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A BRIEF INFORMATION ON TUNA POLE-AND-LINE LANDINGS AND FISHING EFFORTS IN LARANTUKA, FLORES TIMUR DISTRICT, NUSA TENGGARA TIMUR PROVINCE, INDONESIA

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ABSTRACT

This research examines tuna pole-and-line landings data by focusing on trend and effort levels in Larantuka, Flores Timur District, Nusa Tenggara Timur Province, Indonesia. The analyzed fisheries data indicate trends that might be useful for monitoring and management purposes. The research data used were from the landings, number of trips, and fishing gear data on tuna pole-and-line from 2005 to 2014 provided by local fisheries authority. Data was also sourced from previous publications and field surveys. This research analyzes data on tuna pole-and-line fishery trends, relationships between landings, number of trips, and fishing gears used. Overall, the data on tuna landings from 2005-2014 increased whilst on the contrary there was a decrease in the numbers of trips and fishing gears used. The relationship between landings to trips (slope = -0.0087; p-value = 0.7639) and gears (slope = 8.1285; p-value = 0.2715) can be interpreted as being a unit increase in number of trips, which tended to be linked with a decrease of 0.0087 tons in landings. In contrast, a unit increase in gears tended to be associated with an increase of 8.1285 tons in landings.The research did not show statistically significant relationships among landings, numbers of both trips, and fishing gears.

Keywords: Eastern Indonesia; effort; fisheries data; pole-and-line; tuna

INTRODUCTION

The long traditional and settled fisheries of tuna in Indonesia are one of the most significant of the nation’s fishing activities. Both the customary and mechanical degrees of tuna fishing rely upon accessibility from nature (FAO, 2016b; Fernández-Polanco, 2016; Khan *et al.*, 2019; MMAF, 2015). The tuna traditional fishing in many islands in eastern Indonesia is mostly shown by the artisanal fishing techniques (Harsono *et al.*, 2014; Khan *et al.*, 2020c). The local skipjack tuna (*Katsuwonus pelamis*) stock in eastern Indonesia is supplemented periodically by large migrations from the western tropical Pacific Ocean stocks (Harsono *et al.*, 2014; McElroy & Uktolseja, 1992). The tuna resources in Indonesian waters are currently considered to be under pressure and most species have become fully exploited or are potentially over-exploited (Fernández-Polanco, 2016), only skipjack is considered to have been kept up at a moderate level (MMAF, 2015; Sunoko & Huang, 2014). Furthermore, yellow fin tuna (*Thunnus albacares*) has been fully exploited in entire Indonesia, except in the Makassar Strait waters, Bone Bay, Flores Sea, Bali Sea, Aru Sea, Arafura Sea and the Eastern Timor Sea areas (MMAF, 2013; Sunoko & Huang, 2014; Zainuddin *et al.*, 2017).

Understanding the long term patterns from fish arrivals and exertion information is important to provide a better picture of the generally condition of fish stocks and of any changes taking put in them to manage this resources (Arrizabalaga *et al.*, 2012; Kawamoto & Nakamae, 2017; Miyake *et al.*, 2004; Pet-Soede *et al.*, 1999) and from this to establish an approach which will achieve a secure level of sustainability (FAO, 1997). One of the most obvious requirements for fisheries management is to obtain reliable data on current and predicted stock levels. Estimating levels of fishing effort is crucial to fisheries scientists, because it can provide information for calculating catch volume per unit of effort (CPUE) which is a standardized index, providing an indirect measure of relative stock abundance (Matsuzaki & Kadoya,

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2015). When utilizing effort data, its spatial component deserves proper attention because the spatial distributions of fleets both locally and regionally may change over time, and non-randomly distributed fishing efforts may falsely lead to the extremes of both hyper-stability or hyper-depletion and/or unreliable abundance indices (Bordalo-Machado, 2006; Chang & Yuan, 2014; Rose & Kulka, 1999).

The requirement to provide science-based advice for stock size allowing for their migratory nature in data-poor situations has forced analysts to be creative in using available data to infer catch rates, fish biology, and socio-economic interactions (NOAA, 2014; Staples *et al.*, 2014). Trends in landings and fishing effort can be derived from the formal fisheries annual data statistics that are published by the government or from field surveys (Khan *et al.*, 2020c; Sims & Simpson, 2015), however, it is a challenging task even to estimate the actual level of fishing effort (Froese *et al.*, 2012) as biological features such as primary productivity change with time (FAO, 1997). Differences in fisheries classifications and definitions among nations also make international comparisons difficult (de Graaf *et al.*, 2015; Khan *et al.*, 2020b; NOAA, 2014; Staples *et al.*, 2014). This research aims to analyze tuna pole-and-line landings, number of trips and fishing gears trends and investigate their relationships.

