

Research of the exploitation level of greasyback shrimp (*Metapenaeus ensis*) in Kebumen waters

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Abstract. Kebumen Regency in Central Java Province is a major shrimp producer area in Indonesia. The shrimp caught in this area include the greasyback shrimp (*Metapenaeus ensis*) which holds considerable economic value. This research was performed to examine the level of exploitation of greasyback shrimp based on growth, mortality, and exploitation rates. Data were collected from October to December 2024, while a systematic random sampling was used in sampling the carapace length (CL) of greasyback shrimp. The sample size comprised 10% of the total catch, amounting to 391 individuals. The initial CL after being caught (CL_{C50%}) was 3.91 cm with an infinite CL (CL_∞) of 9.0 cm. The highest recruitment was estimated to occur in August. The utilization rate of 0.26 indicated that the utilization of greasyback shrimp in Kebumen waters is underexploited. The results of this research can serve as important basis for sustainable fisheries management to maintain the balance of stocks and sustainability of greasyback shrimp in the region.

Key Words: CL_∞, CL_{C50%}, exploitation level, maximum sustainable yield, mortality.

Introduction. Shrimp is a strong fisheries commodity in Indonesia, with total production reaching 250,981 tons in 2022 (KKP 2024). Globally, Indonesia is among the world's major shrimp exporters, with a total production of 82,093 metric tons (Bureau of Fisheries and Aquatic Resources of the Philippines 2021; Infofish Trade News 2024). Shrimp production in Indonesia is supplied from capture fisheries activities (including greasyback shrimp (*Metapenaeus ensis*) and aquaculture (especially whiteleg shrimp *Litopenaeus vannamei*, and giant tiger prawn *Penaeus monodon*). In 2020, Indonesia shrimp production from catches was 207,114 tons, while shrimp cultivation production was 881,599 tons (KKP 2024). Several regions are known as shrimp producers, including Kebumen Regency, Central Java Province that produces greasyback shrimp.

Greasyback shrimp is locally referred to as 'udang dogol', 'udang laki', 'udang kayu' and 'udang api-api'. Greasyback shrimp habitat covers the Indo-West Pacific waters, from the Arabian Sea, the Malaysian to Indonesian archipelagos (Holthuis 1980). Shrimp commodities (including greasyback shrimp) have high economic value in the global market (Sumaila et al 2007). Indonesia ranks fourth in the world shrimp export trade, with export volume of 220,889 metric tons in 2023 (Infofish Trade News 2024). The price of greasyback shrimp is determined by quality, size, location, and season (supply and demand). Furthermore, the shrimp prices in global market also affects local shrimp prices in Indonesia since a part of shrimp production in Indonesia is intended for export. Ikram et al (2019) reported that the price of greasyback shrimp in Kutai Kartanegara Regency (Kalimantan Island, Indonesia) varied between IDR 80,000 and IDR 120,000 per kg. In 2021, the price of shrimp in Philippines from farmers ranged from PhP 195.25 to PhP 229.69 per kg (PhP 1 = IDR 285.80 = USD 0.02, on 28/02/2025) (Philippine Bureau of Fisheries and Aquatic Resources 2021). Meanwhile, greasyback shrimp price from fishermen at Kebumen was approximately IDR 70,000 per kg.

Kebumen Regency is a productive coastal region, where economic activities are dominated by capture fisheries. Trammel net is primarily used as the fishing gear in harvesting shrimp (including greasyback shrimp) (FAO 2008; Hufiadi et al 2020). Shrimp production in Kebumen Regency in 2021 reached 226 tons before it decreased to 136

tons in 2022 (BPS-Statistics of Kebumen Regency 2024). This situation could be triggered by overfishing which appears as a global threat (Wittayakorn-Puripunpinyoo 2017; Pham et al 2023). To address this issue, it is regarded important to examine the greasyback shrimp stock in order to effectively conserve greasyback shrimp resources for the short and long terms. This research was performed to examine the level of greasyback shrimp exploitation in Kebumen waters.

Material and Method

Location and time of research. The research was conducted in Kebumen Regency (Figure 1). Greasyback shrimp were landed and traded at Fish Auction Place (FAP) Karang Duwur, and FAP Logending. Surveys and interviews were conducted with fishermen and greasyback shrimp traders. The average carapace length (CL) of greasyback shrimp was also measured from October to December 2024.

