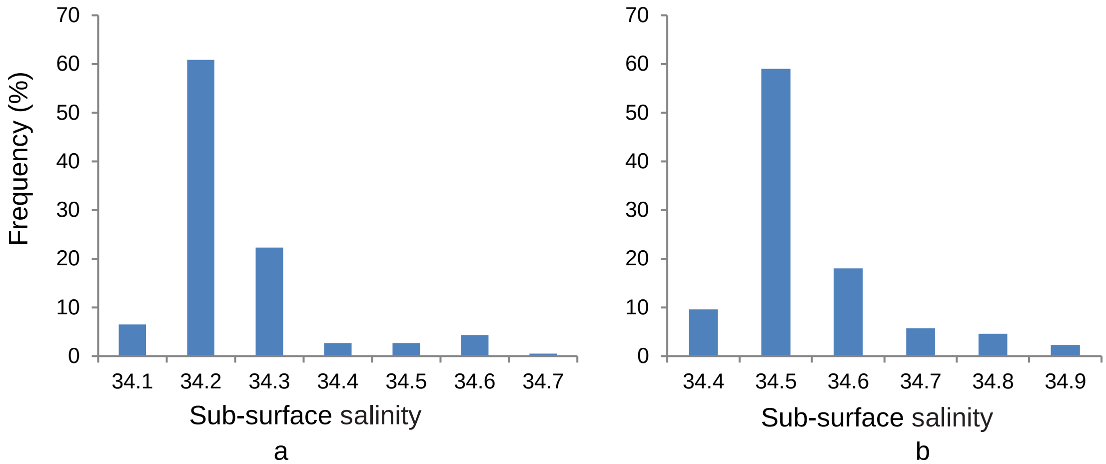


Figure 7: Sea-subsurface salinity and freqeuncy (%) of Bigeye tuna during (a) northeast and (b) southeast monsoon

Conclusion

This study showed that most of fishing activities occured in offshore areas south of Bali – West Nusa Tenggara. At depth of 155 m, Bigeye tuna prefers to stay in SSC value of 0.03 – 0.05 mg/m^3, SST value of 16 – 18°C and SSS value around 34 psu.

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References

Arrizabalaga, H., Dufourd, F., Kellc, L., Merinoa, G., Ibaibarriagad, L., Chustd, G.,Irigoine X, Santiagod, J., Muruaa, M., Frailea, I., Chiffleta, M., Goikoetxead, N., Sagarminaga, Y., Aumontf, O., Boppg, L., Herrerah, M., Fromentini, J. M., and Bonhome, S. (2015). Global habitat preferences of commercially valuable tuna. *Deep sea research Part II: Tropical studies in Oceanography Elsevier,* 113, 102-112.

Barata, A., Bahtiar, A., and Hartati, H. (2011). Pengaruh Perbedaan Umpan dan Waktu Setting Rawai Tuna Terhadap Hasil Tangkapan Tuna di Samudera Hindia. *Jurnal Penelitian Perikanan Indonesia,* 17(2), 133-138.

Brill, R. W., Bigelow, K. A., Musyl, M. K., Fritsches, K. A., and Warrant, E. J. (2005). Bigeye tuna (*Thunnus obesus*) behavior and physiology and their relevance to stock assessments and fishery biology. *Col. Vol. Sci. Pap. ICCAT*., 57(2), 142–161.

Davis, T.L.O & Farley, J.H. (2001). Size Distribution of Southern Bluefin Tuna (*Thunnus maccoyii*) by Depth on Their Spawning Ground. *Fisheries Bulletin*. 99, 381 – 386.

Ffield, A., K. Vranes, A. L. Gordon, R. D. Susanto, and S. L. Garzoli. (2000). Temperature variability within Makassar Strait. *Geophys. Res. Lett*,. 27, 237–240.

Gordon, A., Sprintall, J., Aken, V. H. M., Susanto, R. D., Wijffels, S., Molcard, R., Ffield, A., Pranowo, W., and Wirasantosa, S. (2010). The Indonesian throughflow during 2004–2006 as observed by the INSTANT program. *Dyn. Atmos. Oceans*. 50,115–128.

Hartoko, A. (2010). Spatial distribution of Thunnus. sp, vertical and horizontal sub-surface multilayer temperature profiles of in-situ agro float data in Indian Ocean. *J Coastal Development*. 14, 61-74

Hanamoto, E. (1987). Effect of oceanographic environment on bigeye tuna distribution. *Bull. Jap. Soc. Sci. Fish. Oceanogr*. 3, 203–216.

Howell, E. A., Hawn, D. R. and Polovina, J. J. (2010). Spatio temporal variability in bigeye tuna (*Thunnus obesus*) dive behavior in the central North Pacific Ocean. *Prog. Oceanogr*. 86, 81–93.