MATERIALS AND METHODS

Study Area

The research site was located at Larantuka's fish landing, Flores Timur District, Nusa Tenggara Timur Province. Larantuka fish landing is a unique location, which is surrounded by two Indonesian Fisheries Management Area (FMA) or *Wilayah Pengelolaan Perikanan (WPP)*. Seventy percent of this district comprises sea water as it faces the Sawu Sea (part of WPP 513) in the south and the Flores Sea (part of the WPP 713) in the north (Figure. 1) (MMAF, 2014a). According to Yuniarta *et al.* (2017), eastern Indonesia has traditionally been recognized as the center of tuna fishing in the country for many years. This location was chosen as it has the most extensive temporal records of tuna fisheries data (Khan *et al.*, 2020a; Khan *et al.*, 2020c).

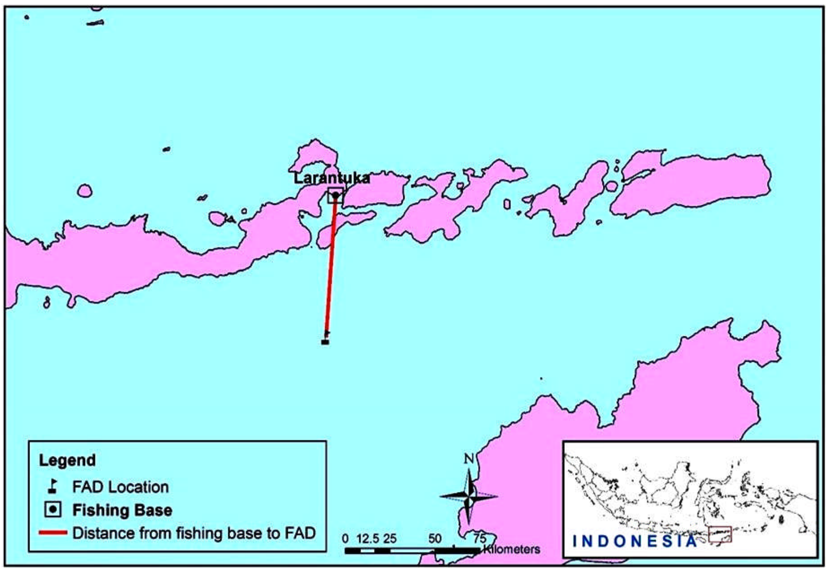

Figure 1. La rantuka, Flores Flores Timur District, Nusa Tenggara Timur Province.

Sources of Data

Tuna pole-and-line landings, number of fishing trips and fishing gear data for the period 2005-2014 were obtained from several sources, including from local fisheries authority of the Flores Timur District; related literature; and from a field survey. Landings data is a number of tuna (both skipjack and yellowfin species) landed by fishers and trip data is a number of fishing operation trips taken by pole-and-line fishing fleets. Each trip data refers to a journey taken by a pole-and-line fishing vessel from a fishing base to a fishing ground and returns (Khan *et al.*, 2020c). Fishing gear data is a number of pole-and-line fishing fleets operated by fishers.

This research collected individual perceptions on compiled statistical data that were solicited among selected stakeholders. It used prepared questionnaires combined with both open-ended and closed person-to-person question sessions (Gubrium & Koro-Ljungberg, 2005). Respondents were visited at their work locations (Turner *et al.*, 2014) and were contacted by means of the so-called "snowball" technique, whereby initial participants suggested, with some encouragement, other potential participants (Gubrium & Koro-Ljungberg, 2005). The questionnaires were translated into *Bahasa Indonesia* (the Indonesian national language) and the responses that were obtained from the respondents were translated into English for subsequent analysis. The reasons for these questions, and the intended use of the answers, were discussed with the respondents in advance (Turner, 2010). Participants were asked for their number of tuna pole-and-line landings, type of fishing gears and number of trips.

Statistical Analyses

This research analyzed data on landings, trips and gears of Flores Timur District for ten consecutive years from 2005 until 2014. The results are presented using simple plots in order to capture the trends. The term 'trends', in this manuscript, means any observable periodic changes within the specific 10 years period (Hall & Roman, 2013; Staples *et al.*, 2014). Pearson partial correlation method was employed to identify the strength relationships among landing, gear, and trip variables after controlling for other variables with assumptions: (1) linearity related (2) continues variables (3) variables normally distributed (Johnson & Wichern, 2007; Rosner, 2016). Statistics significance level was fixed at <0.05 and the magnitudes of partial correlation coefficients were classified based on previous research, such as Fowler (1998), Rowntree (2003) and De Muth (2014) as shown in Table 1.

Table 1. The classification level for partial correlation coefficients

Coefficient range	Classification
0.00 – 0.19	Very week
0.20 – 0.39	Weak
0.40 – 0.69	Modest
0.70 – 0.89	Strong
0.90 – 1.00	Very strong

Generalised least squares (GLS) model was employed in order to determine the factor of landing-associated. Tuna landings were handled as being a dependent variable, whilst the numbers of both trips and gears were considered as being independent covariates with the assumptions that the residuals were linear and the residuals were normally distributed. The final predictive regression model that was used was:

$$Y \text{ (tuna landings)} = \beta_0 + \beta_1 \text{(trips)} + \beta_2 \text{(gears)} + \varepsilon \quad \ldots\ldots (1)$$

Where Y is the dependent variable, β_0 the model constant, β_1 and β_2 are the independent factors, and ε is an error. All tests and plots were performed in the R software environment (Everitt & Hothorn, 2010; Martínez-Rincón *et al.*, 2012; R Core Team, 2013).

