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Fishing Season of Large Tuna from Purse Seine Fishery in Tumumpa, Manado, North Sulawesi

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Abstract

Knowledge on seasonal fishing pattern is essential in fisheries research in order to increase the effectiveness of fishing and at the same time protecting the fishing ground from excessive fishing practices. Determining the seasonal fishing pattern of large pelagic fishes, namely large tuna (yellowfin and bigeye), small tuna (mackerel) and skipjack tuna were the objective of this study. Data from the 2013-2015 fishing operation time series were used to analyze the fishing season using the percentage average per unit effort (CPUE) method. The main focus of this study was purse seine fishery. The research showed that high fishing season of large pelagic fishes allegedly occurred during May to July, which reached its peak on May. On the other hand, low fishing season occurred during January to April, with the lowest on March. There were similarities between large tuna, small tuna and skipjack in term of their seasonal fishing pattern, although they did not show any good correlation (r<0.5). This might due to fact that even tough large tuna, small tuna and skipjack tuna shared the same ecological niche but apparently, they did not show any interaction (symbiosis) but competition.

Keywords: *fishing season, large pelagic fishes, purse seine, Tumumpa Manado*

Introduction

Fishing season is a consequence on how fishes respond to the environmental changes. It is marked with the higher abundance of fishes' biomass in certain period of time. Usually, this condition associated with the availability of food source, supported by good environmental parameters such as: temperature, chlorophyll-a and sea current (Safruddin *et al*., 2014). Estimating the fishing season is essential in fisheries research in order to increase the effectiveness of fishing and at the same time protecting the fishing ground from excessive fishing practices.

Previous researches on fishing season of tuna, especially in eastern region of Indonesia mainly focused on skipjack fisheries (Kekenusa, 2006; Kekenusa and Paendong, 2016). Hariati (2011) also gave a glimpse of the mini purse seine fisheries in Banda Sea but unfortunately the information only limited to certain group species of neritic tunas and small pelagic fishes. The main obstacle on analyzing the fishing season based on specific species is there was no clear separation on the catch composition, especially in purse seine fisheries where the production of juvenile tuna is usually lumped together in the logbook.

Determining the seasonal fishing pattern of large pelagic fishes, namely large tuna (yellowfin tuna/*Thunnus albacares* and bigeye tuna/*Thunnus obesus*), small tuna (mackerel/*Auxis sp; Euthynnus sp.*) and skipjack tuna (*Katsuwonus pelamis*) from purse seine fishery were the solely objective of this study. The result of the study expected to be considered as a basic information in term of making fisheries management policy in the future, especially in the eastern region of Indonesian seas.

Materials and Methods

Tumumpa Coastal Fishing Port (CFP) is located in the coastal area of Tumumpa village, district Tuminting, Manado, with specific geographical location between 01.523°N and 124.841°E (Figure 1.). It is only 50 km from the largest fishing port in Sulawesi Utara, namely Bitung Oceanic Fishing Port (PPS). Most of the fleet based in CFP. Tumumpa are purse seiners, ranged from 5-100 GT.

Source of data

Primary data were obtained from daily recording of landing activities based on CFP. Tumumpa. The dataset then combined with the

