Study on *Katsuwonus pelamis* fishing business at Sadeng Fishery Port, Yogyakarta, Indonesia

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Abstract. *Katsuwonus pelamis* is a prime fishery commodity widely spread in Indonesian waters. Referring to our data analysis, the production trend in Sadeng Fishery Port is significantly increasing over the 5 year timeline, from 2016 to 2020. In order to receive an authentic and detailed examination of the *K. pelamis* fishing business there, all related aspects, such as exploitation level, fishing gears, facilities, sales, and business financial condition have been successfully analyzed. As a conclusion, *K. pelamis* resource in the South Java Sea has been over-exploited, as indicated by a negative slope of CPUE and effort function. Fishing technologies used by local fishermen were still conventional and unproperly maintained, which lowers reliability, efficiency, and cruising range. Existing ice factory was also not in an operational state, since some of the major parts were broken. However, the *K. pelamis* on the markets were fresh, the sales were considered efficient, and the fishing business was financially profitable and feasible.

Key Words: exploitation level, fishing season, catch quality, sales, financial analysis.

Introduction. Indonesia is an archipelagic country with massive potential in the fishery business, due to the abundance of many fish species, among which the *Katsuwonus pelamis* (Amiluddin 2020; Kekenusa & Paendong 2016). *K. pelamis* is a high-migratory and cosmopolitan species commonly found in tropical and sub-tropical waters (Arai et al 2005; Satria & Kurnia 2017). In the Indonesian seas, they live in the Indian Ocean (West Sumatra Sea, South Java Sea, Bali Sea, South Lombok Island Sea, Sumbawa Island Sea) and Eastern Indonesia seas (Celebes Sea, Maluku Sea, Arafuru Sea, Banda Sea, Flores and Makassar Strait) (WWF 2015; Tuli 2018).

The Government of Special Region of Yogyakarta released a government regulation, No. 16 of year 2011 that stipulates the transformation of Sadeng Fishery Port into an economic growth center for the coastal area of the eastern part of Gunung Kidul Regency, based on the fishery commodities business and tourism as the primary and secondary income, respectively. Following the regulation issuance, the local government and fishermen obtained benefits, since the total fish catch in that area has increased significantly, raising the overall income. Based on data from Sadeng Fishery Port, *K. pelamis* production experienced an increasing trend with a noticeable fluctuation from 2016 to 2020 (Figure 1). The lowest production, of 305.99 tons, occurred in 2016, while the highest occurred in 2020, with a total of around 1,395.53 tons.

Even though *K. pelamis* has a high reproduction rate, with all-year-round spawning (Kantun et al 2021) and widespread availability, it is still prone to the possibility of being over-exploited (Wujdi et al 2017). The increasing demand, overfishing, and lack of awareness from the government and society contribute significantly to the sustainability of the *K. pelamis* population. Therefore, examining the current *K. pelamis* exploitation level in Sadeng Fishery port and other aspects related to the *K. pelamis* fishing business is necessary.

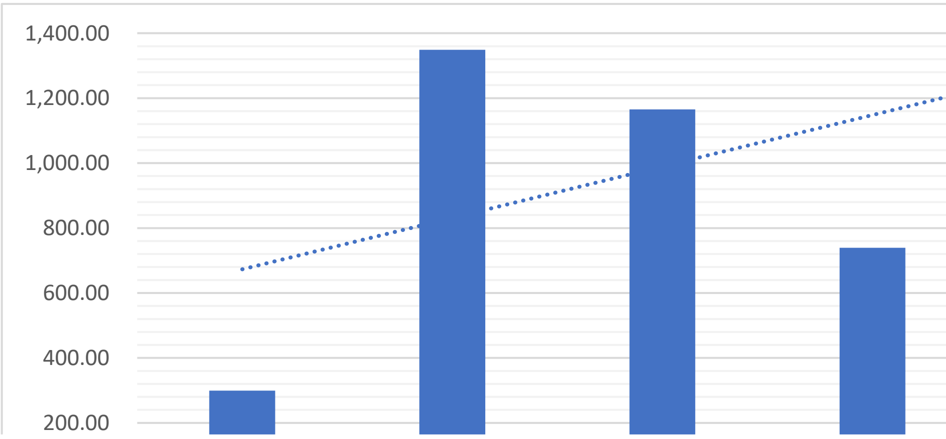

Figure 1. *Katsuwonus pelamis* production at Sadeng Fishery Port from 2016 to 2020.