RESULTS AND DISCUSSION

Results

Tuna pole-and-line trends

Fisheries data (landings, gear and trip) shows a fluctuation within 10 years (2005-2014) as shown in Table 2.

Table 2. Number of landings, fishing gears, and fishing trips (2005-2014)

Year	Landings (tons)	Gear (units)	Trip
2014	3871	85	5100
2013	3871	85	5100
2012	1056	30	3600
2011	2215	45	2867
2010	1823	56	3304
2009	544	50	2608
2008	1655	190	2240
2007	1010	290	1800
2006	525	290	46400
2005	868	296	47360

Overall, tuna landing data from 2005-2014 have demonstrated increases in Flores Timur. These findings are consistent with the observations of previous studies, for instance, Miyake *et al.* (2004) reported a rapid growth in tuna catches from the 1980s, resulting in Indonesia being the largest global producer of yellowfin tuna in 1997. Additionally, Sunoko and Huang (2014) stated that Indonesian tuna landings had increased between 2004 and 2014, then supplying more than 16% of tuna catches globally by 2014 (MMAF, 2014b). The pole-and-line tuna landings clearly tended to increase appreciably in Flores Timur from 2005-2014 (Figure. 2).

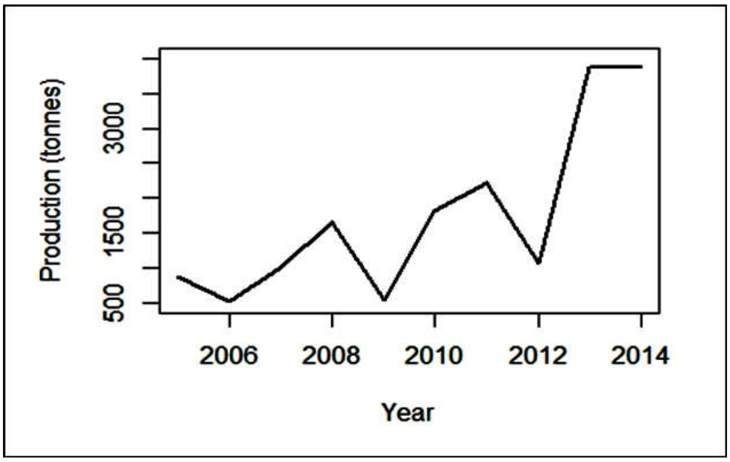

Figure 2. Annual landings in Flores Timur District, 2005-2014.

However, the FAO reported that a global decline in tuna catches had developed since 2004 (FAO, 2016a, 2016b) which was mirrored by a declining trend in tuna catches in the Indian Ocean since 2006 (Satheeshkumar & Pillai, 2013). Other examples, in Hawaii since the 1940s, Ecuador in the 1950s, Senegal in the early 1960s, the Basque region of Spain in the early 1970s, Japan in the late 1970s, Brazil in 1985, the Canary Islands in 1994, the Azores in the1990s, the Maldives in 2006 and Indonesia in the late 1990s (Gillett, 2015), all reported declines in tuna catches. Furthermore, other studies revealed that fishing limitations, including those regarding fishing rights (Caballero-Miguez *et al.*, 2014); quotas (Squires *et al.*, 2013) for cod fishing in Newfoundland, Canada (Schrank & Roy, 2013); illegal fishing for sturgeon in the Caspian Sea (Ye & Valbo-Jørgensen, 2012); areas closed for purse-seine fleets fishing for tuna in the eastern tropical Atlantic (Torres-Irineo *et al.*, 2011); and the closed season in the Pearl River Estuary (Wang *et al.*, 2015), were all factors pertaining directly and indirectly to the abundance or otherwise of tuna.

It should be noted that the number of fishing gears in the district of Flores Timur had decreased appreciably since 2007 (Figure. 3) similarly with the annual pole-and-line fishing trips for the same period of time (Figure. 4).

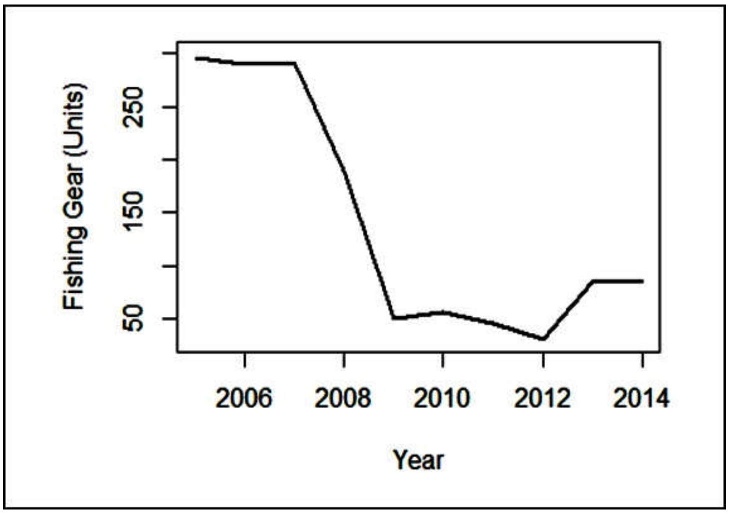

Figure 3. Annual pole-and-line gears in Flores Timur district, 2005-2014.