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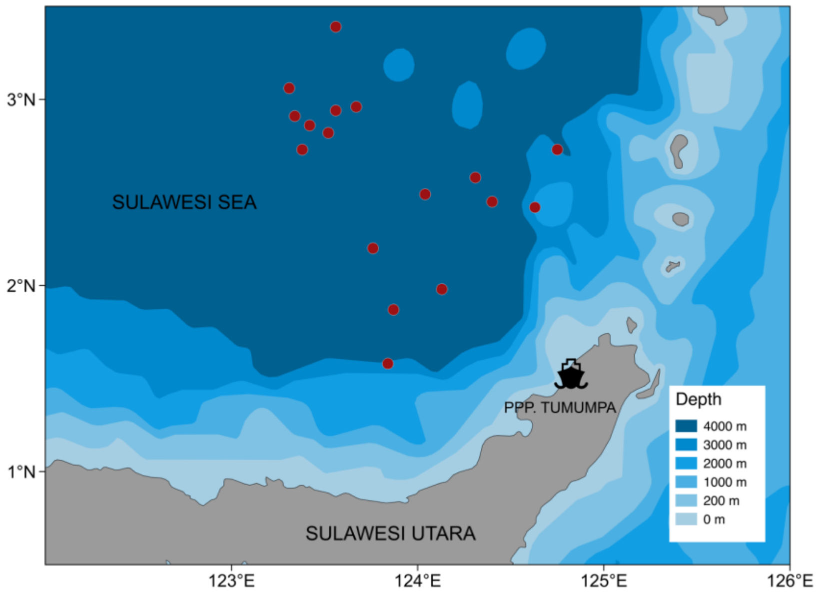

Figure 1. Map of study area and GPS-based FADs deployment locations from purse seine fleet based in CFP. Tumumpa, Manado

data from January 2013 to December 2015. The dataset consists of total catch by group species (kg), fleet definition (purse seine, longline, pole and line, etc), gear type, area of fishing, gross tonnage, and vessel information. The research focused on purse seiners, since it was the dominant fleet in the area (99.36%). Although there was a clear segregation between large pelagic and small pelagic purse seiners fleets mentioned in the SLO (warrant fishing operation) but, through preliminary analysis there was no significant catch composition between two fleets. It means both purse seine fisheries licenses were mostly used to catch large pelagic species. Therefore, both data were combined in the analysis.

Data analysis

Analysis on fishing season pattern of large pelagic fisheries was performed using average percentage method (Spiegel, 1961) with modification from Dajan (1998). The main output is Seasonal Fishing Indices (SFI) in which, hypothetically, high fishing season is when FS>100 (above average); low fishing season is when FS<100 (below average); and if FS=100 it means the season reach its equilibrium. Catch per unit of effort (CPUE) was defined as total catch by group species (kg) divided by total effort (days at sea). Days at sea is the time required for fishermen from the port to the fishing ground and back at the same day. Steps of analysis are presented below:

Calculation of monthly CPUE (Ui) and average of monthly CPUE in a year ($\overline{U}$).

$$\overline{\boldsymbol{U}} = \frac{\mathbf{1}}{\boldsymbol{m}} \sum_{\boldsymbol{i}=\mathbf{1}}^{\boldsymbol{m}} \boldsymbol{U_i}$$

Where:

$\overline{U}$: Average of monthly CPUE in a year (kg.days^{-1})

Ui : Monthly CPUE (kg.days^{-1})

m : Number of month in a year (n)

Calculation of U_p which is the ratio of U_i towards U (in percent):

$$\boldsymbol{U_p} = \frac{\boldsymbol{U_i}}{\boldsymbol{U}} \times \mathbf{100}\%$$

Calculation of fishing season indices (FS)

$$\boldsymbol{FS_i} = \frac{\mathbf{1}}{\boldsymbol{y}} \sum_{\boldsymbol{i}=\mathbf{1}}^{\boldsymbol{y}} \boldsymbol{U_p}$$

Where:

FS_i : The indices at particular season (i)

y : Number of year calculated (n)

If the sum of FS_i in a year doesn't equal 1,200%, adjustment should be made with the following formula:

$$\boldsymbol{AFS_i} = \frac{\mathbf{1200}}{\sum_{\boldsymbol{i}=\mathbf{1}}^{\boldsymbol{y}} \boldsymbol{IM_i}} \times \boldsymbol{IM_i}$$

Where:

AFS_i : Adjusted fishing season indices

If there is any extreme value of U_p, it would not include on the calculation of FS, instead the median value (Md) of the FS would be used. If the total sum of the median value doesn't equal with 1,200%, another adjustment should be made as follow:

$$AMFS_i = \frac{1200}{\sum_{i=1}^{y} Md_i} \times Md_i$$

Where:
AMFSi: Adjusted median fishing indices

Results and Discussion

A total of 7,843 landing data were managed to be extracted from SLO (warrant fishing operation) form during January 2013 to December 2015. Purse seiners dominated the fleet composition (99.36%), while the rest consist of light boat, hand line, pole and line (huhate) and mini pole and line (funae). Based on gross tonnage information, purse seine fleet dominated by size 20-30 GT (51%), and 30-50 GT (39%) (Figure 2). More than 80% of purse seiners catch composition were dominated by large pelagic fishes (composition of combined skipjack, mackerel, yellowfin and bigeye tuna>50%) (Figure 3.). This result shown that regardless the purse seine fishing license, they all make large pelagic tunas as target.

The monthly average catch for large pelagic tuna group showed strong seasonal pattern, especially for skipjack and mackerel (Figure 4.). High catch of skipjack occurred between May and June and low catch between November and January. The highest catch recorded was in June, 2014 with slightly over than 1 million kg, on the other hand, the lowest catch recorded was in December, 2015 with total 78,000 kg. High catch of mackerel occurred between May to December, while low catch between January and February. Highest production of mackerel was recorded in December 2015, with 534,920 kg, on the other hand the lowest production was recorded in January, 2013 with 47,575 kg. Meanwhile, the catch of tuna relatively stable, with slight increase during June-July and slight decrease between November and January. Three seasonal fishing indices of large pelagic fishes models were successfully created based on moving average method. All three models showed similar trend, where the high fishing season started from May to June and the low fishing season occurred between January and April (Figure 5.).

Based on the licensed given, the purse seine fleets in CFP. Tumumpa, Manado were divided into 2 categories, the first is large pelagic purse seiners (PSPB) and the latter was small pelagic purse seiners (PSPK). But in practical, both licensed chased the same resource, which is large pelagic fisheries, although small portion of the PSPK fleets determined to abide the rules. Given the fact that PSPK fleets have smaller mesh size, it could badly affect the large pelagic resource, since smaller size of juvenile tunas, skipjack and mackerel are more likely to be caught during operation. It is also to be noticed that both PSPB and PSPK allegedly using the same mesh size configuration (1-4 inch) (Hariati, 2011; Kefi *et al.*, 2013; Talakana *et al.*, 2017). Using small mesh sizes was considered as IUU (Illegal, Unreported and Unregulated) fishing, aside from fishing without or fake license, transshipment, double flags and unreported fishing (non-reporting or misreporting, under-reporting of fish catch) (Palma and Tsamenyi, 2008; Edy *et al.,* 2017).

IUU fishing is a serious trans-national problem worldwide, especially in Indonesia. It cost more than IDR 300 trillion/year (Jaelani and Basuki, 2014), as for in Sulawesi Sea such practice has cost a third of total annual value (Palma and Tsamenyi, 2008). It is apparent that most of the IUU fishing related with Filipino and Chinese fishermen. Palma and Tsamenyi (2008) estimated that 70% of all tuna catches by Filipino vessels in the Indonesian EEZ are landed in The Philippines without being reported to designated Indonesian ports. In order to counter this problem, Ministry of Marine Affairs and Fisheries issued Ministerial Decree No. 57/2014 on prohibition of transshipment within the sea of Indonesia National Jurisdiction. This law specifically designed to combat the IUU fishing in Indonesian waters, including Sulawesi Sea. The immediate effect reflected on Figure 4, where the catch of 2015 was much lower compared to previous two years (2013 and 2014) of observation, even though the number of effort was relatively stable. As a comparison, according Philippine Fisheries Development Authority (PFDA) there was a sharp downfall of tuna landing in General Santos during 2014-2015. Production of skipjack decline almost 76%, from 50,417 mt in 2014 to 28,658 mt in 2015. The same rule applied to yellowfin tuna for domestic market, which decreased down to 43%, from 8.289 mt in 2014 to 5.794 mt in 2015.

