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# Population Biology of Spotted Sardinella (*Amblygaster sirm* Walbaum, 1792) Landed at the Pekalongan Nusantara Fishing Port

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**Abstract:** This study aimed to analyze key aspects of the population biology of spotted sardinella (*Amblygaster sirm*), including length-frequency distribution, sex ratio, growth pattern, and condition factor. An observational approach was employed using fish samples obtained from commercial landings at a fishing port. The specimens were caught by mini purse-seine vessels operating in Fisheries Management Area of the Republic of Indonesia (WPPNRI) 713 and landed at the Pekalongan Nusantara Fishing Port between July and October 2025. A total of 605 individuals were examined, comprising 337 males and 268 females. The chi-square test indicated a significantly unbalanced sex ratio, with a calculated $\chi^2$ value of 27.4 compared with a critical $\chi^2$ value of 7.81 (df = 3; $p$ = 4.85). Total length ranged from 14.8 to 25.7 cm. Both males and females exhibited negative allometric growth, with $R^2$ values of 0.805 and 0.835, respectively. The mean condition factor was 0.9803, reflecting a relatively slender body form consistent with the observed negative allometric growth pattern. Overall, these findings provide baseline information on the population biology of *A. sirm* that may support future assessments and inform sustainable fisheries management.
**Keywords:** Negative allometric growth; spotted sardinella; population biology; Pekalongan; WPPNRI 713

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## INTRODUCTION

Pekalongan City is one of Indonesia's coastal regions with substantial marine fisheries potential, supported by the presence of the Pekalongan Nusantara Fishing Port (PPN Pekalongan), a Type B fishing port (Andira et al., 2019). As an important fisheries landing center in Central Java, PPN Pekalongan contributes substantially to regional capture fisheries production and economic activity. According to PPN Pekalongan statistics, capture fisheries production reached approximately 13,000 tonnes in 2024, with an annual production value of approximately IDR 200 billion. The catches landed at this port originate from several Fisheries Management Areas of the Republic of Indonesia (WPPNRI), including WPPNRI 712, 713, 718, 572, and 573, with approximately 1,000 fishing trips recorded in 2024 (Data Statistik PPN Pekalongan, 2024).

One of the commercially important small pelagic species landed at PPN Pekalongan is spotted sardinella (*Amblygaster sirm* Walbaum, 1792). This species has considerable economic value (Suseno et al., 2014) and is commonly utilized as raw material for salted-fish products and the fish-canning industry (Purwoko et al., 2019). Beyond its economic importance, *A. sirm* also contributes to pelagic food-web dynamics as prey for larger predatory fishes (Kasim et al., 2015), including tuna in the

waters off Pemangkat (Fauzi et al., 2024). Changes in the abundance of this species may therefore have implications not only for fisheries production but also for trophic interactions within pelagic ecosystems.

Landings of *A. sirm* caught using mini purse seines at PPN Pekalongan reached approximately 1.9 million kg in 2024. The species is widely consumed because of its relatively affordable market price of approximately IDR 8,000 $kg^{-1}$ (PIPP, 2025). *Amblygaster sirm* is a pelagic fish that inhabits waters at depths of approximately 10–75 m, and its optimal fishing season has been reported to occur during the west monsoon, particularly from December to March (Sari et al., 2021). The high level of utilization of this resource highlights the importance of monitoring its biological characteristics and population structure to support sustainable exploitation.

Concerns regarding the sustainability of *A. sirm* fisheries have been raised in the Java Sea. PPN Pekalongan statistics show that annual landings increased from 1,833,629 kg in 2020 to 1,948,151 kg in 2024. Although increasing landings alone do not necessarily indicate overfishing, previous biological assessments have suggested substantial fishing pressure on this species. Sari et al. (2021) reported an exploitation rate (E) of 0.65 $year^{-1}$, indicating that the exploitation level exceeded the reported optimum threshold. These findings emphasize the need for updated biological information to evaluate population responses under continued fishing pressure.

The sustainability of *A. sirm* resources may also be influenced by environmental variability in addition to fishing pressure. Purwoko et al. (2019) reported that *A. sirm* resources in the Java Sea were under considerable fishing pressure. At the same time, environmental conditions can influence the distribution and abundance of pelagic fishes. Salinity and dissolved oxygen have been reported to interact directly with pelagic fish abundance, whereas chlorophyll concentration, pH, temperature, and current velocity show partial correlations with the occurrence of pelagic fishes (Ma'mun et al., 2019). Thus, population patterns observed in exploited pelagic fish stocks may reflect the combined effects of fishing activities and environmental conditions.

Effective fisheries management requires biological information that can describe population structure and temporal variation. However, the use of biological data for *A. sirm* remains limited in some fishing areas, particularly with respect to length structure, sex composition, growth characteristics, and condition. Population biological studies can provide information on growth, reproductive characteristics, and population structure, which are important for evaluating the condition of exploited fish resources and for supporting fisheries management. Accordingly, updated biological assessments are needed to complement existing information on *A. sirm*, particularly in areas contributing substantially to commercial landings.