Material and Method

Description of the study sites. This study was conducted from December 2020 until May 2021 at the Sadeng Fishery Port (Pelabuhan Perikanan Pantai or PPP), Girisubo District, Gunung Kidul, Special Region of Yogyakarta, Indonesia (Figure 2).

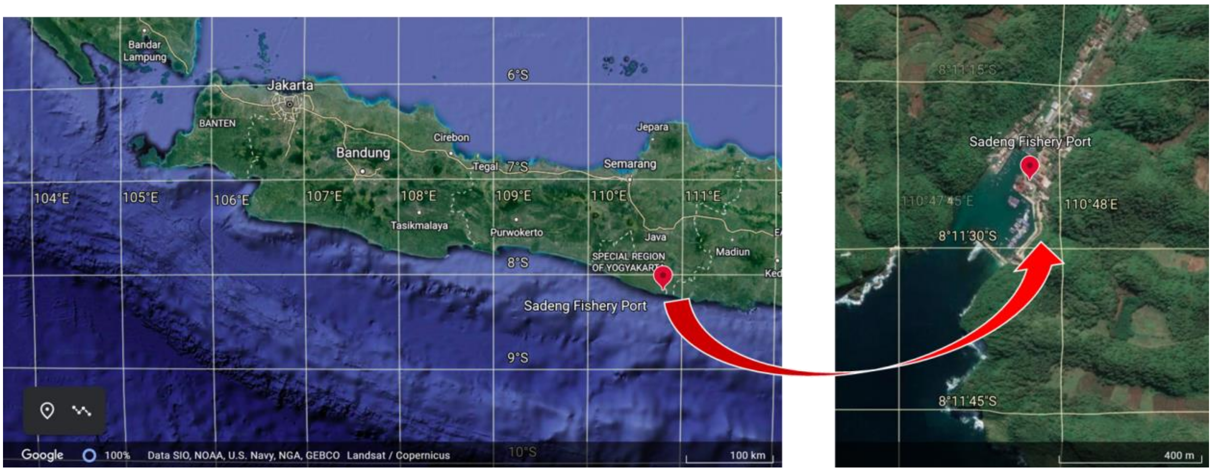

Figure 2. The location of Sadeng Fishery Port, Special Region of Yogyakarta, Indonesia.

Data collection. Data are divided into two kinds, primary and secondary. Primary data were collected by using observation, direct interviews, and documentation, while secondary data were collected from existing sources (Siyoto & Sodik 2015). Any sampling in this research was done by using the Snowball method.

K. pelamis exploitation level. The exploitation level was examined by finding the relationship function of CPUE and Effort. The effort definition used in this research is the total number of fishing trips with 2 types of fishing gears: purse seines and hand lines. The Catch per Unit of Effort (CPUE) was calculated using the following formulas, incorporating the time series of total catch and effort (Nurhayati 2013).

$$CPUE_{st} = \frac{C_{st}}{E_{st}} \qquad FPI_{st} = \frac{CPUE_{st}}{CPUE_{st}} \qquad CPUE_i = \frac{C_i}{E_i} \qquad FPI_i = \frac{CPUE_i}{CPUE_{st}}$$

Where:
C_{st} - total catch by standard fishing gear;
C_i - total catch by used fishing gear;
E_{st} - total effort of standard fishing gear;
E_i - total effort of fishing gear *i*;

FPI_{st} - fishing power index of standard fishing gear;
FPI_i - fishing power index of fishing gear *i*;
$CPUE_{st}$ - total catch per effort of standard fishing gear;
$CPUE_i$ - total catch per effort of fishing gear *i*.

Since these two fishing gears have different catching abilities, effort standardization is needed to find the equivalency (Nurdin & Yusfiandayani 2016). The fishing gear that has the highest Catch Per Unit Effort (CPUE) is set as the standard Effort (Nurhayati 2013). From our data, the purse seine has the highest average CPUE value, of 4.29 tons trip^{-1}. Thus, purse seine is set as the standard with an FPI value = 1. The hand line FPI is calculated by dividing its CPUE value by the purse seine CPUE value, so that the FPI value of the hand line will be less than 1 (Al Aziz 2017). The standard handline Effort is calculated by multiplying the handline FPI with the actual Effort. Finally, the relationship between the fishing effort and CPUE can be obtained by using the regression method.