Skipjack tuna is the main target for purse seine fleets. It also become a target species for other gears, such as: pole and line and hand line (Widodo and Nugraha, 2009, Kefi *et al.*, 2013, Simbolon *et al.*, 2013) with by-product species such as mackerel and juvenile yellowfin and bigeye tuna (Harley *et al.*, 2010; Hampton and Williams, 2011). Most of skipjack tuna caught during May and July, with peak season occurred on May, on the other hand, the low season occurred on January to April with lowest catch appeared on March. This result was supported by previous study from Safruddin *et al*. (2014) in Mamuju waters, where the most productive fishing season occurred during May, which the skipjack fishing season started in January August and November. But the result is contradictive compared with the finding from Kekenusa (2006) to

Figure 2. Purse seine fleet proportion based on gross tonnage information

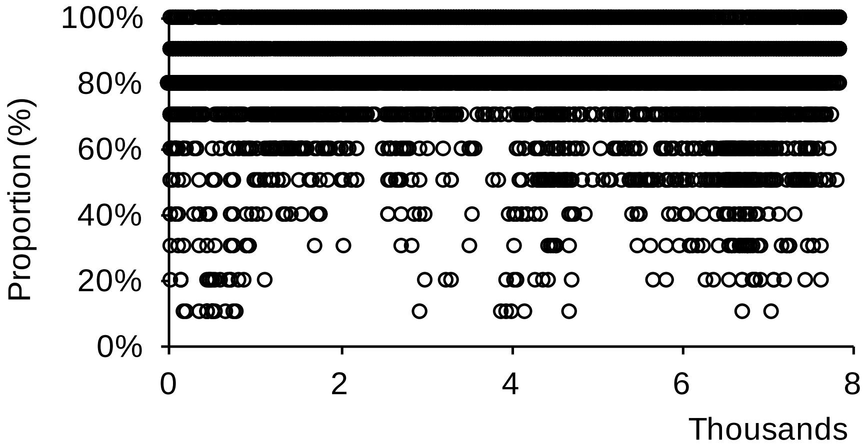

Figure 3. Aggregated catch proportion of yellowfin, bigeye, skipjack and small-tuna based on landing data from CFP. Tumumpa, Manado.

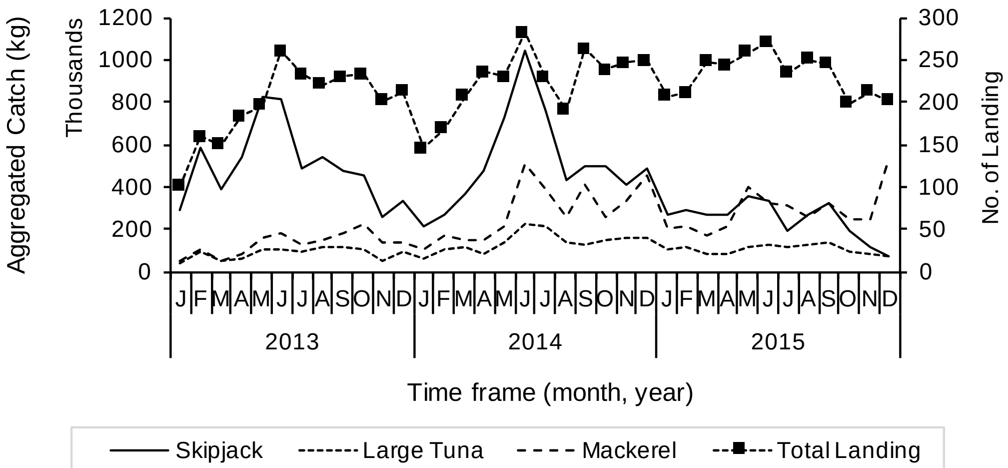

Figure 4. Development of aggregated catch of yellowfin, bigeye, skipjack and small-tuna based on warrant of fishing operation (SLO) derived from CFP. Tumumpa, Manado during 2013-2015.