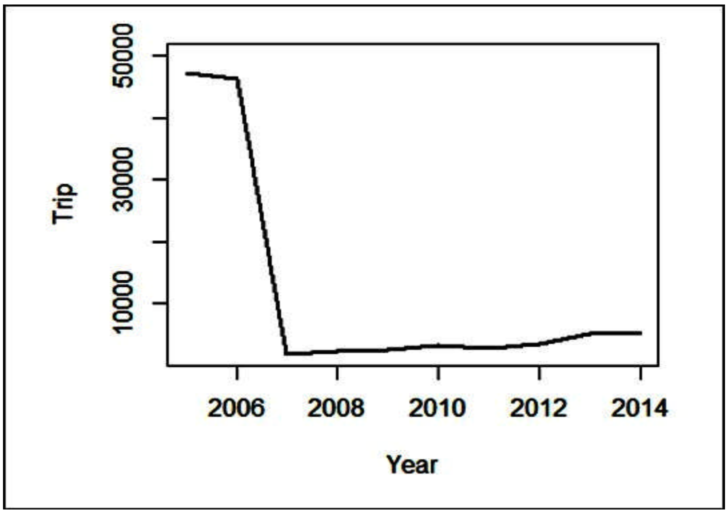

Figure 4. Annual pole-and-line fishing trips in Flores Timur district, 2005-2014.

Tuna pole-and-line relationships

Statistical analysis from this research found that both independent variables (gear and trip) had weak correlation to the dependent variable (landings). Furthermore, the correlation between independent variables (gear and trip) showed modest correlation category (Table 3).

Table 3. Correlation analysis results matrix

Variable	Landings	Gear	Trip
Landings	1	-0.4239 (p>0.05)	-0.3364 (p>0.050)
Gear		1	0.6685 (p<0.05)
Trip			1

The correlation result between the dependent (landings) and independent variables (gear and trip) from this research also reflected another research by Maunder and Punt (2013), which revealed a combination of data resources for fisheries trend analysis and correlation patterns (Moutopoulos & Koutsikopoulos, 2014). The weak to modest correlation among variables might be attributed to more than one factor. It is noted that social and economic factors (Staples *et al.*, 2014) which might contribute to the number of trip and gear performances, technologies (Joseph, 2003), landing site social behaviors (Miyake *et al.*, 2010), fishing ground distances, and also market prices (Davies *et al.*, 2014; Teh *et al.*, 2012; Williams & Terawasi, 2011) were identified as the main drivers for this research findings.

Table 4. Generalised least squares model on landings

Predictor	Slope	SE	t	p-value
Intercept	1048.0772	10698428	0.0001	0.9999
Trips	-0.0087	0	-0.3123	0.7639
Gears	8.1285	7	1.1936	0.2715

Discussion

Fluctuation on fisheries data are consistent with the observations of previous studies, for instance, Miyake *et al.* (2004) reported a rapid growth in tuna catches from the 1980s, resulting in Indonesia being the largest global producer of yellowfin tuna in 1997. Additionally, Sunoko and Huang (2014) stated that Indonesian tuna landings had increased between 2004 and 2014, then supplying more than 16% of tuna catches globally by 2014 (MMAF, 2014b).

The best fit GLS model regarding the landings data included the effects of both tuna pole-and-line trips and gears (Table 4). The relationship between landings to trips (slope = -0.0087; p-value = 0.7639) and gears (slope = 8.1285; p-value = 0.2715) can be interpreted as being a unit increase in number of trips, which tended to be linked with a decrease of 0.0087 tons in landings. In contrast, a unit increase in gears tended to be associated with an increase of 8.1285 tons in landings.

There were no statistically significant relationships between landings and numbers of both fishing gears and trips in Flores Timur District. The *p*- value for the relation between landings and trip was 0.7639 and *p*-value for relation between landing and gears was 0.2715. Sunoko and Huang (2014) revealed that there were 513 pole-and-line fishing gears in Indonesia in 1979, whereas three decades later, this figure had increased to 12,727. But from 2012-2015, pole-and-line fishing declined both globally and nationally (Gillett, 2015). Fishing trip durations of Flores Timur typically between 7 and 14 days. This difference is due to several factors, including fishing season, engine type and boat size (Buchary, 1999), distance to fishing grounds (McElroy, 1991; Pet-Soede *et al.*, 2001; Russo *et al.*, 2016), the availability of live-bait, which is crucial for pole-and-line fishing (Khan *et al.*, 2018; McElroy & Uktolseja, 1992), and government regulations (for example, when the government of Indonesia increased the fuel subsidy in 2010 (Alfian, 2010) it was led to an increase in the number of fishing trips at a national level that year. Before 1990, Indonesian pole-and-line fishing vessels had capacities of 7–15 GT for one day trips, 20–30 GT for one-to-five-day trips, and 100–300 GT for 15-to-30-day trips (Buchary, 1999; McElroy, 1989). Havice (2013) found that the catch rate and the number of trips influenced landings (Chan *et al.*, 2014).

However, the FAO reported that a global decline in tuna catches had developed since 2004 (FAO, 2016a, 2016b) which was mirrored by a declining trend in tuna catches in the Indian Ocean since 2006 (Satheeshkumar & Pillai, 2013). Other examples, in Hawaii since the 1940s, Ecuador in the 1950s, Senegal in the early 1960s, the Basque region of Spain in the early 1970s, Japan in the late 1970s, Brazil in 1985, the Canary Islands in 1994, the Azores in the1990s, the Maldives in 2006 and Indonesia in the late 1990s (Gillett, 2015), all reported declines in tuna catches. Furthermore, other studies revealed that fishing limitations, including those regarding fishing rights (Caballero-Miguez *et al.*, 2014); quotas (Squires *et al.*, 2013) for cod fishing in Newfoundland, Canada (Schrank & Roy, 2013); illegal fishing for sturgeon in the Caspian Sea (Ye & Valbo-Jørgensen, 2012); areas closed for purse-seine fleets fishing for tuna in the eastern tropical Atlantic (Torres-Irineo *et al.*, 2011); and the closed season in the Pearl River Estuary (Wang *et al.*, 2015), were all factors pertaining directly and indirectly to the abundance or otherwise of tuna.

It is worth noting that the numbers of fishing gears and fishing trips were not in themselves significant indicators, or predictors of tuna landings. This may be because of (1) errors in data input, such as missing entries and errors in typing (Yuniarta *et al.*, 2017); (2) data submitted by enumerators being improperly collected and analyzed due to diverse geographical conditions (Gillett, 2011); (3) vessel capacity (tonnage) and engine power all varying in each location (Yuniarta *et al.*, 2017), (4) different levels of economic and infra-structure development in each location (Khan *et al.*, 2020a), and/or (5) changes in surrounding areas (FAO, 2016b) At the research location was found that the number of enumerators was limited.

Ship landings activity that occur throughout the day with high catch numbers causing enumerators are unable to handle data collection accurately. Another issue found was that the data were not synchronized between one institution and another, making it difficult for researchers to see which data was better used for analysis. The issue of data continues to be an unresolved problem. Nevertheless, good fisheries management in the future needs a reliable and supportive database. Besides that, the availability of data can also be the main information that can be used as capital to persuade investors in the fisheries industry. Provision of qualified human resources must be available. Therefore, the policy direction for fisheries resources management can be implemented properly.

CONCLUSIONS

The landing trend showed that overall landings had increased up to 2012 but gears and trips had declined since 2007. Thus, on the relation between landings and effort, the research has shown that there are no significant relationships between them, probably because of the different fishing technologies and fishing efforts at the research site.

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REFERENCES

Alfian. (2010, Wednesday, 22 September 2010). Govt gets green light to raise fuel quota. *The Jakarta Post*. Retrieved from http://cbe.thejakartapost.com/news/2010/09/22/govt-gets-green-light-raise-fuel-quota.html

Arrizabalaga, H., Murua, M., & Majkowski, J. (2012). Global status of tuna stocks: Summary sheets. In (Vol. 19, pp. 645 - 676). AZTI-Tecnalia: Revista de Investigación Marina.

Bordalo-Machado, P. (2006). Fishing effort analysis and its potential to evaluate stock size. *Reviews in Fisheries Science, 14*(4), 369-393. doi:10.1080/10641260600893766

Buchary, E. A. (1999). *Evaluating the effect of the 1980 trawl ban in the Java Sea, Indonesia: an ecosystem-based approach.* (Master of science). The University of British Columbia, Vancouver.

Caballero-Miguez, G., Varela-Lafuente, M. M., & Dolores Garza-Gil, M. (2014). Institutional change, fishing rights and governance mechanisms: The dynamics of the Spanish 300 fleet on the Grand Sole fishing grounds. *Marine Policy, 44*, 465-472. doi:http://dx.doi.org/10.1016/j.marpol.2013.10.015

Chan, V., Clarke, R., & Squires, D. (2014). Full retention in tuna fisheries: Benefits, costs and unintended consequences. *Marine Policy, 45*(0), 213-221. doi:http://dx.doi.org/10.1016/j.marpol.2013.10.016

Chang, S. K., & Yuan, T. L. (2014). Deriving high-resolution spatiotemporal fishing effort of large-scale longline fishery from vessel monitoring system (VMS) data and validated by observer data. *Canadian Journal of Fisheries and Aquatic Sciences, 71*(9), 1363-1370. doi:10.1139/cjfas-2013-0552

Davies, T. K., Mees, C. C., & Milner-Gulland, E. J. (2014). The past, present and future use of drifting fish aggregating devices (FADs) in the Indian Ocean. *Marine Policy, 45*(0), 163-170. doi:http://dx.doi.org/10.1016/j.marpol.2013.12.014

de Graaf, G. J., Nuno, F., Ofori Danson, P., Wiafe, G., Lamptey, E., & Bannerman, P. (2015). International training course in fisheries statistics and data collection. In *FAO Fisheries and Aquaculture Circular No. 1091* (Vol. FIPS/C1091 (En), pp. 134). Rome: Food and Agriculture Organization (FAO).

De Muth, J. E. (2014). *Basic statistics and pharmaceutical statistical application* (3rd ed.). Boca Raton, Florida: Chapman & Hall / CRC Press.

Everitt, B. S., & Hothorn, T. (2010). *A handbook of statistical analyses using R* (2nd ed.). USA: CRC Press.

FAO. (1997). *Fisheries management*. In (FAO Technical Guidelines for Responsible Fisheries ed., pp. 82). Rome: Food and Agri culture Organization.

FAO. (2016a). *Globefish-Analysis and information on world fish trade. Tuna - December 2015*. Retrieved from http://www.fao.org/in-action/globefish/market-reports/resource-detail/en/c/358022/

FAO. (2016b). *The state of world fisheries and aquaculture 2016: Contributing to food security and nutrition for all*. Rome: Food and Agriculture Organization.

Fernández-Polanco, J. (2016). An overview of the global tuna market. In (pp. 72). Rome: Food and Agriculture Organization.

Fowler, J., Cohen L. and Jarvis P. (1998). *Practical statistics for field biology* (Second ed.). New York: Wiley & Sons.

Froese, R., Zeller, D., Kleisner, K., & Pauly, D. (2012). What catch data can tell us about the status of global fisheries. *Marine Biology, 159*(6), 1283-1292. doi:http://dx.doi.org/10.1007/s00227-012-1909-6

Gillett, R. (2011). *Bycatch in small-scale tuna fisheries: A global study*. Rome: Food and Agriculture Organization.

Gillett, R. (2015). Pole-and-line tuna fishing in the world: status and trends. In (Vol. 6, pp. 17). London: International Pole and Line Foundation.

Gubrium, E., & Koro-Ljungberg, M. (2005). Contending with border making in the social constructionist interview. *Qualitative Inquiry, 11*(5), 689-715. doi:10.1177/1077800405278776

Hall, M., & Roman, M. (2013). *Bycatch and non-tuna catch in the tropical tuna purse seine fisheries of the world*. Rome: Food and Agriculture Organization of the United Nations.

Harsono, G., Atmadipoera, A. S., Syamsudin, F., Manurung, D., & Mulyono, S. B. (2014). Halmahera eddy features observed from multisensor satellite oceanography. *Asian Journal of Scientific Research, 7*(4), 571-580. doi:10.3923/ajsr.2014.571.580

Havice, E. (2013). Rights-based management in the Western and Central Pacific Ocean tuna fishery: Economic and environmental change under the vessel day scheme. *Marine Policy, 42*(0), 259-267. doi:http://dx.doi.org/10.1016/j.marpol.2013.03.003

Johnson, R. A., & Wichern, D. W. (2007). *Applied multivariate sta tistical analysis* (6 ed.): Pearson Practice Hall.

Joseph, J. (2003). Managing fishing capacity of the world tuna fleet. In FAO (Ed.). Rome: Food and Agriculture Organization of the United Nations.

Kawamoto, T., & Nakamae, A. (2017). Catch trend of bigeye tuna Thunnus obesus by purse seine using fish aggregating devices, by flag states and area of operation in tropical regions of the Western and Central Pacific Ocean. *Fisheries Science, 83*(2), 161-170. doi:10.1007/s12562-016-1047-z

Khan, A. M. A., Dewanti, L. P., Apriliani, I. M., Supriadi, D., Nasution, A. M., Gray, T. S., . . . Polunin, N. V. C. (2020a). Study on market process of tuna pole-and-line fishery in eastern Indonesia: A study case in Sorong, Papua Barat Province. *Indonesian Fisheries Research Journal, 26*(1), 33-39. doi:http://dx.doi.org/10.15578/ifrj.26.1.2020.33-39

Khan, A. M. A., Gray, T. S., Mill, A. C., & Polunin, N. V. C. (2018). Impact of a fishing moratorium on a tuna pole-and-line fishery in eastern Indonesia. *Marine Policy, 94*, 143-149. doi:10.1016/j.marpol.2018.05.014

Khan, A. M. A., Mill, A. C., Gray, T. S., Jiang, M., Arief, H., Brown, A., . . . Polunin, N. V. C. (2020b). Reliability of the data on tuna catches obtained from the dockside in Indonesia: A study of stakeholders' perceptions. *Marine Policy, 122*(2020), 104242. doi:https://doi.org/10.1016/j.marpol.2020.104242

Khan, A. M. A., Nasution, A. M., Purba, N. P., Rizal, A., Zahidah, Hamdani, H., . . . Polunin, N. V. C. (2020c). Oceanographic characteristics at fish aggregating device sites for tuna pole-and-line fishery in eastern Indonesia. *Fisheries Research, 225*(2020). doi:10.1016/j.fishres.2019.105471