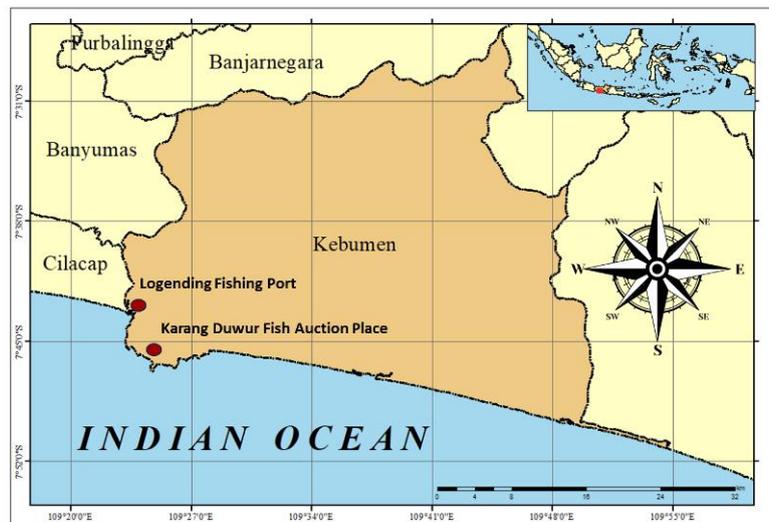


Figure 1. Kebumen map.

Research materials. The research focused on greasyback shrimp (Figure 2) caught by Kebumen fishermen using outboard motorboats, trammel nets, and one-day fishing. CL was sampled through systematic random sampling, measuring 10% of the catch (King 1995; Sparre & Venema 1998; Suradi et al 2017), totaling 391 individuals.



Figure 2. Greasyback shrimp.

Analysis method. The data of this research were analyzed using the FiSAT II tool. The growth function was estimated using the von Bertalanffy equation (Sparre & Venema 1998), while the estimated L_{∞} and growth rate (K) values were measured using the ELEFAN (Electronic length frequency analysis) I method. Gulland's (1983) formula was employed to measure t_0 values. Total mortality estimation was performed using FiSAT II, while natural mortality estimation employed Pauly's (1980) formula. Several formulas used in this research are presented as follows (Silvestre & Garces 2004; Suradi et al

2017; Dutta 2023; Bhakta et al 2024; Doinsing & Ransangan 2024; Islam et al 2024; Sakib et al 2024):

$$\begin{aligned}
 CL_t &= CL_\infty (1 - e^{-k(t-t_0)}) \\
 \text{Log}(-t_0) &= -0.3922 - 0.2752 \text{Log } CL_\infty - 1.038 \text{Log } K \\
 \text{Log } (M) &= -0.0066 - 0.279 \text{Log } CL_\infty + 0.6543 \text{Log } K + 0.4634 \text{Log } T \\
 F &= Z - M \\
 E &= F/Z \\
 E_{MSY} &= 0.5 \\
 F_{MSY} &= 0.5 Z \\
 C_{MSY} &= (F_{MSY}/F).C
 \end{aligned}$$

where: CL_t is the carapace length (CL) at age t (cm); CL_∞ is the infinite carapace length of the greasyback shrimp (cm), K is the growth coefficient; the notation t is the age of the greasyback shrimp (years); the notation t_0 is the estimated theoretical age of the greasyback shrimp when it has a carapace length of 0 cm (years); T is the average water temperature ($^\circ\text{C}$), assumed to be 30°C ; F is index of mortality due to fishing; Z is total mortality; M is natural mortality; E is the level of exploitation; E_{MSY} is the level of exploitation at maximum sustainable yield (MSY); F_{MSY} is the index of fishing mortality at MSY; C_{MSY} is the production of greasyback shrimp at MSY in tons; C is the existing production of greasyback shrimp in tons.

Results. Field observations indicate that Kebumen fishermen catch greasyback shrimp using trammel nets and outboard motorboats in coastal waters up to 4 miles from shore. The shrimp inhabit estuaries and marine waters at depths of 18-64 m, with muddy bottoms (Holthuis 1980), which provide shelter and natural food sources like detritus, plankton, and benthic organisms (Purnamaningtyas & Tjahjo 2018; Tjahjo et al 2023). The measured CL of greasyback shrimp ranged from 1.0 to 10.9 cm (Table 1).

Table 1
Size composition of greasyback shrimp caught in Kebumen waters

<i>CL interval (cm)</i>	<i>Median</i>	<i>Frequency</i>	<i>Percentage (%)</i>	<i>Cumulative percentage (%)</i>
1.0-2.9	2.0	14	3.6	3.6
3.0-4.9	4.0	190	49.2	52.8
5.0-6.9	6.0	169	43.8	96.6
7.0-8.9	8.0	11	2.8	99.5
9.0-10.9	10.0	2	0.5	100.0

Greasyback shrimp caught by Kebumen fishermen were sold fresh to traders. The highest catch frequency occurred in the 3.0-4.9 cm CL range, with 190 individuals (43.8% of the total sample). CL frequency helps determine shrimp growth parameters (Sparre & Venema 1998; Suradi et al 2017; Dutta 2023; Bhakta et al 2024). The first catch size (CL_c 50%) was estimated by plotting the cumulative frequency percentage against carapace length (Figure 3).