Maximum sustainable yield and sustainable catch effort. The maximum sustainable yield and sustainable catch effort were calculated using the Schaefer, and Fox exponential surplus production models. Both approaches are regression formulae incorporating the catch, standardized effort, and natural logarithm of the CPUE variables, in order to determine the points of intersection and slopes, as seen in Table 1 (Sparre & Venema 1998). In the Schaefer model, the net growth rate of fish stocks is described as a logistic function between the effort and CPUE (Atmaja et al 2017), while the Fox model utilizes a natural logarithmic relationship.

Table 1

Schaefer linear model and fox exponential model

Variable	*Schaefer linear model*	*Fox exponential model*
MSY	$-\frac{a^2}{4b}$	$-\left(\frac{1}{d}\right) \times exp^{(c-1)}$
E_{MSY}	$-\frac{a}{2b}$	$-\frac{1}{d}$

Where:
a - interception value of Schaefer model;
b - slope of Schaefer model;
c - interception value of Fox model;
d - slope of Fox model;
MSY - maximum sustainable yield;
E_{MSY} - sustainable catch effort.

Fishing season pattern. The temporal pattern was studied based on the moving average of the catch and effort time series data (Dajan 2004; Rahmawati et al 2013). The result of this calculation is the Fishing Season Index (FSI) for each month. Fishing season is indicated with FSI > 100%. Otherwise, the period is not a fishing season.

The catch quality. It was determined by using organoleptic tests on fish samples from local markets as stated in the Indonesian National Standard (SNI) 2729:2013. Population quality, μ, is approximated as a range with a 95% confidence level (BSNI 2013).

$$P(\bar{x} - (1,96 * s / \sqrt{n})) \leq \mu \leq P(\bar{x} + (1,96 * s / \sqrt{n}))$$

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad s^2 = \frac{n\sum x_i^2 - (\sum x_i)^2}{n(n-1)} \qquad s = \sqrt{\frac{n\sum x_i^2 - (\sum x_i)^2}{n(n-1)}}$$

Where:
n - total number of panelists;
s^2 - variance of quality value;
1.96 - standard deviation coefficient at range 95%;
$\bar{x}$ - average quality value;
x - quality value from panelist i, where i = 1,2,3......n;
s - standard deviation of quality value.

***K. pelamis* sales**. *K. pelamis* is distributed through several supply chains, from producers to consumers. Two important quantitative variables to assess the sales aspect are fishermen's share (FS) and marketing efficiency (ME) (Iswahyudi 2019; Riandi et al 2017). FS is with the ratio of the fisherman's selling price divided by the last buying price of the chain times 100%. FS is inversely correlated with the total margin from each chain. While ME is calculated by dividing the total marketing cost by the selling price in each chain. The sales chain can be considered efficient if FS => 40% (Downey 1987) and ME < 33%, while if ME ranges 34 - 67%, it is considered less efficient. Otherwise, the sales are inefficient (Riandi et al 2017).

$$SM = CP - PP$$

$$FS = \left(\frac{PP}{CP}\right) \times 100\%$$

$$ME = \left(\frac{MP}{CP}\right) \times 100\%$$

Where:
SM - sales margin (USD kg^{-1});
CP - price on consumer level (USD kg^{-1});
PP - price on producer level (USD kg^{-1});
MP - total marketing cost (USD kg^{-1}).

The business financial feasibility. It was analyzed by calculating profit, RC ratio, and Return on Investment (ROI) (Hutajulu et al 2019). Invested cost, fixed cost, variable cost, and yearly revenue data were gathered from direct interviews with fishermen.

$$\pi = TR - TC$$

$$TC = VC + FC$$

$$\frac{R}{C} = \frac{TR}{TC}$$

$$ROI = \frac{\pi}{Initial\ Investment} \times 100\%$$

Where:
π - profit;
TC - total cost;
R - revenue;
C - cost;
VC - variable cost;
FC - fixed cost;
TR - total revenue.

Fishing technology, and port facilities that support *K. pelamis* fishing and product distribution are analyzed descriptively by using data from direct observation on site and records from Port Office.

Results. The *K. pelamis* exploitation level, maximum sustainable yield and sustainable catch effort, fishing season pattern, catch quality, sales, and business financial analysis are described as follows.