Khan, A. M. A., Rizal, A., Dewanti, L. P., Apriliani, I. M., Junianto, Supriyadi, D., . . . Polunin, N. V. C. (2019). Skipjack (*Katsuwonus pelamis*) tuna pole-and-line marketing supply chains in Indonesia: case study in Pulau Bacan. *AACL Bioflux, 12*(2), 636-641. Retrieved from http://www.bioflux.com.ro/docs/2019.636-641.pdf

Martínez-Rincón, R. O., Ortega-García, S., & Vaca-Rodríguez, J. G. (2012). Comparative performance of generalized additive models and boosted regression trees for statistical modeling of incidental catch of wahoo (Acanthocybium solandri) in the Mexican tuna purse-seine fishery. *Ecological Modelling, 233*, 20-25. doi:http://dx.doi.org/10.1016/j.ecolmodel.2012.03.006

Matsuzaki, S.-i. S., & Kadoya, T. (2015). Trends and stability of inland fishery resources in Japanese lakes: introduction of exotic piscivores as a driver. *Ecological Applications, 25*(5), 1420-1432. doi:10.1890/13-2182.1

Maunder, M. N., & Punt, A. E. (2013). A review of integrated analysis in fisheries stock assessment. *Fisheries Research, 142*(0), 61-74. doi:http://dx.doi.org/10.1016/j.fishres.2012.07.025

McElroy, J. K. (1989). Indonesia's tuna fisheries: Past, present and future prospects. *Marine Policy, 13*(4), 285-308. doi:http://dx.doi.org/10.1016/0308-597X(89)90015-8

McElroy, J. K. (1991). The Java Sea purse seine fishery: A modern-day 'tragedy of the commons'? *Marine Policy, 15*(4), 255-271. doi:http://dx.doi.org/10.1016/0308-597X(91)90003-T

McElroy, J. K., & Uktolseja, J. C. B. (1992). Skipjack pole-and-line operations in east Indonesia: A comparative analysis of catch performance. *Marine Policy, 16*(6), 451-462. doi:http://dx.doi.org/10.1016/0308-597X(92)90073-X

Miyake, M. P., Guillotreau, P., Sun, C.-H., & Ishimura, G. (2010). *Recent developments in the tuna industry: Stocks, fisheries, management, processing, trade and markets*. Rome: Food and Agriculture Organization of the United Nations.

Miyake, M. P., Miyabe, N., & Nakano, H. (2004). Historical trends of tuna catches in the world. In (Vol. FAO Fisheries Technical Paper 467). Rome: Food and Agriculture Organization of the United Nations.

MMAF. (2013). Indonesia Tuna Profile. In R. o. I. Ministry of Marine Affairs and Fisheries (Ed.).

Jakarta: Ministry of Marine Affairs and Fisheries, Republic of Indonesia.

MMAF. (2014a). Fisheries Management Plan for Marine Management Area 718 Aru, Arafuru, Timor Sea. In R. o. I. Ministry of Marine Affairs and Fisheries (Ed.), (Vol. 1, pp. 100). Jakarta: Ministry of Marine Affairs and Fisheries, Republic of Indonesia.

MMAF. (2014b). National plan of action; tuna, skipjack and neritic tuna management plan of Indonesia. In R. o. I. Ministry of Marine Affairs and Fisheries (Ed.). Jakarta: Directorate of Fisheries Resources Management, Directorate General of Capture Fisheries, Ministry of Marine Affairs and Fisheries, Republic of Indonesia.

MMAF. (2015). *Marine and fisheries in figures 2015* In *Kelautan dan Perikanan dalam angka tahun 2015* (Vol. I, pp. 308). Jakarta: The Center for Data, Ministry of Marine Affairs and Fisheries, Republic of Indonesia.

Moutopoulos, D. K., & Koutsikopoulos, C. (2014). Fishing strange data in national fisheries statistics of Greece. *Marine Policy, 48*, 114-122. doi:http://dx.doi.org/10.1016/j.marpol.2014.03.017

NOAA. (2014). NOAA fisheries draft protocol for prioritizing fish stock assessments. In *Prioritizing Fish Stock Assessments* (pp. 38): U. S. Department of Commerce - NOAA.

Pet-Soede, C., Machiels, M. A. M., Stam, M. A., & van Densen, W. L. T. (1999). Trends in an Indonesian coastal fishery based on catch and effort statistics and implications for the perception of the state of the stocks by fisheries officials. *Fisheries Research, 42*(1–2), 41-56. doi:http://dx.doi.org/10.1016/S0165-7836(99)00034-X

Pet-Soede, C., Van Densen, W. L. T., Hiddink, J. G., Kuyl, S., & Machiels, M. A. M. (2001). Can fishermen allocate their fishing effort in space and time on the basis of their catch rates? An example from Spermonde Archipelago, SW Sulawesi, Indonesia. *Fisheries Management and Ecology, 8*(1), 15-36. doi:10.1046/j.1365-2400.2001.00215.x

R Core Team. (2013). R: A language and environment for statistical computing. In. Vienna, Austria: R Foundation for Statistical Computing.