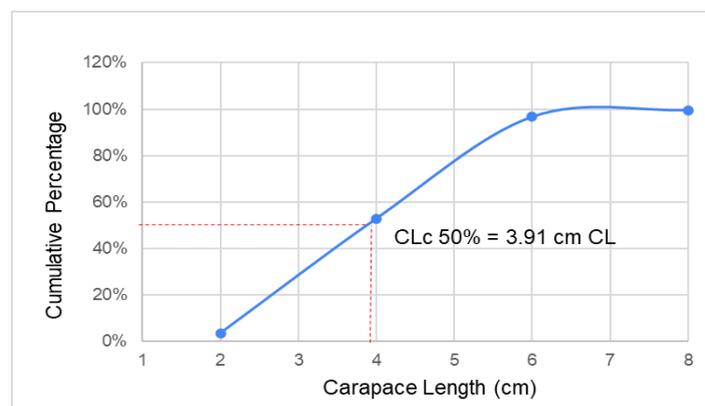


Figure 3. Analysis of $CL_c50\%$.

The research found that the first catch size of greasyback shrimp (CL_c50%) was 3.91 cm CL. As a comparison, Hasanah et al (2017) reported a first gonadal maturity size (CL_m) of 3.59 cm CL in Tanah Laut waters (South Kalimantan), while Suman et al (2019) recorded 3.77 cm CL in Binuangeun waters (West Java). The first catch size is a key parameter for assessing fishing gear selectivity (Sparre & Venema 1998). A CL_c50% value higher than CL_m suggests that greasyback shrimp fishing is environmentally sustainable (Bhakta et al 2024). The estimated values of CL_∞, K, mortality, and exploitation level in this study can be seen in Table 2.

Table 2

Estimation of CL_∞, K, mortality and exploitation level

<i>Parameter</i>	<i>Value</i>
CL _∞	9.0 cm CL
K	1.01
Total mortality (Z)	3.50
Fishing mortality (F)	0.90
Natural mortality (M)	2.60
Exploitation rate (E)	0.26 (under-exploited)
Assumption of fishing mortality*	33 tons
Estimated maximum sustainable yield (MSY) production	64.2 tons
Estimated economic value of MSY production**	IDR. 4.5 billion

Note: * using 2023 production data; ** using the assumption that the price of greasyback shrimp at fishermen is IDR 70,000/kg.

The research found that the growth rate of greasyback shrimp is 1.01 per year, with an estimated Z of 3.50 per year and an E of 0.26. It can be inferred from the results that the species is still underexploited in Kebumen waters (Sparre & Venema 1998; Suradi et al 2017; Samad et al 2023; Dutta 2023; Bhakta et al 2024). The relationship between K and CL_∞ values follows the pattern described by Silvestre & Garces (2004), where species with high M and K values and low CL_∞ values tend to have fast turnover rates, characteristic of small, short-lived species. Recruitment analysis suggests a peak in August (Figure 3), with a recruitment proportion of 27.15%, while spawning is estimated to peak in April based on the von Bertalanffy equation (assuming CL 4 cm has an age of 4 months). These findings highlight the need to consider recruitment patterns in fisheries management, particularly regarding the greasyback shrimp fishing season.

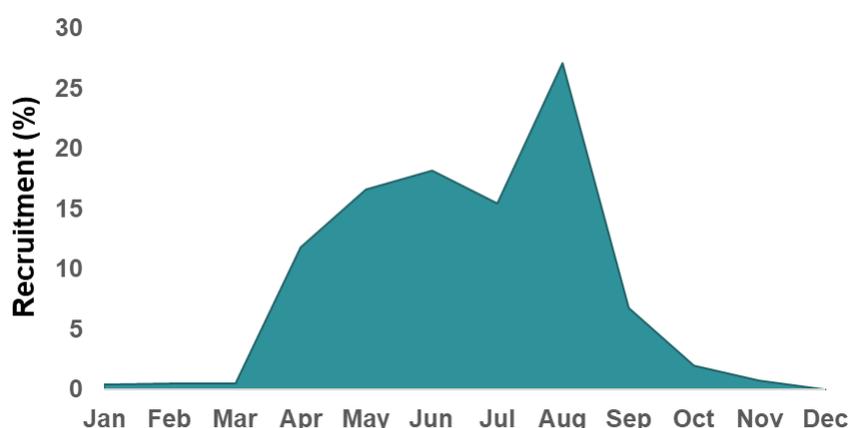


Figure 3. Recruitment time estimation.

Discussion. Greasyback shrimps are found in various Indonesian marine waters, including those of Kebumen Regency, located on Java Island's southern coast (109°33'–109°50' E, 7°27'–7°50' S). Kebumen hosts eight Fish Auction Places (FAPs), with FAP

Karang Duwur and FAP Logending serving as primary hubs for landing and marketing greasyback shrimp (DKP Kebumen 2020; BPS-Statistics of Kebumen Regency 2024).