***K. pelamis* exploitation level**. The relationship function derived from the regression of fishing effort and CPUE is $y = -0.0655x + 5.7346$, as depicted in Figure 3. The slope or regression coefficient is -0.0655, which means that each additional fishing trip (effort) will cause a CPUE decrease of 0.0655 tons. It can be said that *K. pelamis* population has been over-exploited.

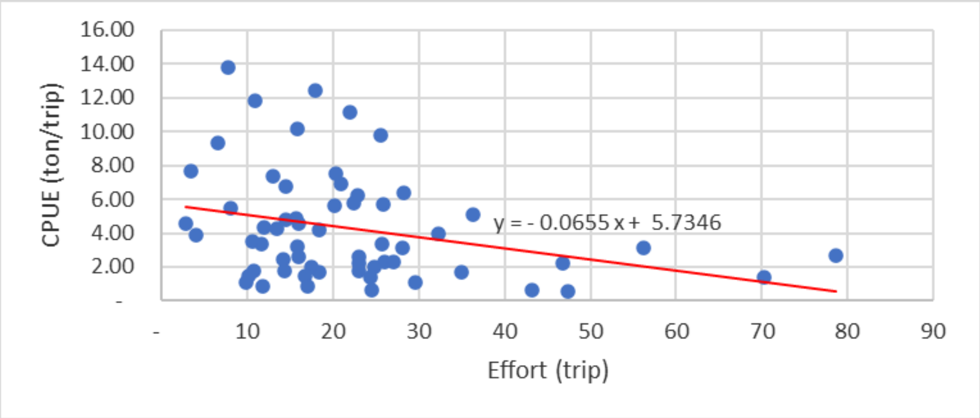

Figure 3. Relationship of effort and CPUE.

Maximum sustainable yield and sustainable catch effort. Schaefer and Fox approaches produce slightly different results (Table 2). Both approaches lines are provided in Figure 4. The comparisons of actual monthly catch during the 5-year timeline and MSY limit from Schaefer and Fox models are illustrated in Figure 5 and Figure 6.

Table 2

Interception and slope values with Schaefer and Fox models

Item	*Schaefer*	*Fox*
a or c	5.7346	1.5494
b or d	-0.0655	-0.0172
r	-0.2966	-0.3129
r^2	0.0880	0.0979
MSY	125.58 tons	100.91 tons
E_{MSY}	44 trips month^{-1}	58 trips month^{-1}

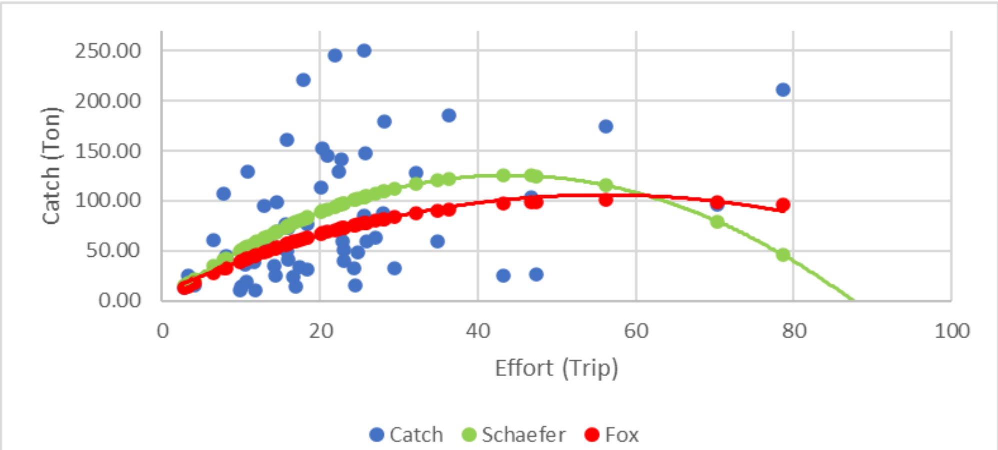

Figure 4. Schaefer and Fox functions.

