BIODIVERSITAS
Volume 23, Number 7, July 2022
Pages: 3480-3487

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d230723

Estimation of population parameters and fishery status of spotted scat, *Scatophagus argus* (Scatophagidae) in Pabean Bay, Indramayu, West Java, Indonesia

EMMANUEL MANANGKALANGI[1,2], I NYOMAN DATI PERTAMI[2,3], ARIES ASRIANSYAH[4], REIZA MAULANA ADITRIAWAN[4], RIDWAN SALA[5,♥], MUHAMMAD FADJAR RAHARDJO[2,4]

[1]Department of Fisheries, Faculty of Fisheries and Marine Science, Univeristas Papua. Jl. Gunung Salju, Manokwari 98314, West Papua, Indonesia
[2]Indonesian Ichthyology Societies. Jl. Raya Jakarta Bogor Km 46, Cibinong, Bogor 16911, West Java, Indonesia
[3]Department of Aquatic Resources Management, Faculty of Marine Science and Fisheries, Universitas Udayana. Jl. Raya Unud, Jimbaran, Badung 80361, Bali, Indonesia
[4]Department of Aquatic Resources Management, Faculty of Fisheries and Marine Science, Institut Pertanian Bogor. Jl. Agatis, Kampus IPB Dramaga, Bogor 16680, West Java, Indonesia
[5]Department of Marine Science, Faculty of Fisheries and Marine Science, Universitas Papua. Jl. Gunung Salju, Manokwari 98314, West Papua, Indonesia. Tel./fax.: +62-986-211430, ♥email: ridwansala@gmail.com

Manuscript received: 5 May 2022. Revision accepted: 22 June 2022.

Abstract. *Manangkalangi E, Pertami IND, Asriansyah A, Aditriawan RM, Sala R, Rahardjo MF. 2022. Estimation of population parameters and fishery status of spotted scat,* Scatophagus argus *(Scatophagidae) in Pabean Bay, Indramayu, West Java, Indonesia. Biodiversitas 23: 3480-3487.* Pabean Bay is a fishing ground for various types of estuarine fish, including spotted scat, *Scatophagus argus*. This study aims to describe this type of fish population and its level of exploitation by using length-frequency distribution data for one year (January to December 2015). Fish samples were obtained from the catch of fishers using *sero* fishing gear and gill nets. Analysis of first caught size, growth parameters, mortality, recruitment pattern, and fishery status used FiSAT II program and some empirical formulas. The results of this study indicate that the length of the first time caught (L_c) is 100.195 mm and is smaller than the size of the first maturity (L_m). The asymptotic length (L_∞) and growth coefficient (K) were 191.65 mm and 0.18 year^{-1}. Recruitment took place throughout the year with a peak in two periods (February-March and August-September). Total mortality, natural mortality, and catch mortality were 0.84 year^{-1}, 0.37 year^{-1}, and 0.47 year^{-1}.The exploitation rate (E) of this fish was 0.56 year^{-1}. The condition of this fish resource showed slow growth and was indicated to experience overfishing conditions. This information is expected to be considered, especially the use of *sero* and gillnet fishing gears with small mesh sizes and the frequency of catching it so that the fishing activities will not negatively impact the sustainability of this fish resource in the area.

Keywords: Overfishing, Pabean Bay, population parameters, *Scatophagus argus, sero*

INTRODUCTION

The central issue for coastal fisheries, including in Indonesia, is the condition of dwindling resources, and the main contributor to this degradation is overfishing. Moreover, this is aggravated by environmental degradation (Stobutzki et al. 2006). Conditions of depleting resources and overfishing are symptoms of the ineffective management of fishing capacity (Stobutzki et al. 2006). Therefore, it is necessary to estimate the stock of fish resources, even though fisheries worldwide are currently facing the problem of data-poor fisheries (Costello et al. 2012; Dowling et al. 2019). However, the development of stock assessment methodologies based on length distribution has made it easier to study fish population dynamics from most poor fishery data (Hordyk et al. 2015; Mildenberger et al. 2017; Chong et al. 2020). Predictions about how the condition of fish stocks and fisher respond to different levels of fishing effort are a form of suggestion for alternative management to policymakers (King 2007).

One of the fish resources in coastal waters is spotted scat, *Scatophagus argus*. This fish is one of the species that live in sea waters and estuaries, mangroves, and creeks that are still influenced by the tides of seawater (Kottelat 2001). Several previous studies have reported allegations that this fish species migrate by developmental stage (ontogenetic) between the outer coastal waters and the interior of the estuary (Gupta 2016; Morioka et al. 2020a,b). This fish species is recruited to estuaries-mangroves from the outer coastal areas at a total length of <20 mm (aged 30-43 days) and then uses the estuary as a rearing area until it grows to a total length of about 110 mm (aged 160 days) in males and a total length of 160 mm-180 mm (290 days old) in females (Morioka et al. 2020b). The existence of an ontogenetic habitat shift between the early developmental stages of these fish has also been demonstrated on an experimental scale (Mookkan et al. 2014; Su et al. 2019). Adult individuals then migrate from estuary-mangrove waters to outer coastal areas. This migration is thought to be related to the onset of gonadal maturation, the need for larger food sizes, and also a large body size will be relatively safer against the risk of predation and tidal cycle conditions (Grol et al. 2014; Huijbers et al. 2015; Dubuc et al. 2019). Research results from Su et al. (2019) showed that these fish reproduce in waters with salinity conditions between 15 and 25 ppm. Spawning of these fish takes place throughout the year with a bimodal peak in two periods: (i) June-August and (ii) October-December in the waters of Mandapam, the southern coast of India (Gandhi et al. 2014).