June, while the low season started afterward. Although, he used a longer dataset (1994-2004) but he only analyzed the catch from pole and line fisheries. So, the result was incomparable since both fisheries have different fishing ground and operational type.

Fishing season identification is very useful. It can be used as an input control where more fleets are allowed to fish when the season occurred and less fishing license are issued when the season is low. Interestingly, the fishing season for all group species have similar trend. This perhaps because the analysis came from the same gear. However, Pearson's correlation index showed that correlation between skipjack CPUE and large tuna CPUE was moderate (r=0.43, n=7843). It is mean, every skipjack caught there is higher probability of juvenile yellowfin and bigeye also caught. On the other hand, the correlation between skipjack CPUE and mackerel CPUE was low, as well as large tuna CPUE and mackerel CPUE (0.21 and 0.36, respectively) (Figure 6). It means, other than large tuna, mackerel was caught incidentally during the fishing operation, perhaps they do not share the same ecological niche, although it should be proven by stomach content analysis. A study from Malone *et al.* (2011) explained that yellowfin tuna did not prey on organisms associated with Fish Aggregating Device (FADs), while bigeye tuna was a deep-sea dweller (Brill, 1994), thus it rarely interacts with prey on the surface, except at night (Allain *et al.*, 2012).

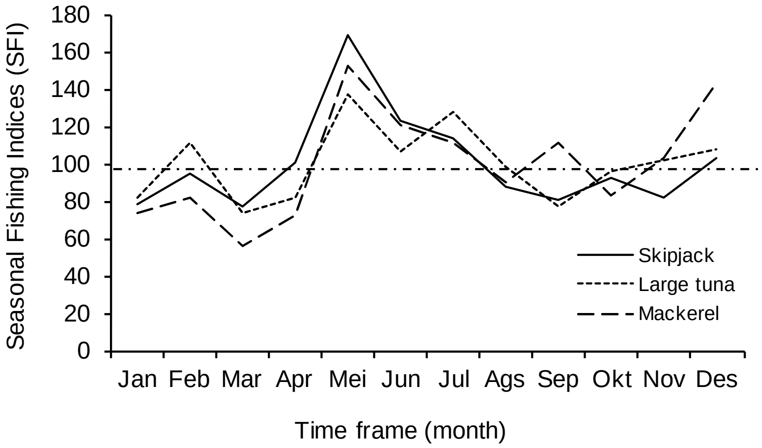

Figure 5. Comparison of seasonal fishing indices of large tuna, skipjack and mackerel from purse seine fishery based in CFP. Tumumpa, Manado.

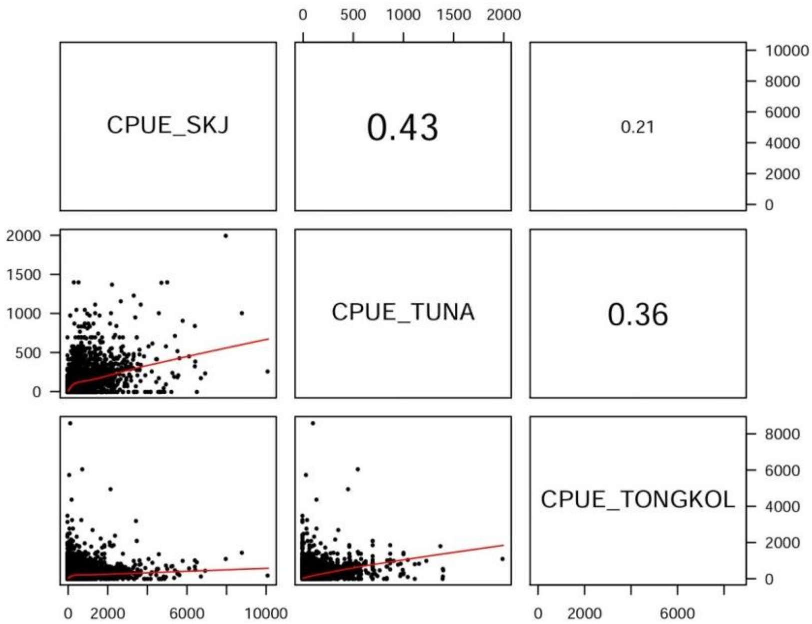

Figure 6. Pearson's correlation coefficient between CPUE of large tuna (CPUE_TUNA), mackerel (CPUE_TONGKOL) and skipjack tuna (CPUE_SKJ)