Previous studies have examined various biological characteristics of *A. sirm* and related small pelagic fishes in different regions. Asriyana (2015) investigated growth and condition factors of *Sardinella atricauda* in Kendari Bay, while studies in the Andaman waters examined growth and mortality of *A. sirm* (Pradeep et al., 2014) and its biometric characteristics (Devi et al., 2018). Reproductive biology and population characteristics of *A. sirm* have also been investigated in Sri Lankan waters (Athukoorala et al., 2015) and Tanzania (Sululu et al., 2020). In Indonesian waters, Sari et al. (2021) investigated the biological characteristics of *A. sirm* in Rembang waters, while Fauzi et al. (2024) examined its population dynamics and stock status in the Natuna Sea. At PPN Pekalongan, Purwoko et al. (2019) evaluated abundance indicators of *A. sirm* in the Java Sea.

Despite these previous studies, several biological characteristics of *A. sirm* caught in WPPNRI 713 and landed at PPN Pekalongan remain insufficiently

documented. In particular, information on monthly variation in size structure, sex ratio, sex-specific length–weight relationships, growth patterns, and condition factors remains limited. Moreover, previous studies have generally provided limited information on whether these biological parameters differ between males and females over shorter temporal scales. Therefore, the present study provides updated biological data for July–October 2025, sex-specific analyses of key population parameters, and an assessment of monthly variation in size structure. These data are expected to complement existing information on the population biology of *A. sirm* from WPPNRI 713. Accordingly, this study aimed to analyze the length-frequency distribution, sex ratio, sex-specific growth patterns, and condition factors of *A. sirm* caught in WPPNRI 713 and landed at PPN Pekalongan from July to October 2025.

## METHOD

### Study Location and Period

The study was conducted from July to October 2025 at the Pekalongan Nusantara Fishing Port (PPN Pekalongan), Central Java, Indonesia (Figure 1). This study employed a landing-based observational design, in which spotted sardinella samples were obtained from catches landed at PPN Pekalongan. Spotted sardinella (*Amblygaster sirm*) were caught by mini purse-seine vessels operating in Indonesian Fisheries Management Area (WPPNRI) 713, which includes the Flores Sea and Makassar Strait.

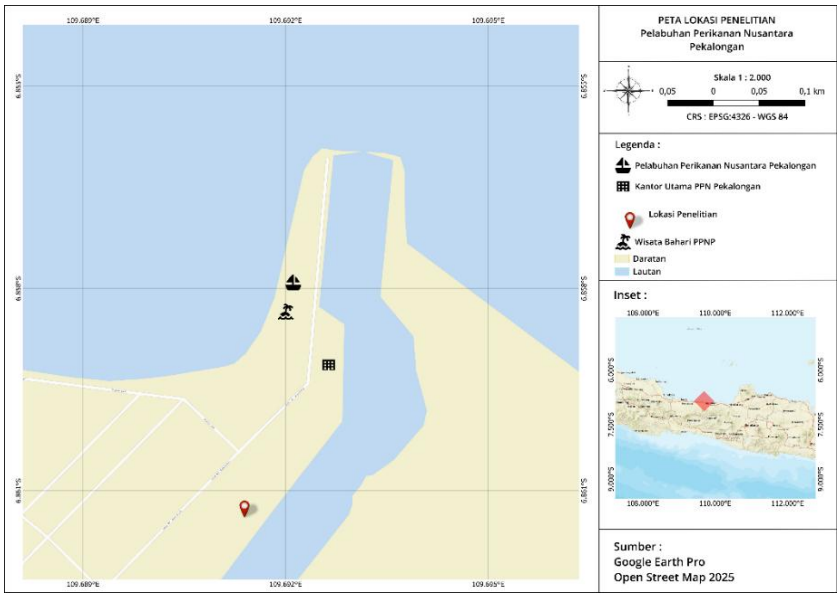


**Figure 1.** Map of the study location at Pekalongan Nusantara Fishing Port

### Data Collection

Data were collected through direct observation of *A. sirm* specimens obtained from catches landed by mini purse-seine vessels at PPN Pekalongan. Sampling was conducted once per month for four consecutive months, from July to October 2025. A total of 605 individuals were examined, comprising 337 males and 268 females. The monthly sample sizes were 165 individuals in July, 123 in August, 162 in September, and 155 in October.

Samples were selected using a purposive sampling approach. Fish were purchased from several mini purse-seine vessels with monthly fishing trips to ensure that a broad range of body sizes, from the smallest to the largest individuals, was represented in each landing group and that only intact specimens were included. Total

length was measured to the nearest 0.1 cm, and body weight was recorded to the nearest 0.01 g. Each specimen was dissected using standard fish dissection equipment, and sex was determined by macroscopic examination of the gonads following the procedure described by Nurmia et al. (2023).

**Figure 2.** Spotted sardinella (*Amblygaster sirm* