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CPUE STANDARDIZATION OF FRIGATE TUNA (*Auxis thazard*) CAUGHT BY PURSE SEINE OFF THE COAST OF WESTERN SUMATERA (FMA 572)

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ABSTRACT

Frigate tuna (*Auxis thazard*) is one of the major commercial tuna species, both in industrial and small scale fisheries, particularly in the waters off Western Sumatera. In Indonesia, *A. thazard* is a group of locally called "tongkol" together with *A. rochei*, *Thunnus tonggol*, and *Euthynnus affinis*. This study describes a preliminary examination of frigate tuna catch from purse seine off the coast of western Sumatera (FMA 572). The data were collected daily by an enumerator on the fish landing site from 2013 to 2017, including fishing gear, number of days at sea, catch, length, and weight of frigate tuna. The fishing ground coordinate data provided by the observer on board the vessel. General Linear Model (GLM) with gamma was applied in this study to standardize the CPUE by year, quarter, season, and GT as fixed variables. The results showed that the variation of CPUE was mostly influenced by year and quarter, while season and fleet size (GT) showed less impact on the catch. In general, even though the catch trend declines during the observation years, the population of frigate tuna off the coast of western Sumatera (FMA 572) were considered sustainable.

Keywords: *Auxis thazard*; CPUE; frigate tuna; purse seine; standardization

INTRODUCTION

Frigate tuna (*Auxis thazard*) (Fig. 1) is a pelagic species from the Scombridae family found in almost all tropical and subtropical waters (Tao *et al.*, 2012). Its habitat is at sea level up to 50 m depth and it has a migration pattern at the optimum temperature between 27°C and 27.9°C (Herrera & Pierre, 2009; Maguire, 2006). In Indonesia, frigate tuna is a group locally called "tongkol" together with *A. rochei*, *Thunnus tonggol*, and *Euthynnus affinis* (Tampubolon *et al.*, 2018).

Frigate tuna is one of the major commercial tuna species, both in industrial and small scale fisheries, particularly in western Sumatera, specifically in Fisheries Management Area (FMA) 572 with a potential estimate of 1,353,000 ton per year (Bangun *et al.*, 2015). This species is one of the main targets of the purse seine in western Sumatera and normally forms schools below Fish Aggregated Devices (FADs). There are two types of purse seine fisheries in Indonesia: the small pelagic purse seine and the large pelagic purse seine. The difference of them is on the mesh size of net and fishing area (Tampubolon *et al.*, 2017). The vessel size operated in western Sumatera is between 70 and 100 GT with one inch mesh size,

700 m length, and 60 m net width (Hariati & Sadhotomo, 2007).

The concept of Catch Per Unit Effort (CPUE) as abundance indicator has been used for more than a century in fisheries biology. The stock abundance index can be estimated throughout the CPUE data. The fishing effort standardization, assuming the catch rate (CPUE) is proportional to the abundance of the fish stock, has been a research issue. This assumption means that CPUE is linearly or exponentially related to stock abundance: the larger the stock, the larger the CPUE. Therefore, CPUE becomes a relative index of stock abundance and stock fluctuations can be monitored through time series data of CPUE (Poulsen & Holm, 2007).

Frigate tuna exploitation tends to increase every year. The Indian Ocean Tuna Commission (IOTC, 2014) reported that more than 90% of frigate tuna were caught in four countries: Indonesia (59%), India (14%), Sri Lanka (11%), and Iran (7%). Although many studies dealing with CPUE in Scombrids have been made, only a few actually addressed the CPUE of frigate tuna. The objective of the present study was to provide an overview of the CPUE standardization of frigate tuna caught by purse seine in the waters off western

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Sumatera (FMA 572). The results are useful to assess the status of frigate tuna, which is an important fishery

resource in the Indian Ocean, particularly for artisanal fisheries.



Figure 1. Frigate tuna (*Auxis thazard*) (Randall, 1997).

MATERIALS AND METHODS

Since 2009, the management of Indonesian fisheries has been based on the Fisheries Management Areas of the Republic of Indonesia (FMA-RI), following the Decree of the Minister of Marine Affairs and Fisheries No. PER.01/MEN/2009. The data were collected daily by enumerators on fish landing sites in Sibolga, western Sumatera (FMA 572) from 2013 to 2017. The data collected include fishing gear, number days at sea, amount of catch, length, and weight. GPS records were reported by an observer on board the vessel to map the position of fishing ground. (Figure. 2).

The data were analysed in R software. To standardize the CPUE, the General Linear Model (GLM) was applied using year, quarter, season, and Gross Tonnage (GT) as fixed variables. The details explanation of variables used in this study:

- Year = 2013 to 2017
- Quarter = I (January-March), II (April June), III (July-September), and IV (October-December)

-Season = West Monsoon (December - May) and East Monsoon (June - November)

-Gross Tonnage (GT) = 1 is the vessel size <30 GT and 2 is the vessel size >30 GT

The CPUE equation is $CPUE = C/E = qD$, where C is catch, E is effort, q is the catchability coefficient, and D is density. Calculation was made and based on the GLM model (Candy, 2004):

$$CPUE_{ij} = c + \beta_{1j}Year_{ij} + \beta_{2j}Quarter_{ij} + \beta_{3j}Season_{ij} + \beta_{4j}GT_{ij} + \varepsilon_i \dots \dots \dots (1)$$

The application of GLM method in developing CPUE standardization follows the work of Sadiyah *et al.* (2012) on tuna longline. Gamma distribution was applied in this study considering no zero catch in the data. Model goodness-of-fit and model comparison was carried out with the Akaike Information Criterion (AIC) (Shono, 2005) as large sample were used in the analysis.

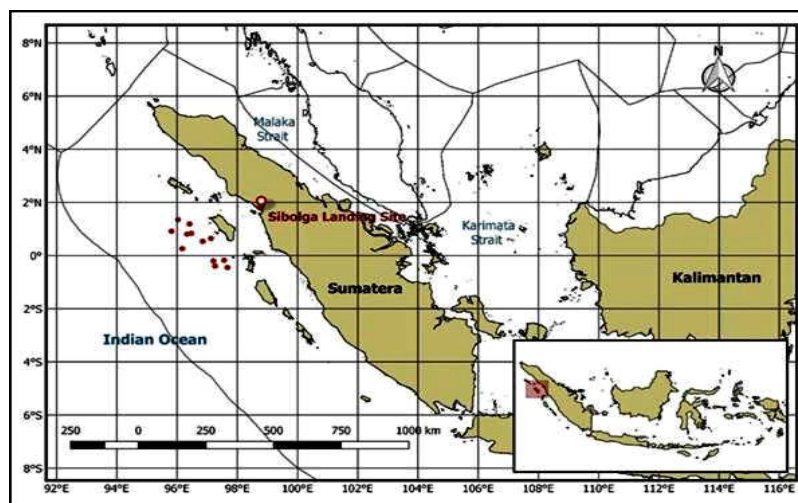


Figure 2. Purse seine fishing grounds (red dots) and Sibolga landing sites.

RESULTS AND DISCUSSION

Results

Table 1 shows the highest efforts occurred in 2016 with 608 trips and the lowest was in 2013. On average, it was 14 days per trip from 2013 to 2017. Fishing activities happens every month with the peak in April

and the lowest catch in January for the purse seine fishery in western Sumatera operating between 2013 and 2017 (Fig. 3). The catch data of 212 purse seiners show an increasing trend from January to April then decreasing until August. It was slightly rising again in September to October but then flat until December.

Table 1. The summary of purse seine trips operated from Sibolga, western Sumatera from 2013 to 2017.

Year	Trips	Total days-at-sea	Mean GT
2013	257	2,934	75.37
2014	311	4,127	79.19
2015	560	7,587	80.28
2016	608	8,909	78.68
2017	445	6,535	78.47

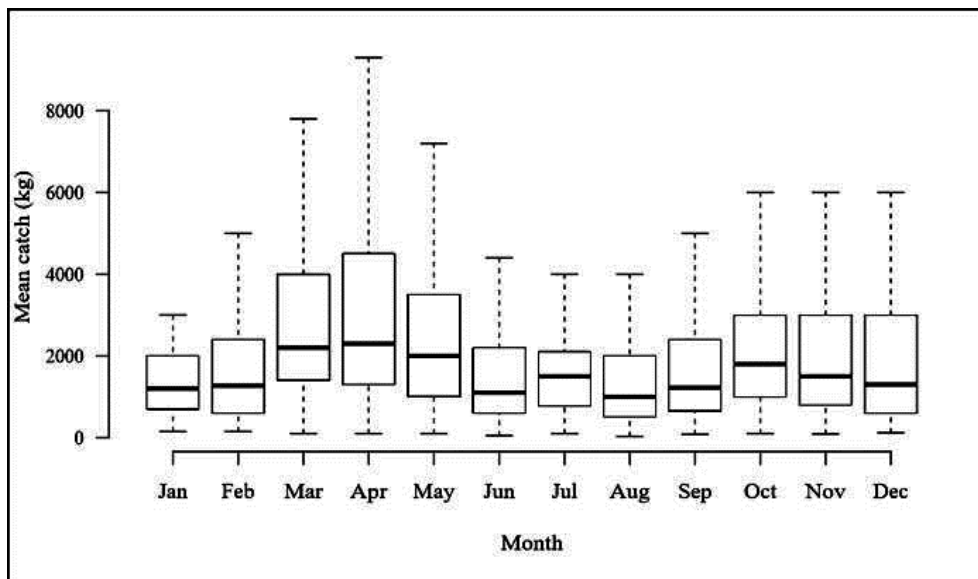


Figure 3. The monthly mean catch and standard deviation of frigate tuna caught by purse seine in western Sumatera during 2013-2017.

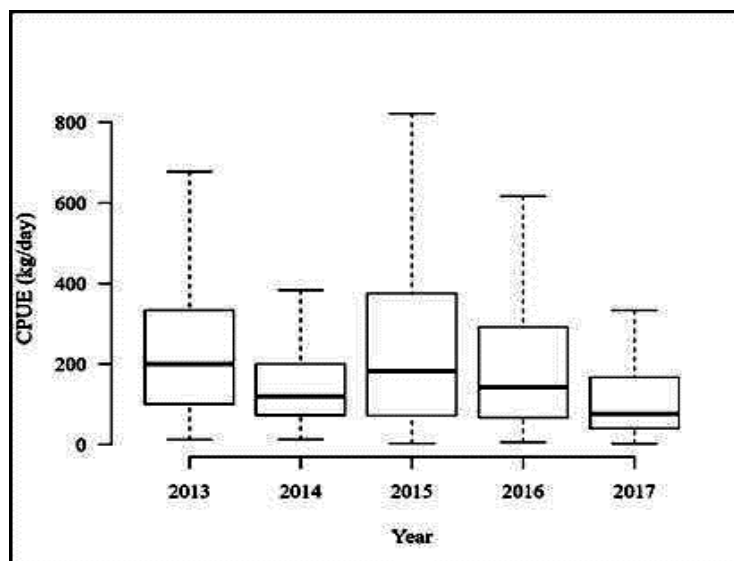


Figure 4. Annual of CPUE nominal series (kg/day) of frigate tuna from purse seine operating between 2013 and 2017.

The nominal CPUE of frigate tuna reached its maximum in 2010 and decreased to minimum in 2014 (Fig. 4). In general, it decreased at the second of the observation year (2014) but then increased again in 2015 until 2017.

The result from frigate tuna CPUE standardization using GLM with gamma shows that the most accounted variables are by the year and quarter (Table 2). The season and fleet size (GT) provide less

significant effect on the catch compared to the year and quarter. Furthermore, the residual analysis (Fig. 5) was used to validate the model, as well as to detect the outliers. The residuals distribution along the fitted values, the QQ plots, and the residuals histogram in Fig. 5 showed that the model fitted well with no major outliers. Overall, the final examination result shows the declining trend of frigate tuna CPUEs over the five year observations (Table 3 and Fig. 6).

Table 2. The parameters used for frigate tuna CPUE standardization using GLM with gamma distribution. * = $P \leq 0.05$; ** = $P \leq 0.01$; and *** = $P \leq 0.001$

Parameter	Df	Deviance	Resid. Df	Resid. Dev	Pr(>Chi)
(intercept only)			1905	1889.4	
Year	4	112.386	1901	1777	< 0.001 ***
Quarter	3	69.208	1898	1707.8	< 0.001 ***
GT	1	5.033	1897	1702.7	0.02946 *
Season	1	5.033	1896	1693.3	0.002848 **

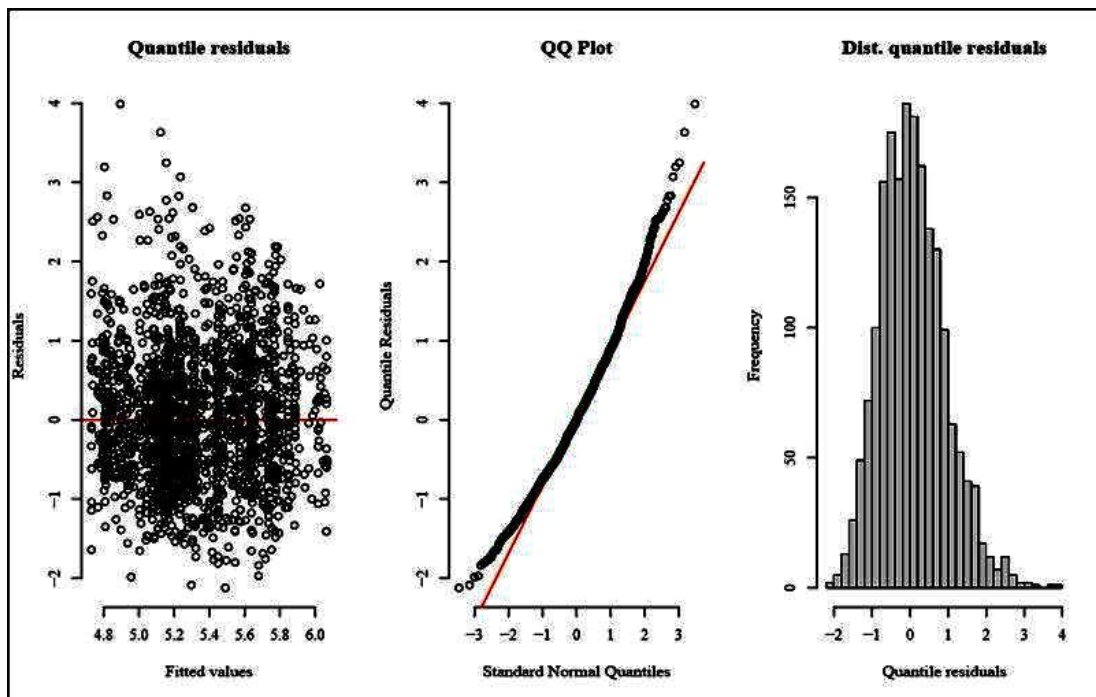


Figure 5. Residual analysis for the final frigate tuna CPUE standardization model from purse seine fishing in the waters off western Sumatera from 2013 to 2017. The residuals along the fitted values on the log scale (left), the QQ plot (middle), and the Pearson's histogram of the distribution of the residuals (right).

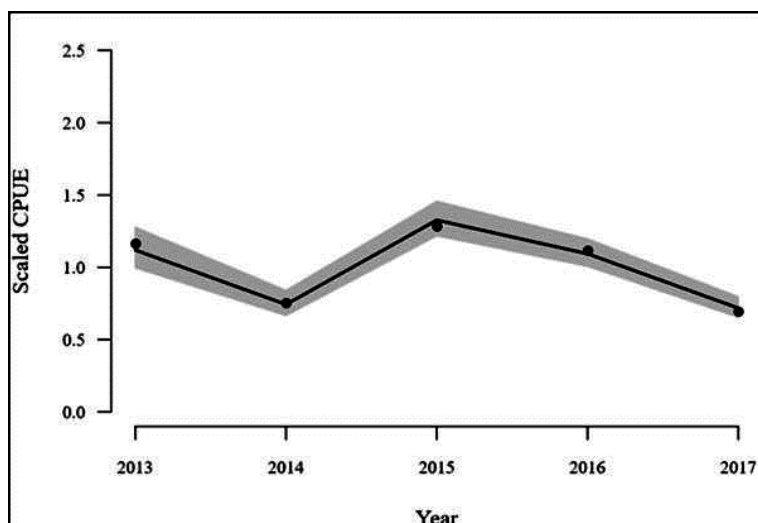


Figure 6. Scaled standardized CPUE series for frigate tuna catch using gamma model from 2013 to 2017.