Although it is not a target species for fishing (Irham et al. 2021), in some areas in the Indo-West Pacific, this species is used as food (Kottelat 2001). Especially at the juvenile stage, this species also has an attractive color pattern, making it a potential ornamental fish (Kottelat 2001; Hadiaty et al. 2012). The existence of this species in coastal waters of Indonesia has been widely reported by several previous studies related to habitat, growth patterns, food, and reproduction (Hadiaty et al. 2012; Suprastini et al. 2014; Aida 2015; Nurhayati et al. 2016; Widarmanto et al. 2019), including in the Pabean Bay, Indramayu (Tampubolon et al. 2018). However, information on population dynamics is still very limited (Sholichin et al. 2021). Furthermore, its conservation status is Least Concern (LC) and the population trend of this species is also unknown (Collen et al. 2010). This study aims to estimate the population parameters of *S. argus* caught in the waters of Pabean Bay, Indramayu, and its fishery status using length-frequency data obtained from January to December 2015. For this purpose, parameters such as the size of the first caught (L_c), growth rate, recruitment pattern, mortality (Z, F, M), and exploitation rates were studied.

MATERIALS AND METHODS

A number of *S. argus* were collected from the catches of fishermen between January to December 2015 in Pabean Bay, Indramayu, West Java, Indonesia (Figure 1). The fishing gears commonly used by fishers were: *sero* (mesh size of 1 mm and height of net 1 m), and gill nets (mesh size of 1.5 inches, height of 1.5 m, length of 72 m). The sero bag section were set in the afternoon or late at night and hauled in the morning, then the catch was collected with a scoop. The gill nets were set at the time of sampling at each station. To obtain a representative sample size variation of *S. argus*, sample collection was also carried out at three stations within the bay: Station I (in the inner part of the bay), Station II (in the middle of the bay), and Station III (in the outer part of the bay) (Figure 1). Then, the samples (431 fish) were taken to the Macrobiology Laboratory I, Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, IPB University to measure body length (This study used total length). The 431 individual fish were the total of all *S. argus* fish landed by fishers during data collection at the fish landing site in Pabean Bay. The data collection was conducted once a month. Sampling date at each month was arbitrarily chosen.