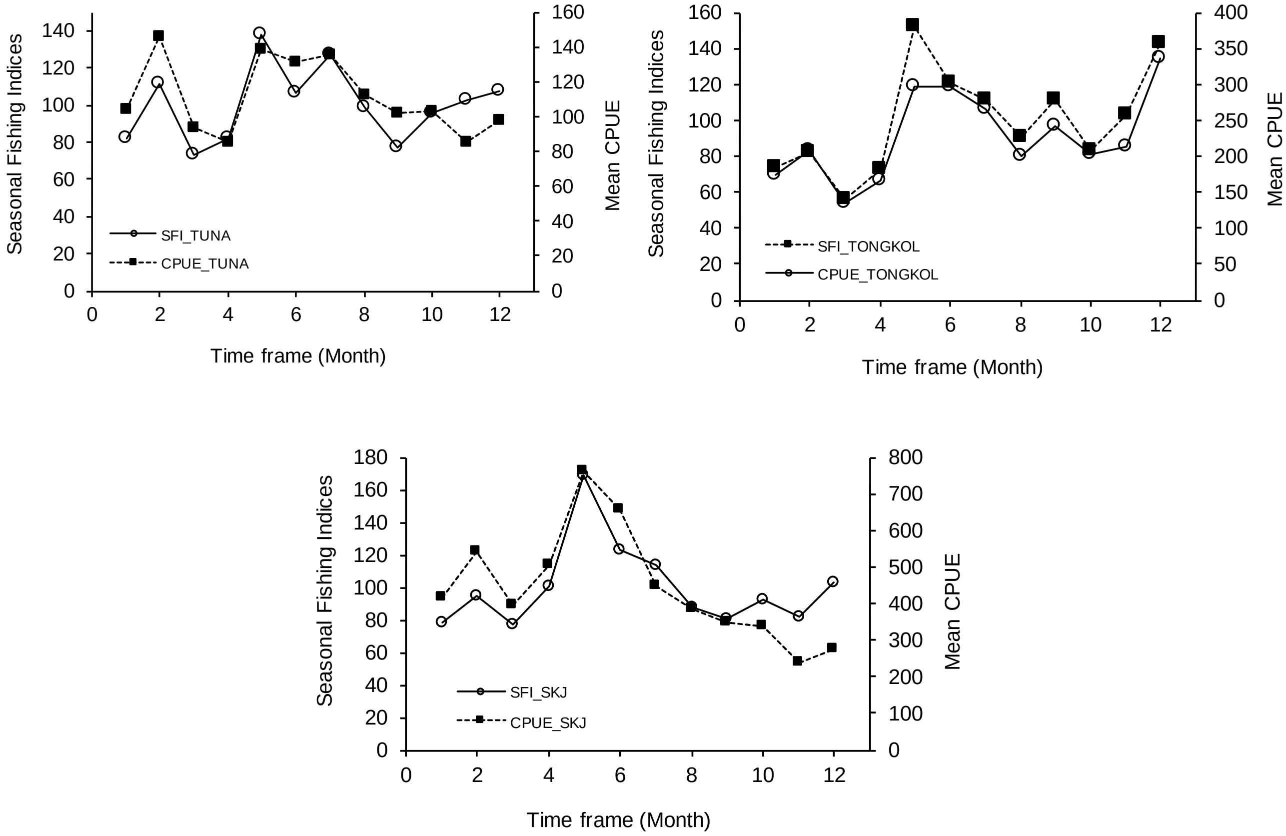

Figure 7. Head-to-head comparison between nominal CPUE and seasonal fishing indices of large tuna (upper left panel), mackerel (upper right panel) and skipjack tuna (lower left panel) landed in CFP. Tumumpa, Manado.