Table 3. Frigate tuna nominal and standardized CPUEs (kg/days-at-sea) caught by purse seine off the western Sumatera coast, covers nominal CPUE, point estimates (Std. CPUE), standard error of the standardized index (SE), and confidence level.

Year	Nominal CPUE	CPUE standardization index (kg/days-at-sea)			
		Std. CPUE	SE	Asymptotic Lower Confidence Level	Asymptotic Upper Confidence Level
2013	247.01	224	14.15	200	256
2014	159.65	149	8.79	133	168
2015	272.11	266	12.16	244	292
2016	236.71	219	9.66	202	240
2017	146.91	144	7.24	131	160

Discussion

Hoyle *et al.* (2014) stated that the main hypothesis to standardize the CPUE is the catch should be proportional to fish abundance. They also mentioned that catchability and density always change. Catchability is dependent on the skipper skills, vessel capacity, fishing gear, and technology (fish finder), whereas density is influenced by environmental conditions and the size of the fish population. That is why standardization of the CPUE is very crucial and potentially related to the stock density in the long term. The main goal of CPUE standardization is to minimize the variability of confounding factors that might influence the catch rate calculation (Maunder & Punt, 2004).

Frigate tuna fishery in western Sumatera belongs to small scale fisheries, which are associated with low capital, low income, and susceptible to any government policies, for instance subsidized fuel (Allison & Ellis, 2001). The CPUE values are very important information in explaining the fishery stock

status (Setyadji *et al.*, 2016). Various factors associated with environmental condition, fishing practice, government policies, and social and religious affairs can generate the effect on temporal trends of nominal CPUE (Mira *et al.*, 2014; Sadiyah *et al.*, 2012; Setiawan *et al.*, 2013; Setyadji *et al.*, 2018; Teliandi *et al.*, 2013). In addition, purse seine in Sibolga is an active gear, which is associated with the use of Fish Aggregating Devices (FADs). Yusfiandayani (2013) mentioned that in Indonesia FADs is a common traditional gear to attract free schooling fish. It is likely that frigate tuna catch and abundance in Sibolga is also influenced by the presence of FADs.

In this study, all variables (year, quarter, season, GT) used in GLM analysis were sufficiently representative for all confounding factors. According to Maunder & Punt (2004), in standardized CPUE using GLM analysis, a strong interaction and closed relationship always appear. Year and quarter were the main factors that influenced the CPUE values in this observation compared to season. Seasonal fishing index in the small-scale fisheries also plays an

important role to determine CPUE values (Rochman *et al.*, 2017; Wiyono *et al.*, 2006). This is in line with the present study whereby quarter, year, and season showed significant influence on nominal CPUE. Furthermore, fishing season depends on effort (Simbolon & Limbong, 2012) and also environmental conditions, such as Sea Surface Temperature (SST). The warm SST occurs in March in FMA 571 and 572 of the Indian Ocean (Kusuma *et al.*, 2017).

On the other hand, in the case of purse seine fishery in Sibolga the fleet capacity does not show clear relation to CPUE values. This phenomenon may have been caused by the changes in the fishing fleet strategy (Poulsen & Holm, 2007). In recent years, the skippers have gained knowledge in applying efficient fishing gear technology to increase catchability of the gear (Hoyle *et al.*, 2014). In western Sumatera, especially Sibolga, fishers have been exposed to extension from government programs. This might have driven the changes in catchability of frigate tuna in purse seine fishery. Previous study on the juvenile of yellowfin tuna, big eye tuna, and skipjack is in agreement with the present study, whereby no impact of vessel characteristics on the catch rate (Soto *et al.*, 2013).

CONCLUSIONS

In general, the trend of frigate tuna catch was mostly influenced by quarter, year, and fishing season. In the meantime, fleet size (GT) has less impact on the catch. Although the nominal CPUE showed declining pattern, in general, the population of frigate tuna in western Sumatera waters is considered sustainable. For stock assessment purpose, standardized fishing effort is highly recommended to reduce uncertainty factors and thus increase robustness of the analysis.

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