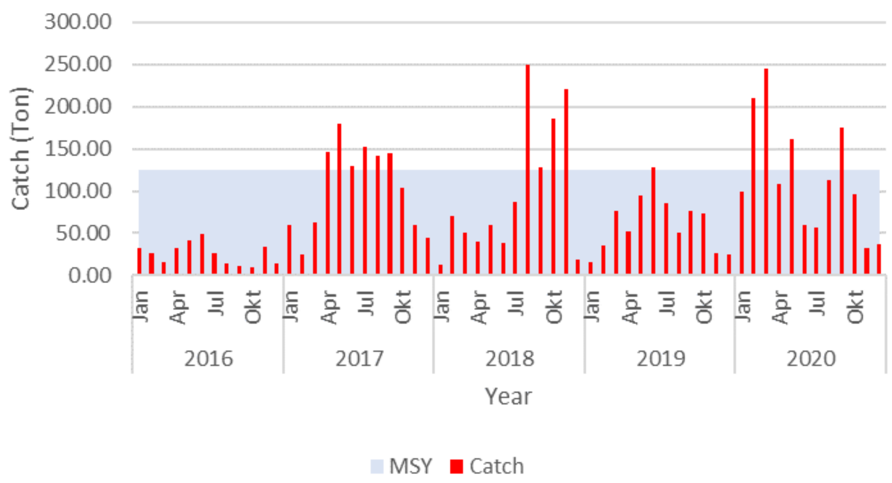

Figure 5. Comparation of monthly production and MSY from Schaefer method.

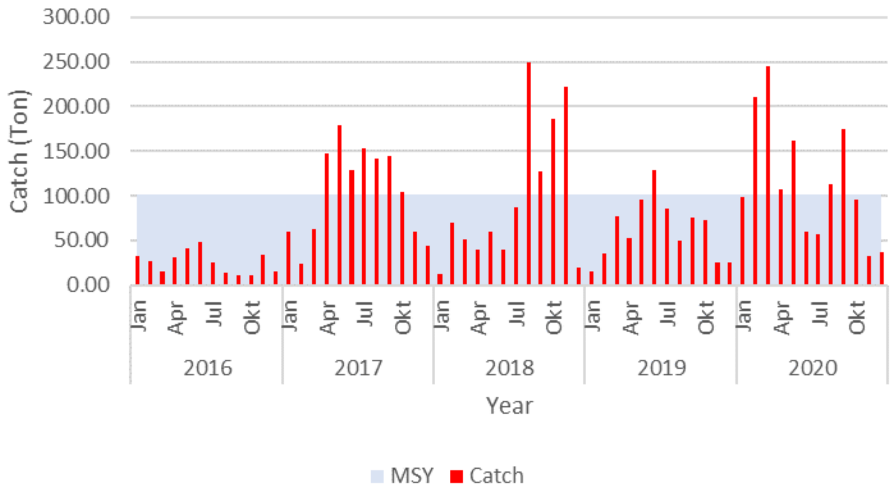

Figure 6. Comparation of monthly production and MSY from Fox method.

Fishing season pattern. The Fishing Season Index (FSI) is depicted in Figure 7. To be noted, the fishing season is associated with the number of catches and is not related to the number of stocks in the waters (Al Aziz 2017).

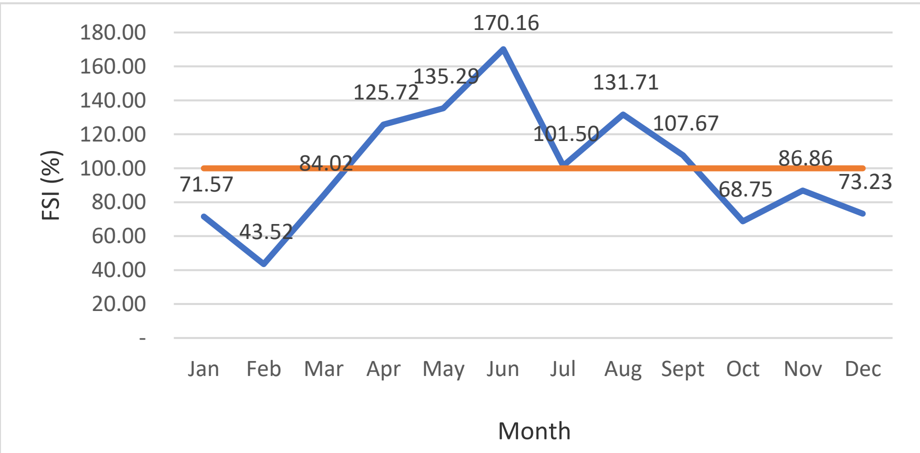

Figure 7. *Katsuwonus pelamis* fishing index at Sadeng fishery port.