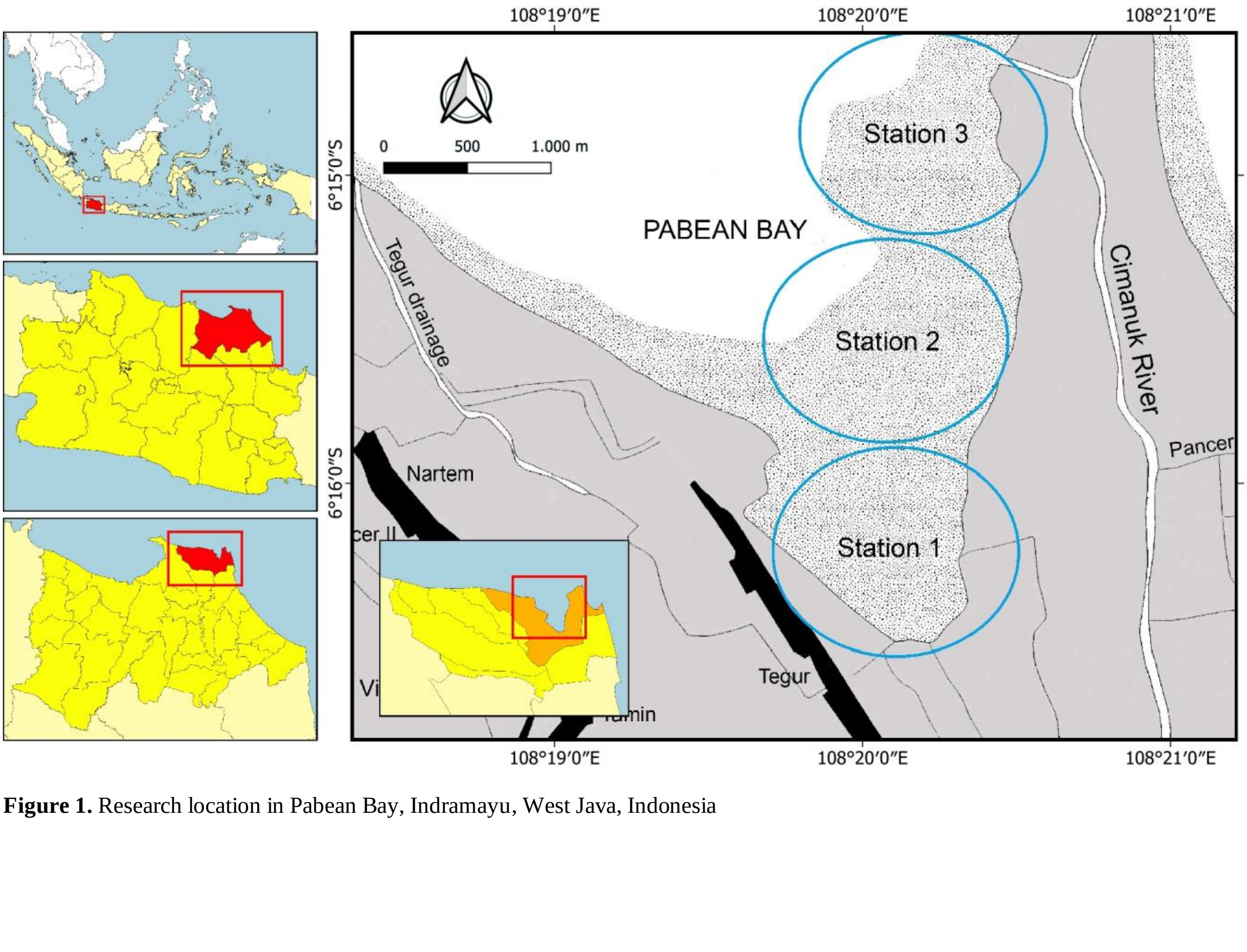

Figure 1. Research location in Pabean Bay, Indramayu, West Java, Indonesia

The measured data were then tabulated into a frequency distribution with an interval of 0.5 cm using the MS Excel 2010 program. The total length-frequency distribution data were then analyzed using the FiSAT II program (version 1.2.2) with the ELEFAN I sub-program to estimate the asymptote length (L_∞) and growth coefficient (K) (Gayanilo et al. 2005). Estimation of theoretical age when the length of the *S. argus* is equal to zero (t_0) is carried out following Pauly's (1983) empirical equation: log ($-t_0$) = -0.3922 – 0.2752 log L_∞ - 1.308 log K. Furthermore, the growth curve can be visualized following the equation proposed by Von Bertalanffy (Pauly 1983): $L_t = L_\infty$ (1- $\exp^{-K(t-t0)}$. Notation L_t = length of *S. argus* (cm) at age t (years), L_∞ = asymptote length of *S. argus* (cm), K = growth coefficient (per year), t_0 = theoretical age of *S. argus* when its length is zero (years), t = age of *S. argus* (years).

Total mortality (Z) was estimated using the curve-to-length method in the FISAT-II program (Gayanilo et al. 2005). The natural mortality rate (M) was estimated using the empirical relationship (Pauly1983): Log M = 0.0066 - 0.279 LogL_∞ + 0.6543 LogK + 0.4634 LogT. L_∞ = growth parameter (cm) and T = average annual water temperature (°C) of Pabean Bay = 29.4°C. Fishing mortality (F) was determined by subtracting M against Z, and exploitation rate (E) was determined from F/Z (Pauly 1983).

The estimation of the length of the first time caught (L_c) was made based on the cumulative probability curve (Sparre and Venema 1998), which was in the 50% condition. Furthermore, it was also estimated that the length of the first catch $L_{c\ opt}$ maximized catch and biomass for a certain fishing pressure with the equation based on Froese et al. (2016).

RESULTS AND DISCUSSION

Size composition

A total of 431 fish were collected in the study period, but three fish were excluded from the analysis due to damaged caudal fin tips. The size of the *S. argus* collected in this study varied between 7.62-151.88 mm (101.53±29.05; mean±SD). This fairly wide variation is assumed to be related to the fishing gear used with different mesh sizes in this study (*sero* can get small sample sizes while gill nets can get large enough sizes). In addition, it corresponds to a location that varies from the inside to the outside of the bay. Size distribution based on body length each month is shown in Figure 2.

Based on the results of several studies, it is shown that variations in fishing gear, mesh size, and sample collection methods affect the variation in the size of the sample collected (Table 1). In addition, fishing location and fishing season may also affect the size variation because they are related to the size and stage of development of fish that is likely to be caught. This study is in line with Sawusdee (2010), who reported that utilizing s*ero* and *seser* fishing gear makes it possible to catch very small fish sizes, even up to the size of larvae and juveniles. In contrast, a gill net with a larger mesh size allows for obtaining large-fish size samples. The reported maximum total length varied between sites (Table 1), and based on (Kottelat 2001), it can be up to 350 mm.

Growth parameters

The results of analysis showed that the growth parameter values are described in this equation: L_t = 191.63 (1-exp $^{-0.180\ (t+0.016)}$). The K parameter value obtained in the present study was lower than in several previous studies (Table 2). Based on the equation, the fish ages caught in this study varied between 0.23 and 17.21 years old (4.46±1.84 year; mean±SD).

Even though K at Pabean bay was higher than in other areas, the growth coefficient (K) of *S. argus* in Pabean Bay was lower than in Semarang Bay (Sholichin et al. 2021) and Pak Panang Bay, Thailand (Sawusdee 2010) (Table 2). It indicated that *S. argus* in Pabean Bay has slower growth than the other two locations. This slow growth rate is thought to be related to water conditions, including primary productivity (nutrient). Conversion of mangrove vegetation into a pond for growing fish in the water of Pabean Bay (Descasari et al. 2016) may affect the density and contribution of litter (nutrients) as the basis of the faunal food chain, including benthic fauna in mangrove forests and the surrounding waters, as reported by Kon et al. (2010) and Carugati et al. (2018). And this condition also implies abundant fauna, including the fish *Scatophagus argus*, which utilizes benthic fauna as food. As been reported that the fish belongs to the omnivorous group that consumes macrobenthos (polychaetes, insects, mollusks, sponges, crustaceans) (Gupta 2016). According to Hernandez and Seijo (2003), fish growth is affected by water conditions and food abundance. If the availability of resources decreases, the animals would tend to grow and reach maturity slowly and at a smaller size (Day and Rowe 2002). Moreover, several researchers revealed that fishing activity would also cause a decrease in fish growth rates (Conover and Munch 2002).

Recruitment pattern

The analysis showed that the *S. argus* recruitment occurs throughout the year, with peak recruitment in two periods, namely February-March and August-September (Figure 3). This pattern indicated the new individuals in this fish population resulting from reproduction. The two-period recruitment pattern for one year is similar to the peak spawning pattern of this fish at this location. So it is suspected that this recruitment pattern indicates that new individuals in this population originate from the reproductive process. *S. argus* spawning period at the Pabean Bay occurred throughout the year, with a bimodal peak occurring in January-February and September-November. However, the recruitment patterns of these fish species varied in various locations. For example, this fish recruitment also occurs throughout the year, but in one peak period, as found in Pak Panang Bay (May-July) (Sawusdee 2010), and Semarang Bay (July) (Sholichin et al. 2021).

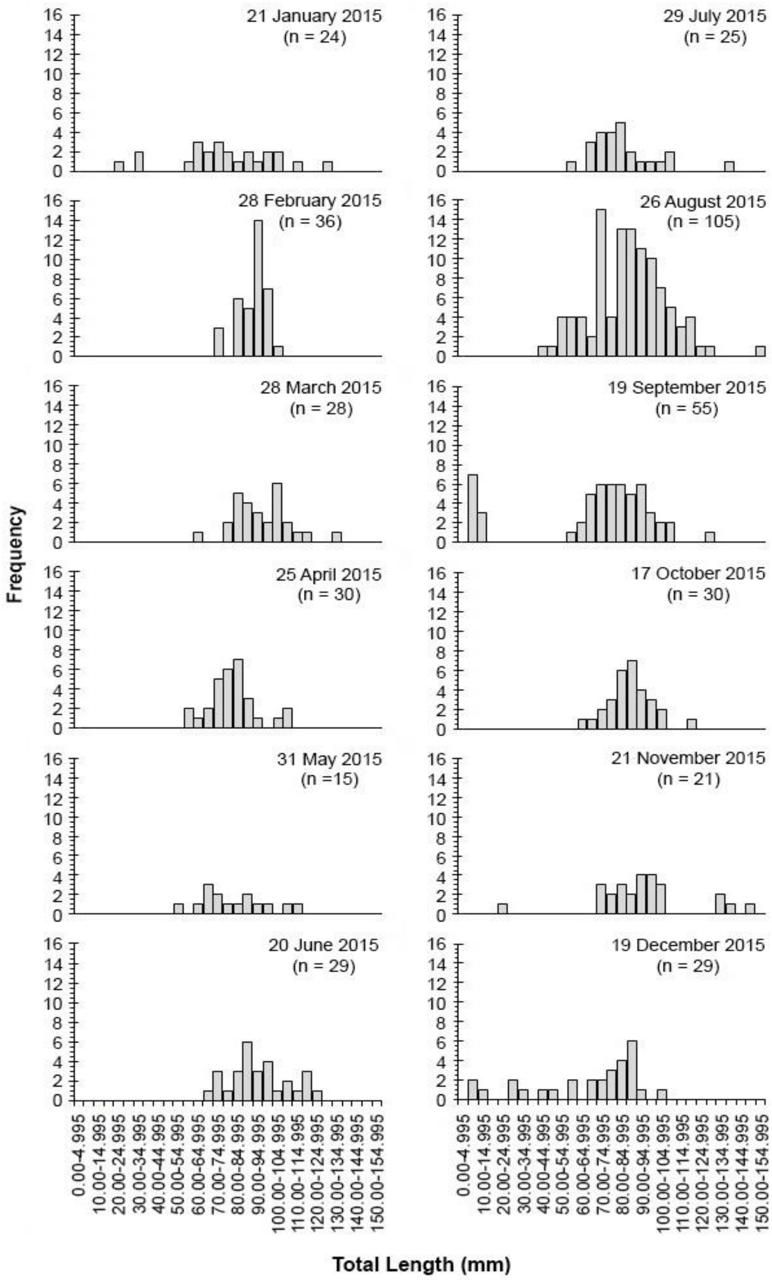

Figure 2. Frequency distribution of the total length of the *Scatophagus argus* in the Pabean Bay, Indramayu, West Java, Indonesia. The dates on the graphs indicate the date of data collection

Table 1. Range of reported total length of *Scatophagus argus* at several locations

Location	Total length caught (mm)	Total length first caught (L_c) (mm)	Fishing gear and or landing	Sources
Pak Panang Bay, Thailand	-	22.2	Seser (push net)	Sawusdee (2010)
Musi River estuary, South Sumatra, Indonesia	130-185	-	Drifting gill nets (2-inch and 3-inch mesh sizes)	Nurhayati et al. (2016)
Bracelet Broken, Johor, Malaysia	90.0-243.0	-	Landing results	Hashim et al. (2017)
Coastal waters Karachi, Pakistan	42.0-290.0	-	Landing results	Musarrat-ul-Ain and Yasmeen (2018)
Semarang Bay, Central Java, Indonesia	82-165	106	Landing results using nets Arad	Sholichin et al. (2021)
Pabean Bay, West Java, Indonesia	11.69-183.01	100.195	Sero and gill nets	This study

Table 2. Growth parameters of *Scatophagus argus* from several locations

Location	L_∞ (mm)	K (year$^{-1)}$	t_0	Sources
Pak Panang Bay, Thailand	178.7	0.47	0.084	Sawusdee (2010)
Semarang Bay, Central Java	178	0.73	0.06	Sholichin et al. (2021)
Pabean Bay	191.63	0.180	0.016	This study

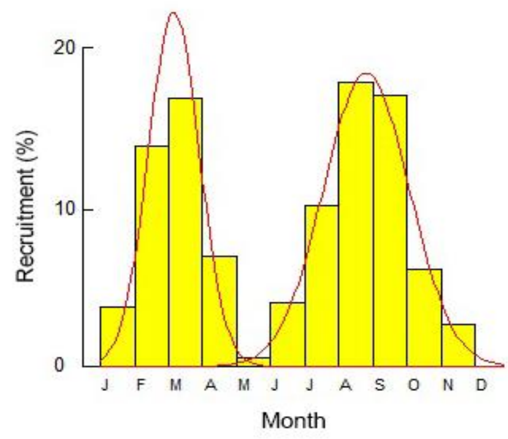

Figure 3. The pattern of *Scatophagus argus* population recruitment in Pabean Bay, Indramayu, West Java, Indonesia in 2015

Table 3. Parameters and population status

Population	Indicators				Status
	$L_c/L_{c\ opt}$	F/M	F/K	E	
S. argus in the waters of Pabean Bay	1.03	1.27	2.61	0.56	Overfishing

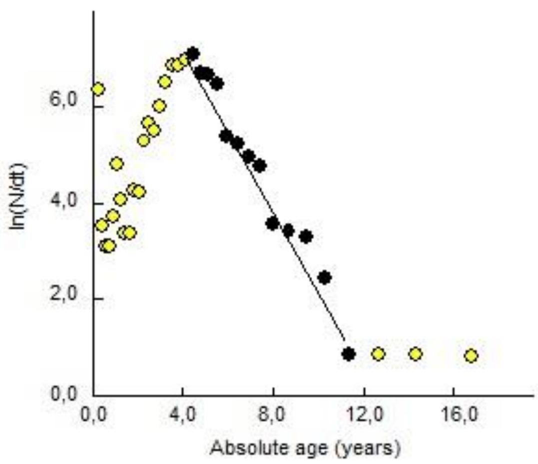

Figure 4. Curves-to-length for estimating total mortality. The yellow dots on the left indicate data that were not used because they were not under full exploitation, and the yellow dots on the right indicate the data too closed to L_∞. The black dots indicate data that were used in the regression analysis

Mortality and exploitation rate

The estimation of the total mortality (Z) of *S. argus* in the Pabean Bay through the curve-to-length is shown in Figure 4 and obtained a value of 0.84 year^{-1}. On the other hand, natural mortality (M) and fishing mortality (F) was 0.37 year^{-1}, and 0.47 year^{-1}, respectively. Fishing mortality (F) is a parameter of fishing effort. It was found that the value of F is greater than the value of M, which indicated that mortality caused by fishing activities was more dominant. Higher fishing mortality was also found in Pak Panang Bay, Thailand, and Semarang Bay, Central Java (Sawusdee 2010; Sholichin et al. 2021).

The size of the first time caught (L_c) and the first time caught optimum ($L_{c\ opt}$)

The length when the fish was first caught (L_c) is the estimated length of the fish caught during the study, as much as 50%. Based on the frequency analysis, the first *S. argus* caught length was 100.195 mm (Figure 5).

This study found that the size of the *S. argus* when the first time caught was smaller than the size of the first time at sexual maturity, namely 103 and 112 mm in male and female individuals. Furthermore, it illustrated that some caught fish had no time to reproduce. In this study, the proportion of immature individuals was 89.79%. Therefore, the length of the first caught (L_c) would indicate the suitability of the mesh size, which becomes crucial in fisheries management (Mehanna et al. 2020).

In addition, the size of the *S. argus* when it was caught for the first time in this study is contradicted by several previous studies (Table 1), and it is related to the type of fishing gear used and the fishing area. This size difference is caused by the differences in mesh size of the fishing gear used, fishing period (month or season), and fishing ground (Hargiyatno et al. 2013).

The optimum length when first caught ($L_{c\ opt}$) found in this study was 97.02 mm. For certain fishing mortality rates, the value of $L_{c\ opt}$ plays an important role in maintaining catches and profits that are close to theoretically optimal while maintaining a large population size (Froese et al. 2016).

Fishery status

This study revealed that the value of $L_c/L_{c\ opt}$ was higher than one (Table 3). Thus, it indicated that a few large individuals were possibly still in these waters. However, the results of this study also showed that the exploitation rate (E) of this fish is 0.56 years^{-1}. Therefore, it was above the optimal value. Optimal exploitation occurs when fishing mortality is equivalent to natural mortality (i.e 0.5), and this value can indicate fishing pressure (Pauly 1983; Rochet and Trenkel 2003; King 2007). Other indicators that showed pressure from fishing activities were the F/M>1 and F/K>1 (Table 3; Figure 6).

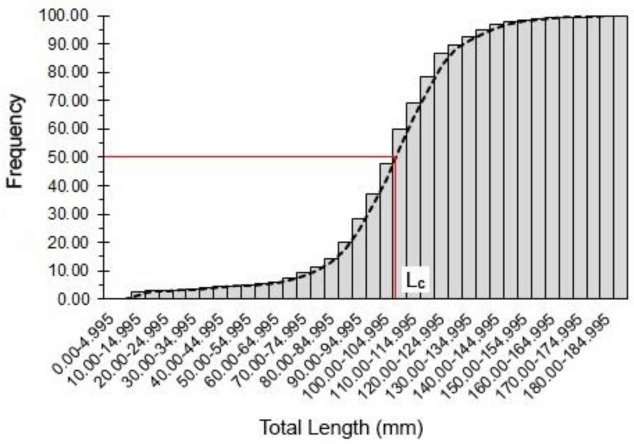

Figure 5. The length of the first caught *Scatophagus argus* (L_c) in Pabean Bay, Indramayu, West Java, Indonesia

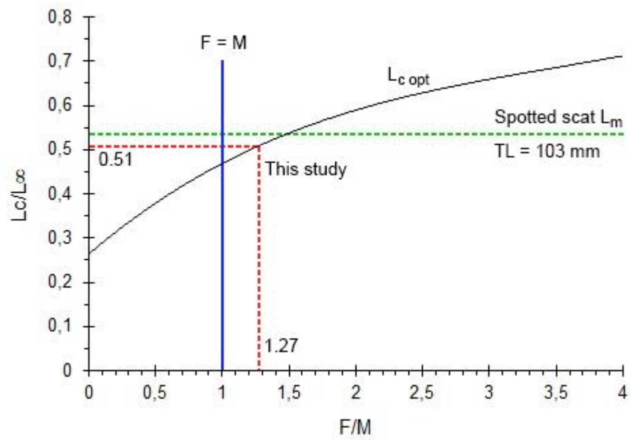

Figure 6. The relationship between relative length on the first capture (L_c/L_∞) and relative mortality of capture (F) to natural mortality (M)

Another indication is that the length of the *S. argus* caught in Pabean Bay was at a sex immature size ($L_c<L_m$). It showed that more than 50% of individuals caught are immature and small in size. Thus, these conditions indicated the possibility of overfishing, both in the form of growth overfishing and recruitment overfishing. According to Widodo and Suadi (2006), growth overfishing occurs when the catch is dominated by small fish or young fish in growth size, while recruitment overfishing occurs when exploitation activities catch more fish that are ready to spawn (spawning stock) or gonadal mature fish.

The present study found that the *S. argus* in Pabean Bay has experienced overfishing, and this condition can also occur in other fish resources in these waters. However, no evidence has been collected yet since fishing activities in this location require several considerations or arrangements, especially related to the use of *sero* fishing gear with a small mesh size and high fishing intensity, the sustainability of the resources of this fish species can be maintained.

Based on the results of this study, it can be concluded that the population of *S. argus* caught in the Pabean Bay has a growth coefficient (K) of 0.180 year^{-1} and an asymptote length of 191.63 mm. The recruitment pattern occurs throughout the year with two peak periods (February-March and August-September). The total (Z), natural (M), and catch (F) mortality were 0.84 year^{-1}, 0.37 year^{-1}, and 0.47 year^{-1}, respectively. The first caught size (L_c) was 100.195 mm, and $L_{c\ opt}$ was 97.02 mm. Therefore, the fishery status of the *S. argus* in Pabean Bay has experienced overfishing.

Some implications in the management of *S. argus* need to be done. As it is known that the capture of *S. argus* was mostly done using *sero* fishing gear. *Sero* is the most common fishing gear used by local communities and is capable in catching a wide spectrum of species and sizes of fish (i.e, small to large fish sizes). Therefore, this fishing gear has the potential to impact on fish diversity and abundance. The results of the present study provide information on the status of *S. argus* in the waters of Pabean Bay which are already in an overfished condition. Therefore, the results of this study are important indicators for monitoring changes in fishery conditions in the future. In addition, the available information on the life history of this fish, including migration patterns, spawning time, and size at first sexual maturity, can be used as a reference in the selection of management strategies. According to Reis-Filho et al. (2019), to ensure sustainable mangrove fisheries, the management strategy focuses on the relationship between stock size structure and its abundance, including integrated fishing area management with the closing of fishing seasons and rotation of fishing zones. Given that *sero* fishery is a small-scale fishery and is considered a significant source of income for local fishers. Thus, the use of this fishing gear and other fishing gears can still be maintained to achieve the goal of sustainable fisheries. For example, setting the fishing zone (determination of gear setting location and number of gear) so as not to block all fish migration routes, as well as limiting the operating time during the spawning season and increasing the net mesh size. In addition, the conservation of mangroves as fish habitats needs to be carried out to support coastal fisheries, including those around the Indramayu coast (Yulianto et al. 2016).

ACKNOWLEDGEMENTS

The author would like to thank the Pabean Bay Fish Fauna Research Team, the Swara Family, and several other fishers in Pabean Bay, as well as the Macro Biology Laboratory staff of the Faculty of Fisheries and Marine Science, IPB University who assisted during the research in the field and the laboratory.

REFERENCES

Aida SN. 2015. Reproductive biology of spotted scat (*Scatophagus argus*) in the Musi River estuary, South Sumatra. In: Rahardjo MF, Zahid A, Hadiaty RK, Manangkalangi E, Hadie W, Haryono, Supriyono E (eds). Proceedings of the 8th National Fish Seminar. Volume 2. Indonesian Ichthyological Society.

Chong L, Mildenberger TK, Rudd MB, Taylor MH, Cope JM, Branch TA, Wolff M, Stäbler M. 2020. Performance evaluation of data-limited, length-based stock assessment methods. ICES J Mar Sci 77 (1): 97-108. DOI: 10.1093/icesjms/fsz212.