Rose, G. A., & Kulka, D. W. (1999). Hyperaggregation of fish and fisheries: how catch-per-unit-effort increased as the northern cod (Gadus morhua) declined. *Canadian Journal of Fisheries and Aquatic Sciences, 56*(S1), 118-127. doi:10.1139/f99-207

Rosner, B. (2016). *Fundamental of biostatistics* (8 ed.). Boston : Cengage Learning.

Rowntree, D. (2003). *Statistics without tears: A primer for non-mathematicians* (1st ed.). New York, USA: Pearson.

Russo, T., Carpentieri, P., Fiorentino, F., Arneri, E., Scardi, M., Cioffi, A., & Cataudella, S. (2016). Modeling landings profiles of fishing vessels: An application of self-organizing maps to VMS and logbook data. *Fisheries Research, 181*, 34-47. doi:http://dx.doi.org/10.1016/j.fishres.2016.04.005

Satheeshkumar, P., & Pillai, N. G. K. (2013). Conservation and management of tuna fisheries in the Indian Ocean and Indian EEZ. *International Journal of Marine Science, 3*(24). doi:http://dx.doi.org/10.5376/ijms.2013.03.0024

Schrank, W. E., & Roy, N. (2013). The Newfoundland fishery and economy twenty years after the Northern cod moratorium. *Marine Resource Economics, 28*(4), 397-413. doi:10.5950/0738-1360-28.4.397

Sims, D. W., & Simpson, S., J. . (2015). Better policing for fishy catch data. *Nature, 520*(7549), 623. doi:10.1038/520623e

Squires, D., Allen, R., & Restrepo, V. (2013). *Rights-based management in international tuna fisheries*. Rome: Food and Agriculture Organization of the United Nations.

Staples, D., Brainard, R., Capezzuoli, S., Funge-Smith, S., Grose, C., Heenan, A., . . . Pomeroy, R. (2014). Essential Ecosystem Approach to Fisheries Management (EAFM). In (Vol. 1, pp. 318). Bangkok: FAO Regional Office for Asia and the Pacific.

Sunoko, R., & Huang, H.-W. (2014). Indonesia tuna fisheries development and future strategy. *Marine Policy, 43*(0), 174-183. doi:http://dx.doi.org/10.1016/j.marpol.2013.05.011

Teh, L. C., Teh, L. S., & Meitner, M. J. (2012). Preferred Resource Spaces and Fisher Flexibility: Implications for Spatial Management of Small-Scale Fisheries. *Human Ecology, 40*(2), 213-226. doi:http://dx.doi.org/10.1007/s10745-012-9464-9

Torres-Irineo, E., Gaertner, D., de Molina, A. D., & Ariz, J. (2011). Effects of time-area closure on tropical tuna purse-seine fleet dynamics through some fishery indicators. *Aquatic Living Resources, 24*(04), 337-350.

Turner, R. A. (2010). *Social and environmental drivers of fishers' spatial behaviour in the Northumberland lobster fishery.* (PhD Ph. D). Newcastle University, Newcastle Upon Tyne. Retrieved from http://hdl.handle.net/10443/2180

Turner, R. A., Polunin, N. V. C., & Stead, S. M. (2014). Social networks and fishers' behavior: exploring the links between information flow and fishing success in the Northumberland lobster fishery. *Ecology and Society, 19*(2), 38. doi:10.5751/ES-06456-190238

Wang, Y., Duan, L., Li, S., Zeng, Z., & Failler, P. (2015). Modeling the effect of the seasonal fishing moratorium on the Pearl River Estuary using ecosystem simulation. *Ecological Modelling, 312*, 406-416. doi:http://dx.doi.org/10.1016/j.ecolmodel.2015.06.011

Williams, P., & Terawasi, P. (2011). Overview of tuna fisheries in the Western and Central Pacific Ocean, including economic conditions – 2010 [online]. *In the 7th Regular Session of the Scientific Committee, WCPFC, 9–17 August 2011*. Retrieved from http://www.wcpfc.int/node/2810

Ye, Y., & Valbo-Jørgensen, J. (2012). Effects of IUU fishing and stock enhancement on and restoration strategies for the stellate sturgeon fishery in the Caspian Sea. *Fisheries Research, 131–133*, 21-29. doi:http://dx.doi.org/10.1016/j.fishres.2012.06.022

Yuniarta, S., van Zwieten, P. A. M., Groeneveld, R. A., Wisudo, S. H., & van Ierland, E. C. (2017). Uncertainty in catch and effort data of small- and medium-scale tuna fisheries in Indonesia: Sources, operational causes and magnitude. *Fisheries Research, 193*, 173-183. doi:https://doi.org/10.1016/j.fishres.2017.04.009

Zainuddin, M., Farhum;, A., Safruddin;, S., Selamat;, M. B., Sudirman;, S., Nurdin;, N., . . . Saitoh;, S.-I. (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), 19. doi:https://doi.org/10.1371/journal.pone.0185601