The catch quality. The results of organoleptic tests on *K. pelamis* samples are presented in Table 3. The organoleptic value of *K. pelamis* is ranged from 7.51 to 7.92 which is relatively fresh (>7).

Table 3

Katsuwonus pelamis organoleptic test results

Description	*Value*
Average Organoleptic Value	7.72
Standard Deviation	0.59
μ Value (confidence coefficient 0.95)	$7.51<\mu<7.92$

The sales of K. pelamis. As can be seen in Figure 8, there are five models of fish marketing schemes in Sadeng Fishery Port. Each scheme delivers different FS and ME which were described in Tables 4 to 8.

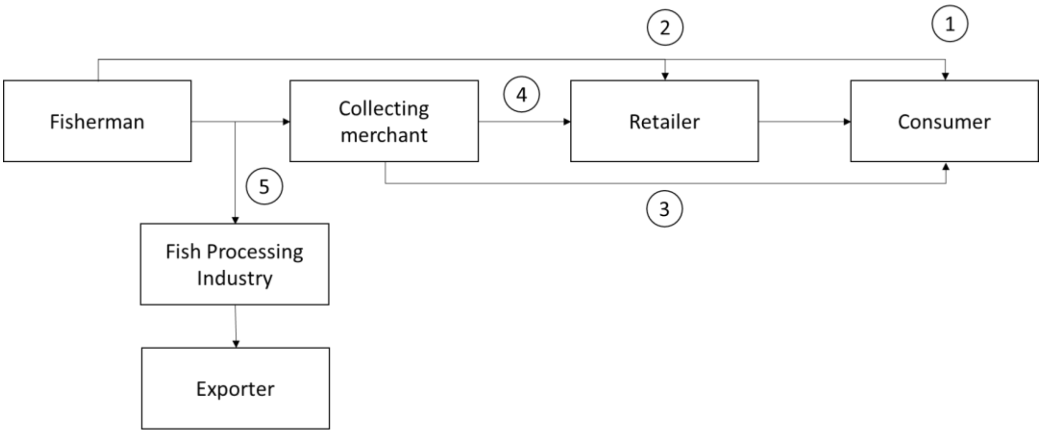

Figure 8. *Katsuwonus pelamis* marketing schemes at Sadeng Fishery Port.

Table 4

Scheme 1: Fishermen – Consumer

Category	*Criteria*	*(USD kg^{-1})*	*Margin (USD)*	*Fisherman's share*
Fishermen	Selling price	1.10		100%
	Operational expenditures	0.57		
	Profit	0.53		
Consumer	Buying price	1.10		
Total marketing price		0		
Marketing efficiency		0%		

This scheme has no marketing price since the end consumer directly buys the product from the fisherman. Although the fisherman's share is 100% and the marketing efficiency is 0% which is perfectly efficient in the sales term, most end consumers rarely buy products directly from the fishermen at the port.

Table 5

Scheme 2: Fishermen – Retailer – Consumer

Category	*Criteria*	*(USD Kg^{-1})*	*Margin (USD)*	*Fisherman's share*
Fishermen	Selling price	0.97		85.8%
	Operational expenditures	0.57		
	Profit	0.4		
Retailer	Buying price	0.97		
	Selling price	1.13	0.16	
	Marketing cost	0.04		
	Profit	0.12		
Consumer	Buying price	1.13		

Category	Criteria	(USD Kg^{-1})	Margin (USD)	Fisherman's share
Total marketing price		0.04		
Marketing efficiency		3.54%		

In this case, the retailers are reaching fixed daily consumers not far from the port. Their market is the settlement within a 0 to 3 km of the port. The marketing costs induced can be considered low (around 0.04 USD kg^{-1}) since it is only calculating the transportation from the port. Moreover, most of these retailers are using their traditional stalls.

Table 6

Scheme 3: Fishermen – Collecting Merchant – Consumer

Category	Criteria	(USD kg^{-1})	Margin (USD)	Fisherman's share
Fishermen	Selling price	0.97		82.9%
	Operational expenditures	0.57		
	profit	0.4		
Collecting Merchant	Buying price	0.97		
	Selling price	1.17	0.20	
	Marketing costs	0.09		
	Profit	0.11		
Consumer	Buying price	1.17		
Total marketing costs		0.09		
Marketing efficiency		7.69%		

A collecting merchant is a kind of intermediate seller who usually sells various products with a higher volume than a retailer and operates in a traditional market up to 5 km from the port.