Collen B, Richman N, Beresford A, Chenery A, Ram M. 2010. *Scatophagus argus*. The IUCN Red List of Threatened Species 2010: e.T155268A4761779. DOI: 10.2305/IUCN.UK.2010-4.RLTS.T155268A4761779.en.

Conover DO, Munch SB. 2002. Sustaining fisheries yields over evolutionary time scales. Science 297 (5578): 94-96. DOI: 10.1126/science.1074085.

Carugati L, Gatto B, Rastelli E, Martire ML, Coral C, Greco S, Danovaro R. 2018. Impact of mangrove forests degradation on biodiversity and ecosystem functioning. Sci Rep 8: 13298. DOI: 10.1038/s41598-018-31683-0.

Costello C, Ovando D, Hilborn R, Gaines SD, Deschenes O, Lester SE. 2012. Status and solutions for the world’s unassessed fisheries. Science 338 (6106): 517-520. DOI: 10.1126/science.1223389.

Day T, Rowe L. 2002. Developmental thresholds and the evolution of reaction norms for age and size at life-history transitions. Am Nat 159 (4): 338-350. DOI: 10.1086/338989.

Descasari R, Setyobudiandi I, Affandi R. 2016. The relationship between mangrove ecosystem and fish diversity in Pabean Ilir and Pagirikan, Indramayu District, West Java. Bonorowo Wetl 6 (1): 43-58. DOI: 10.13057/bonorowo/w060104.

Dowling NA, Smith ADM, Smith DC, Parma AM, Dichmont CM, Sainsbury K, Wilson JR, Dougherty DT, Cope JM. 2019. Generic solutions for data-limited fishery assessments are not so simple. Fish Fish 20 (1): 174-188. DOI: 10.1111/faf.12329.

Dubuc A, Waltham NJ, Bakker R, Marchand C, Sheaves M. 2019. Patterns of fish utilisation in a tropical Indo-Pacific mangrove-coral seascape, New Caledonia. Plos One 14 (4): e0207168. DOI: 10.1371/journal.pone.0207168.

Froese R, Winker H, Gascuel D, Sumaila UR, Pauly D. 2016. Minimizing the impact of fishing. Fish Fish 17 (3): 785-802. DOI: 10.1111/faf.12146.

Gandhi V, Venkatesan V, Ramamoorthy N. 2014. Reproductive biology of the spotted scat *Scatophagus argus* (Linnaeus, 1766) from Mandapam waters, south-east coast of India. Indian J Fish 61 (4): 55-59.

Gayanilo FC Jr, Sparre P, Pauly D. 2005. FAO-ICLARM stock assessment tools II (FiSAT II). Revised version. User's guide. FAO Computerized Information Series (Fisheries). No. 8, Revised version. FAO, Rome.

Grol MGG, Rypel AL, Nagelkerken I. 2014. Growth potential and predation risk drive ontogenetic shifts among nursery habitats in a coral reef fish. Mar Ecol Prog 502: 229-244. DOI: 10.3354/meps10682.

Gupta S. 2016. An overview on morphology, biology, and culture of spotted scat *Scatophagus argus* (Linnaeus 1766). Rev Fish Sci Aquac 24 (2): 203-212. DOI: 10.1080/23308249.2015.1119800.

Hadiaty RK, Allen GR, Erdmann MV. 2012. Diversity of fish species in Arguni Bay, Kaimana, West Papua. Zoo Indonesia 21 (2): 35-42. DOI: 10.52508/zi.v21i2.345. [Indonesia]

Hargiyatno IT, Sumiono B, Suharyanto. 2013. Catch rate, stock density and some biological aspects of jerbung shrimp (*Penaeus merguiensis*) in Dolak waters, Arafura Sea. Bawal 5 (2): 123-129. DOI: 10.15578/bawal.5.2.2013.123-129.

Hashim M, Abidin DAZ, Das SK, Mazlan AG. 2017. Length-weight relationship, condition factor, and TROPH of *S. argus* in Malaysian coastal waters. AACL Bioflux 10 (2): 297-307.

Hernandez A, Seijo JC. 2003. Spatial distribution analysis of red grouper (*Epinephelus morio*) fishery in Yucatan Mexico. Fish Res 63 (1): 135-141. DOI: 10.1016/S0165-7836(03)00039-0.

Hordyk A, Ono K, Sainsbury K, Loneragan N, Prince J. 2015. Some explorations of the life history ratios to describe length composition, spawning-per-recruit, and the spawning potential ratio. ICES J Mar Sci 72 (1): 204-216. DOI: 10.1093/icesjms/fst235.

Huijbers CM, Nagelkerken I, Layman CA. 2015. Fish movement from nursery bays to coral reefs: A matter of size? Hydrobiologia 750: 89-101. DOI: 10.1007/s10750-014-2162-4.

Irham M, Handayani F, Aprilla RM, Deli A. 2021. Catch composition of the Ambai net in Krueng Jambo Aye tidal canal fisheries, North Aceh-Indonesia. Indones Fish Res J 27 (1): 9-15. DOI: 10.15578/ifrj.27.1.2021.9-15.

King M. 2007. Fisheries Biology, Assessment, and Management. Fishing News Book, London.

Kon K, Kurokura H, Tongnunui P. 2010. Effects of the physical structure of mangrove vegetation on a benthic faunal community. J Exp Mar Biol Ecol 383 (2): 171-180. DOI: 10.1016/j.jembe.2009.11.01.