Furthermore, juvenile yellowfin usually performing school around FADs during the day and leave at night (Holland *et al*., 1990). Both juvenile yellowfin and bigeye tuna are likely to stay at the same FADs for 150 and 10 days, respectively (Morgan, 2011). Juvenile yellowfin tuna is more likely be caught alongside skipjack if the set is conducted at day, while juvenile bigeye is rarely caught because of their diurnal movement and short stay at the FADs.

The seasonal fishing indices models fit with monthly CPUE trend for all group species (Figure 7.). This can be explained simply because the index produced from the model solely rely on monthly CPUE as basis, with the exclusion of minimum and maximum value. As and indices, it is not very reliable because fishing season is not only depended on effort but also other influencing variables such as: environmental conditions (temperature, salinity, wave height, wind speed, precipitation level, swimming-layer, sub-surface oceanographic condition and season) (Simbolon and Limbong, 2012; Lan *et al.*, 2013; Rochman *et al.*, 2016) and socio-economy (celebration of religious festivals, man power availability, *etc.*) (Pranowo *et al.*, 2016). In order to get more precise analysis, a mathematical approach which involved above-mentioned variables could be included into the model. A combining of gears could also be considered to get more robust result.

Conclusion

Fishing season for large pelagic purse seine fishery in North Sulawesi started from May to July, and reached its peak on May. Low fishing season occurred during January to April with the lowest was in March. On every skipjack caught there is higher probability of juvenile yellowfin and bigeye also caught (r=0.43). On the other hand, other than large tuna, mackerel was caught incidentally during the fishing operation (r=0.21 and r=0.36, respectively).

References

Allain, V., E. Fernandez., S.D. Hoyle., S. Caillot., J. Jurado-Molina., S. Andrefouet & S.J. Nicol. 2012. Interaction between Coastal and Oceanic Ecosystems of the Western and Central Pacific Ocean through Predator-Prey

Relationship Studies. *PLoS ONE.* 7: 5e36701. doi: 10.1371/journal.pone.0036701.

Brill, R.W. 1994. A review of temperature and oxygen tolerance studies of tunas pertinent to fisheries oceanography, movement models and stock assessments. *Fish. Oceanogr.* 3: 204–216.

Dajan, A. 1998. Pengantar metode statistik jilid I. Lembaga Penelitian Pendidikan Penerangan Ekonomi Sosial (LP3ES). Jakarta. 424 pp.

Edy, Y.J., Usman, S. & Azca, M.N. 2017. Jejaring Illegal Fishing Di Perbatasan Indonesia-Filipina. *Asia Pac. Stud. 1*(1): 109-127.

Hariati, T. 2011. Komposisi hasil tangkapan, musim penangkapan, dan indeks kelimpahan ikan pelagis yang tertangkap pukat cincin mini di Perairan Kendari, Laut Banda. *J. Lit. Perikan. Ind.* 17(2): 139-146.

Hampton, J., & Williams, P. 2011. Analysis of purse seine set type behaviour in 2009 and 2010. WCPFC-SC7-2011-MI-WP-01.

Harley, S.J., Williams, P. & Hampton, J. 2010. Characterization of purse seine fishing activities during the 2009 FAD closures. *Sixth regular session of the WCPFC Scientic Committee, Aug. 10-19, 2010, Nuku'alofa, Tonga. WCPFC-SC6-2010/FT-WP-03*.

Holland, K.N., Brill, R.W. &. Chang, R.K.C. 1990. Horizontal and vertical movements of yellowfin and bigeye tuna associated with fish aggregating devices. *Fish. Bull.* 88: 493-507.

Jaelani, A.K & Basuki, U. 2014. Illegal Unreported and Unregulated (IUU) Fishing: Upaya Mencegah dan Memberantas Illegal Fishing dalam Membangun Poros Maritim Indonesia. *Supremasi*. 3(1): 168-192.