Table 7

Scheme 4: Fishermen – Collecting Merchant – Retailer – Consumer

Category	Criteria	(USD kg^{-1})	Margin (USD)	Fisherman's share
Fishermen	Selling price	0.97		63.8%
	Operational expenditures	0.57		
	profit	0.4		
Collecting Merchant	Buying price	0.97		
	Selling price	1.17	0.20	
	Marketing costs	0.09		
	Profit	0.11		
Retailer	Buying price	1.17		
	Selling price	1.52	0.35	
	Marketing costs	0.17		
	Profit	0.18		
Consumer	Buying price	1.52		
Total marketing costs		0.26		
Marketing efficiency		17.1%		

This scheme is the one that could reach the highest number of consumers since it penetrates the city center market, that is located quite far from the port. Even though the marketing cost is the highest, its marketing efficiency is as low as 17.1%.

Table 8

Scheme 5: Fishermen – Fish Processing Industry

Category	*Criteria*	*(USD kg^{-1})*	*Margin (USD)*	*Fisherman's share*
Fishermen	Selling price	0.97		100%
	Operational expenditures	0.57		
	profit	0.4		
Industry	Buying price	0.97		
Total marketing costs		0		
Marketing efficiency		0%		

The business financial feasibility. Table 9 shows the costs and revenue in one year for each fishing method.

Table 9

Cost and revenue

Description	*Fishing Methods*	
	Handline	*Purse seine*
Revenue (USD)	33,747.38	250,576.41
Investment cost (USD)	23,560.03	177,672.99
Fixed cost (USD)	3,679	20,296.36
Variable cost (USD)	23,669.96	156,725.89
Profit (USD)	6,399	73,554
RC ratio	1.23	1.42
ROI (%)	27%	41%

Fishing technology. The fishing operation at Sadeng Fishery Port is mainly done using handline and purse seine, as seen in Figures 9 and 10, respectively.

Figure 9. Fishing boat equipped with handline (Original photos).

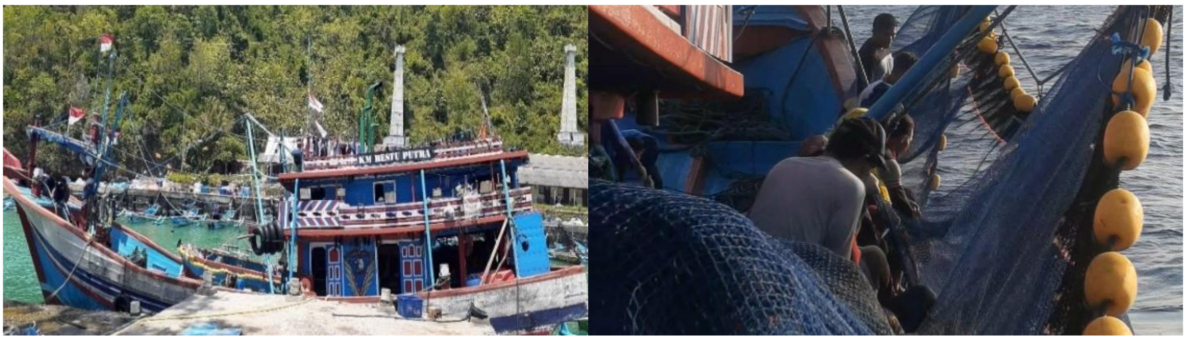

Figure 10. of Fishing boat equipped with purse seine (Original photos).

Port facilities. The existing facilities are classified into 3 categories, which are main, functional, and secondary. Main facilities are the basic or mandatory facilities as the minimum requirements of a port (Table 10). Functional facilities are the facilities that are directly used by port management or other stakeholders to enhance their operation process (Table 11), while other facilities that are not giving effects on the fishermen's and port management's income are categorized as secondary facilities. Most facilities were in proper condition, except for the ice factory (Figure 11).

Table 10

Main facilities

Description	*Volume*	*Condition*
Area	50,000 m^2	Good
Harbor pool >5 GT	22,900 m^2	Good
Harbor pool <5 GT	5,700 m^2	Good
Breakwater	135 m	Good
Dock	485 m	Good
Access road	720 m	Good
Bridge	15 m^2	Good
Open drainage	888.5 m	Good
Boundary fence	450 m	Good

Table 11

Functional facilities

Description	*Volume*	*Condition*
Port offices	total 624 m^2	Good
Port fish auction	225 m^2	Good
Ice factory	3 units	Broken
Water tower	10 m^2	Good
Workshop	72 m^2	Good
Sleepway	1 unit	Good
Cold storage	169 m^2	Good
Net repair site	96 m^2	Good
Navigation lamp	4 units	Good
Light buoy	2 units	Good
Parking site	600 m^2	Good

Figure 11. Broken ice factory (Original photo).