Kottelat M. 2001. Scatophagidae (Scats). In: Carpenter KE, Niem VH (eds). The Living Marine Resources of the Western Central Pacific. Volume 5. Bony Fishes part 3 (Menidae to Pomacentridae). Food and Agriculture Organization of the United Nations, Rome.

Mehanna SF, Eid AHMS, Ali BA, Aabed MS. 2020. Fishing gears, catch composition, and length at first capture of the common fish species in Bardawil lagoon, Egypt. Egypt J Aquat Biol Fish 24 (5): 523-538. DOI: 10.21608/ejabf.2020.108593.

Mildenberger TK, Taylor MH, Wolff M. 2017. TropFishR: An R package for fisheries analysis with length-frequency data. Methods Ecol Evol 8 (11): 1520-1527. DOI: 10.1111/2041-210X.12791.

Mookkan M, Muniyandi K, Rengasamy TA, Premkumar, Ramasubbu S, Raman V, Govindarajan T. 2014. Influence of salinity on survival and growth of early juveniles of spotted scat *Scatophagus argus* (Linnaeus, 1766). Indian J Innov Dev 3 (2): 23-29.

Morioka S, Tanaka K, Yurimoto T, Kassim FM, Okamura K. 2020a. Migratory pattern of the spotted scat (*Scatophagus argus*) in the mangrove estuary of the Matang Mangrove Forest Reserve, Malaysia, estimated by stable isotop analysis. Jpn Agric Res Quart 54 (2): 193-199. DOI: 10.6090/jarq.54.193.

Morioka S, Tanaka K, Yurimoto T, Kassim FM, Okamura K. 2020b. Growth and reproductive status of the spotted scat *Scatophagus argus* in mangrove estuary in Matang Mangrove Forest Reserve, Malaysia. Jpn Agric Res Quart 54 (4): 361-368. DOI: 10.6090/jarq.54.361.

Musarrat-ul-Ain F, Yasmeen R. 2018. A study on length-weight relationships of *S. argus* (family: Scatophagidae) from Karachi coast, Pakistan. Pak J Mar Sci 27 (1): 55-59.

Nurhayati, Fauziyah, Bernas SM. 2016. Length-weight relationship and fish growth patterns in the Musi River estuary, Banyuasin Regency, South Sumatra. Maspari J 8 (2): 111-118. DOI: 10.36706/maspari.v8i2.3487.

Pauly D. 1983. Some Simple Methods for Tropical Fish Stock. FAO Fisheries Technical Paper No. 243. FAO, Rome.

Reis-Filho JA, Harvey ES, Giarrizzo T. 2019. Impacts of small-scale fisheries on mangrove fish assemblages. ICES J Mar Sci 76 (1): 153-164. DOI: 10.1093/icesjms/fsy110.

Rochet M-J, Trenkel VM. 2003. Which community indicators can measure the impact of fishing? A review and proposals. Can J Fish Aquat Sci 60 (1): 86-99. DOI: 10.1139/f02-164.

Sawusdee A. 2010. Population dynamics of the spotted scat *Scatophagus argus* (Linnaeus, 1766) in Pak Panang Bay, Nakhon Si Thammarat, Thailand. Walailak J Sci Technol 7 (1): 23-31. DOI: 10.2004/wjst.v7i1.49.

Sholichin A, Saputra SW, Sabdaningsih A. 2021. Population dynamics of spotted scat fish (*Scatophagus argus* Linn) in the waters of Semarang Bay, Central Java. J Fish Mar Res 5 (3): 668-674. DOI: 10.21776/ub.jfmr.2021.005.03.19.

Sparre P, Venema SC. 1998. Introduction to Tropical Fish Stock Assessment. Part 1. Manual. FAO Fisheries Technical Paper No. 306.1, Rev. 2. FAO, Rome.

Stobutzki IC, Silvestre GT, Garces LR. 2006. Key issues in coastal fisheries in South and Southeast Asia, outcomes of a regional initiative. Fish Res 78 (2-3): 109-118. DOI: 10.1016/j.fishres.2006.02.002.

Su M, Duan Z, Shi H, Zhang J. 2019. The effects of salinity on reproductive development and egg and larvae survival in the spotted scat *Scatophagus argus* under controlled conditions. Aquac Res 50 (7): 1782-1794. DOI: 10.1111/are.14056.

Suprastini, Ardli ER, Nuryanto A. 2014. Diversity and distribution of fish in Segara Anakan Cilacap. Scripta Biologica 1 (2): 147-151. DOI: 10.20884/1.sb.2014.1.2.441.

Tampubolon PARP, Ernawati Y, Rahardjo MF. 2018. Diversity of ichthyofauna at the Cimanuk River Estuary, Indramayu, West Java.

Berita Biologi 17 (1): 39-48. DOI: 10.14203/beritabiologi.v17i1.1331.
Widarmanto N, Haeruddin, Purnomo PW. 2019. Food habits, niche area and trophic level of fish communities in the Kaliwlingi estuary, Brebes Regency. Bawal 11 (2): 69-78. DOI: 10.15578/bawal.11.2.2019.69-78.
Widodo J, Suadi. 2006. Management of Marine Fisheries Resources. Gadjah Mada University Press, Yogyakarta. [Indonesian]
Yulianto G, Soewardi K, Adrianto L, Machfud. 2016. The role of mangrove in support of coastal fisheries in Indramayu Regency, West Java, Indonesia. AACL Bioflux 9 (5): 1020-1029.