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).
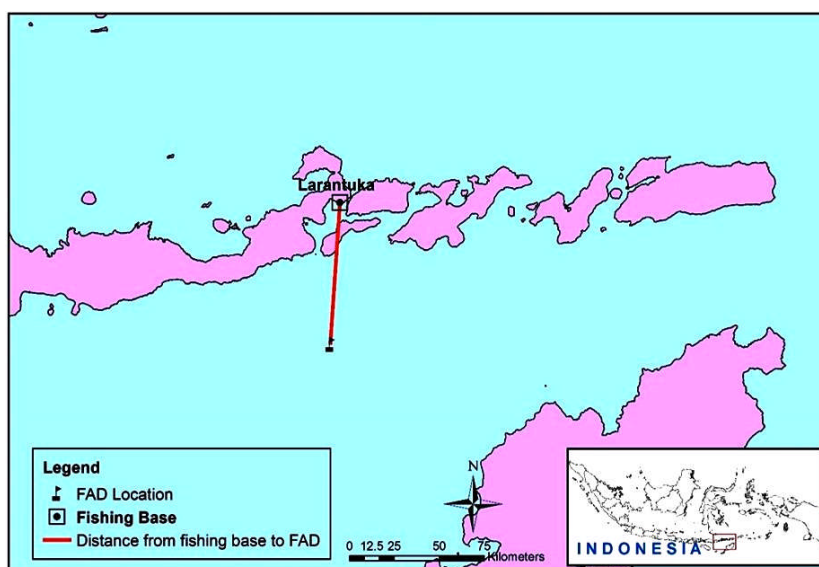

Figure 1. La rantuka, Flores Flores Timur District, Nusa Tenggara Timur Province.

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:

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

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).
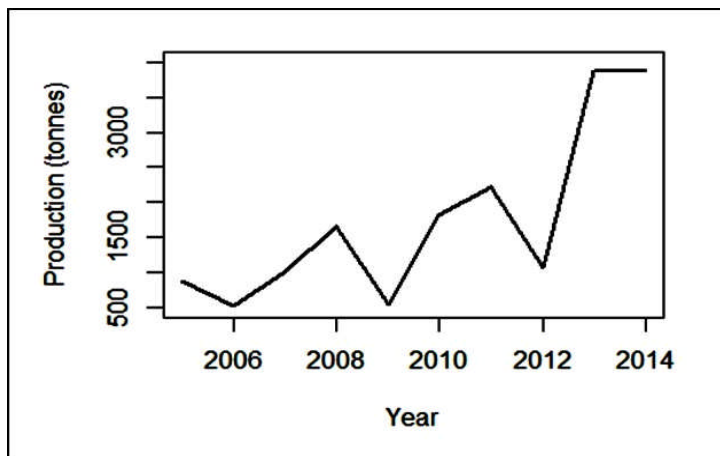

Figure 2.   Annual landings in Flores Timur District, 2005-2014.

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).
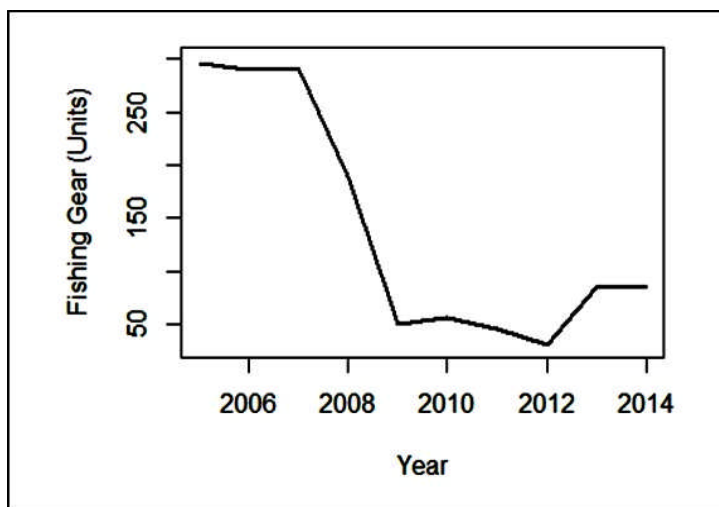

Figure 3.   Annual pole-and-line gears in Flores Timur district, 2005-2014.
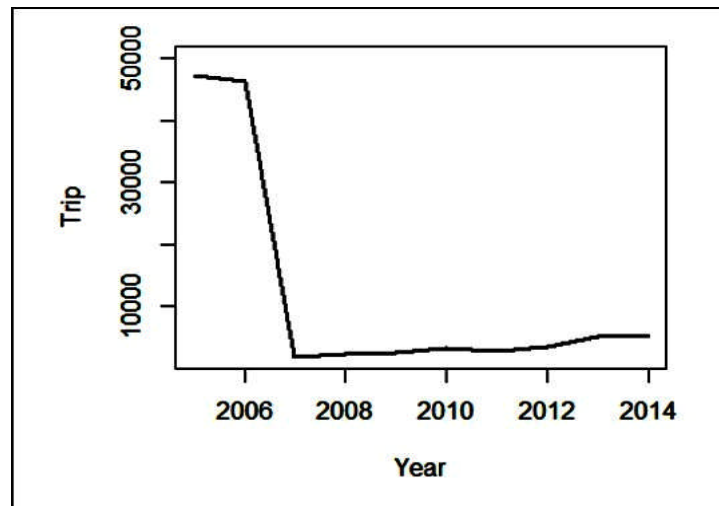
Figure 4.   Annual pole-and-line fishing trips in Flores Timur district, 2005-2014.

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 infrastructure 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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