This research found that the first capture size (CL_{c50%}) of greasyback shrimp in Kebumen waters was 3.91 cm CL, relatively consistent with findings from other regions. The first capture sizes reported in the Bangka Strait, Binuangeun (West Java), and Cirebon were 3.07 cm CL (Lestari et al 2018), 2.8 cm CL (Suman et al 2019), and 2.5 cm CL (Basith et al 2019), respectively. Variations in capture size are primarily influenced by mesh size, with smaller meshes yielding smaller shrimp (Hasanah et al 2017). The selectivity of trammel nets depends on mesh size, fish size, and shape (Karakulak & Erk 2008; Bolat & Tan 2017).

The research also confirms that the first capture size in Kebumen (CL_{c50%} = 3.91 cm CL) exceeds the first gonadal maturity size (CL_m), as reported by Hasanah et al (2017) and Suman et al (2019). Ensuring that the first capture size surpasses the first gonadal maturity size is crucial for sustaining shrimp populations (Silvestre & Garces 2004; Gayanilo et al 2005; Suradi et al 2017; Dutta 2023; Samad et al 2023; Bhakta et al 2024). Given that greasyback shrimp typically reach sexual maturity within 6-12 months (FAO 2008), the current capture practices in Kebumen waters can be considered environmentally sustainable.

The growth rate (K) of greasyback shrimp in Kebumen waters more than 1 (namely 1.01) is classified fast (Gulland 1983; Islam et al 2024). K can be influenced by natural food availability and genetic factors. Faster growth of shrimp and fish resources is associated with faster regeneration and recovery of the resources. In this study, the exploitation status of greasyback shrimp in Kebumen waters is regarded under-exploited, with F smaller than M. The results imply that the utilization of greasyback shrimp in Kebumen waters can be enhanced with strict adherence to the environmentally friendly practices in capture fisheries, including minimum size, and protection of greasyback shrimp broodstock (Suradi et al 2017; Samad et al 2023; Bhakta et al 2024).

It is also necessary to maintain the coastal ecosystem to control the pollution and protect vital habitats (including coral reefs, seagrass, and mangroves). Destructive anthropogenic activities may cause a decline in the stock of marine biological resources, including greasyback shrimp (Makwinja et al 2021; Gernez et al 2023; Soeprbowati et al 2024). The sustainable production level (maximum sustainable yield or MSY) of greasyback shrimp on the coast of Kebumen is estimated at 64.2 tons or equivalent to IDR 4.5 billion at the price of IDR 70,000/kg from fishermen. The estimated MSY production significantly exceeds current production levels. Future research should assess greasyback shrimp production at the maximum economic yield (MEY) to determine the optimal utilization level for maximizing economic returns.

The use of scientific approaches in resource management is crucial in ensuring the ecosystem balance and the sustainability of fisheries businesses. Effective management of capture fisheries is selected in regards to the estimated growth, mortality, recruitment patterns and stock resilience (Doinsing & Ransangan 2024). Wittayakorn-Puripunpinyoo (2017) mentioned several factors that cause overfishing, including over-capacity catching, higher population, increased global fish consumption, fish price fluctuation, and fishing technology.

Based on the results of this data, August is the peak of greasyback shrimp recruitment with a proportion reaching 27.15%. The results of von Bertalanffy growth equation shows that April is the peak spawning as greasyback shrimp spawn at the shrimp age (modus) of 4 months. During the peak spawning season, the spawning site should be well-protected. The management of greasyback shrimp resources should also adhere to the fishing quotas, minimum catch size restrictions, prohibitions on the use of environmentally unfriendly fishing gear, and releasing egg-bearing females (FAO 2008; Zhang et al 2021; Sakib et al 2024; Islam et al 2024). The formulation of capture fisheries policies requires the involvement of local communities (including fishermen and greasyback shrimp traders). Without adequate support from the local community, fish and shrimp resources conservation can fail (Johannesen 2007; Kennedy et al 2020; Wijayanto et al 2022).

Conclusions. The research results indicate that the first capture size of greasyback shrimp is 3.91 cm CL, with an asymptotic carapace length (CL_{∞}) of 9.0 cm CL. Peak recruitment occurs in August. The utilization rate of 0.26 classifies greasyback shrimp in Kebumen's coastal waters as underutilized, suggesting potential for enhanced sustainable exploitation to around the MSY production. Further research can be conducted on greasyback shrimp resources in areas adjacent to Kebumen Regency, namely Cilacap Regency and Purworejo Regency, as a comparison for the results of this study.

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Conflict of interest. The authors declare that there is no conflict of interest.

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