Discussions. Based on our calculation, *K. pelamis* fishing season occurs almost every month. The peak season's duration is of seven months, from March to September. The medium season's duration is of five months, from October to January. In comparison, the famine season occurs in February. Anggraeni et al (2015) and Talib (2017) also stated that the *K. pelamis* fishing season in southern Java occurs almost throughout the whole year. This condition can happen because *K. pelamis* is a migratory fish (Arai et al 2005) and spawns throughout the year (Hartaty & Arnenda 2019). Yoga et al (2014) stated that the upwelling phenomenon happens in the southern Java sea during the east season. This phenomenon is indicated by a low sea surface temperature and high levels of chlorophyll-a. Upwelling causes the southern Java sea to become fertile and increases the fish population (Anggraeni et al 2017).

Unfortunately, the *K. pelamis* exploitation during the fishing season, every year within this 5-year timeline, has exceeded the MSY limit, as can be interpreted from Figure 5, 6, and 7. The periods July to October 2018 and March 2020, as seen in Figure 6, are the most significant, where the catch reached over 200% of the MSY value. This result is in line with other sources from the research literature. According to KKP (2017), it is stated that the exploitation level of large pelagic fish in WPPNRI 573 (the Indian Ocean at the south side of Java, including Sadeng Fishery Port) has been over-exploited. Similarly, Setiyawan (2016) reported that the utilization status of *K. pelamis* in Prigi (Indian Ocean at the south side of Java) has reached the over-exploiting level, with a utilization rate of 114.9%.

According to Akoit & Nalle (2018), if the catch exceeded the MSY value, it can lead to the extinction because the utilization level has exceeded the species' biological growth function. Thus, the calculation of the sustainable fishing effort *(E_{MSY})* calculation is vital to estimate fishing effort at optimum conditions. The calculated sustainable fishing effort (E_{MSY}) value is of 44 trips month^{-1} with the Schaefer’s model and of 58 trips month^{-1} with the Fox model. Nevertheless, the *K. pelamis* fish sold on the markets were fresh, the sales were considered efficient, and the fishing business using handlines and purse seines at Sadeng Fishery Port could be declared financially profitable and feasible. As seen in Table 3, µ is in the range of 7.51 to 7.92 (BSNI 2013). Fisherman’s share in all schemes was >40% (Downey 1987) and the marketing efficiency in the range of 0 to 33% (Riandi et al 2017). The profit induced by using a handline was USD 6,399 per year, while for a purse seine it was USD 73,554 per year. The R/C ratio of handline and purse seine were 1.23 and 1.42, respectively. These parameters indicate that the income obtained from the two fishing methods is greater than the costs incurred (Jumiyati et al 2021; Savitri et al 2017). Additionally, the ROI of both fishing gears was >25%, which shows that the *K. pelamis* fishing business earn high profits (Siahainenia 2021).

According to our observation, the existing fishing gears at Sadeng Fishery Port were still conventional. The fishermen relied on traditional boats, old diesel engines, and some malfunctioned gears. Moreover, most fishermen did not apply a routine maintenance to their gears, which lowers the reliability, fuel efficiency, and cruising distance. All the existing facilities functioned properly except for the ice factory (Figure 11). Consequently, fishermen and sellers must find the ice source outside the port, increasing the operational and marketing costs.

Conclusions. The study of *K. pelamis* fishing business at Sadeng Fishery Port suggested that the *K. pelamis* resource in the South Java Sea has been over-exploited. The fishing technology used by local fishermen was conventional and unproperly maintained. The *K. pelamis* fish arrived on the markets were fresh, with an organoleptic value 7.51<µ<7.92. The sales were considered efficient through all the distribution channels, with the fisherman’s share of a minimum of 63.8%, and the maximum marketing efficiency was of 17.1%. The fishing business was financially profitable and feasible. Most existing facilities were in proper condition, except for the ice factory.

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Conflict of interest. The authors declare no conflict of interest.

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