Hendiarti, N., Suwarso., Aldrian, E., Amri, K., Andiastuti, R. Sachoemar, S.E. & Wahyono, I. B. (2005). Pelagic Fish Catch Around Java. Oceanography. 18(4),112-123.

Hendiarti, N., Siegel, H. & Ohde, T. (2004). Investigation of Different Coastal Processes in Indonesian Waters using SeaWiFS Data. *Deep Sea Research Part II: Tropical Studies in Oceanography, 51,* 85-97.

IOTC. Status of the Indian Ocean Bigeye tuna (BET: *Thunnus obesus*) resource. [online] The Indian Ocean Tuna Commission (IOTC). (2014). (http://www.iotc.org/sites/ default/files/documents/2014/12/IOTC-2014-SC17- ES02 E_-_Bigeye_tuna.pdf), [diakses: 1 Maret 2016]

KKP. (2015). Keputusan Menteri Kelautan dan Perikanan Nomor 107/KEPMEN-KP/2015 tentang Rencana Pengelolaan Perikanan Tuna, Cakalang dan Tongkol. Jakarta-Indonesia: Kementerian Kelautan dan Perikanan Republik Indonesia.

Longhurst, A. R. (2007). Ecological Geography of the Sea. Second Edition. Elsevier

Laevastu, T and Hela, I. (1970). Fisheris oceanography. *London. Fishing news*. pp. 238.

Merta, G.S., Iskandar, B & Bahar, S. (2004). Musim Penangkapan Ikan Pelagis Besar dalam Musim Penangkapan Ikan di Indonesia. BRPL – BRKP

Mohri M., and Nishida, T. (1999). Distribution of bigeye tuna (*Thunnus obesus*) and its relationship to the environmental conditions in the Indian Ocean based on the Japanese longline fi sheries information. IOTC Proceedings. 2, 221–230.

Pepperell, J. (2010). Fishes of the open ocean: a natural history and illustrated guide, 272 p. Univ. Chicago Press. Chicago.

Qu, T., Du, Y., Strachan, J., Meyers, G. & Slingo, J. (2005). Sea Surface Temperature and its Variability in The Indonesian Region. *Oceanography,* 18, 50 – 61.

Susanto, R.D., Gordon, A.L. & Zheng, Q. (2001). Upwelling along the coast of Java and Sumatra and its relation to ENSO. *Geophysical Research Letters*, 29, 1599 – 1602.

Susanto, R.D, Moore II, T. S. & Marra, J. (2006). Ocean Color Variabilty in The Indonesia Seas during SeaWiFS Era. *Geochemistry, Geophysics and Geosystems, 7*(5), 22-35.

Sprintal, J., Potemra, T. J., Hautala, S. L., Bray, N. A & Pandoe, W.W. (2003). Temperature and salinity variability in the exit passages of the Indonesian Throughflow. *Deep Sea Research II*. 50:2183-2204

Sukresno, B., Hartoko, A., Sulistyo, B and Subiyanto. (2015). Empirical Cumulative Distribution Function (ECDF) Analysis of Thunnus.sp using ARGO Float Sub-surface Multilayer Temperature Data in Indian Ocean South of Java. *Procedia Environmental Sciences*, 23, 358 – 367.

Syamsudin, M. L., Saitoh, S.I., Hirawake, T., Bachri, S., Harto, A. B. (2013). Effects of El Niño -Southern Oscillation events on catches of Bigeye tuna (*Thunnus obesus*) in the eastern Indian Ocean off Java. *Fishery Bulletin*, 111(2),175-188.

Tangke, U., Karuwal. W. Ch., Mallawa, A., Zainuddin, M. (2016). Analisis hubungan suhu permukaan laut, salinitas, dan arus dengan hasil tangkapan ikan tuna di Perairan Bagian barat Pulau *Halmahera.Jurnal IPTEKS PSP*, 3(5), 368 – 282.

Tomczak, M. dan Godfrey. M. J. (2001). Regional Oceanography: An Introduction. Available on http:// www.es.flinders.edu.au/mattom/regoc/pdfversion.htm

Ukolseja, Y. (1996). Monthly Average Distribution of Fishing Effort and Catch per Unit Effort for Yellowfin Tuna and Bigeye Tuna in Indonesian Waters of The Indian Ocean, 1978 – 1990. Expert Consultation on Indian Ocean Tunas 6. Available on http://iotc.org.

Wijffels, S.E., Meyers, G. & Godfrey, J. S. (2008). A 20-Yr Avarage of the Indonesia Troughflow: Regional Currents and Interbasin Exchange. *Journal of Physical Oceanography, 38*,1965-1978.

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