Kefi, O.S., Katiandagho, E.M. & Paransa, I.J. 2013. Sukses pengoperasian pukat cincin Sinar Lestari 04 dengan alat bantu rumpon yang beroperasi di Perairan Lolak Provinsi Sulawesi Utara. *J. Ilmu Teknol. Perikanan Tangkap.* 1(3): 69-75.

Kekenusa, J.S. 2006. Analisis Penentuan Musim Penangkapan Ikan Cakalang (*Katsuwonus pelamis*) di Perairan Sekitar Bitung Sulawesi Utara. *J. Protein*. 13(1): 103–109.

Kekenusa, J.S. & Paendong, M.S. 2016. Analisis penentuan musim penangkapan ikan cakalang (*Katsuwonus pelamis* L.) di Perairan Belang Minahasa Tenggara-Sulawesi Utara. *J. Ilmiah Sains*. 16(2): 86-90.

Lan, K.W., Evans, K. & Lee, M.A. 2013. Effects of climate variability on the distribution and fishing conditions of yellowfin tuna (*Thunnus albacares*) in the western Indian Ocean. *Climatic Change.* 119: 63–77. doi: 10.1007/s10584-012-0637-8.

Malone, M.A., Buck, K.M., Moreno, G. & Sancho, G. 2011. Diet of three large pelagic fishes associated with drifting fish aggregating devices (DFADs) in the western equatorial Indian Ocean. *Animal Biodiv. Conserv.* 34(2): 287–294.

Morgan, A.C. 2011. Fish aggregating devices and tuna: Impacts and management options. Ocean Science Division, Pew Environment Group, Washington, DC. 20 pp.

Palma, M.A. & Tsamenyi, M. 2008. Case Study on the Impacts of Illegal, Unreported and Unregulated Fishing in the Sulawesi Sea, APEC Fisheries Working Group. Australian National Center for Ocean Resources and Security. 62 pp.

Rochman, F., Pranowo, W.S. & Jatmiko, I. 2016. The influence of swimming layer and sub-surface oceanographic variables on catch of albacore (*Thunnus alalunga*) in eastern Indian Ocean. *Indonesia Fisheries Res. J.* 22(2): 69-76. doi: 10.15578/ifrj.22.2.2016.69-76

Safruddin, Zainuddin, M. & Rani, C. 2014. Prediksi daerah potensial penangkapan ikan pelagis besar di perairan kabupaten Mamuju. *J. IPTEKS PSP*. 1(2): 185-195.

Simbolon, D., Jeujanan, B. & Wiyono, E.S. 2013. Efektivitas pemanfaatan rumpon dalam operasi penangkapan ikan di Perairan Maluku Tenggara. *J. Amanisal* 2(2): 19-31.

Simbolon, D. & Limbong, M. 2012. Exploration of skipjack fishing ground through sea surface temperature and catches composition analyzes in Palabuhanratu Bay Waters. *J. Coastal Dev.* 15(2): 225-233.

Spiegel, M.R. 1961. *Theory and Problems of Statistics*. Schaum Publ. Co., New York. 359 pp.

Talakana, S., Manoppo, L. & Manu, L. 2017. Komposisi dan distribusi hasil tangkapan kapal pukat cincin KM Grasia 04 di perairan Laut Maluku. *J. Ilmu Teknol. Perikanan Tangkap*. 2(5): 181-186.

Pranowo, W.S., Kuswardani, A.R.T.D., Nugraha, B., Novianto, D., Muawanah, U., Prihatno, H. & Yu, W. 2016. Ocean-Climate Interaction of South Eastern Indian Ocean for Tuna Fisheries & Its Socio-Economy Impacts. *Int. J. Sci. Res*. 5(4): 1956-1961.

Widodo, A.A & Nugraha, B. 2009. Perikanan tuna yang berbasis di Kendari, Sulawesi Tenggara. *Bawal*. 2(6): 299-307.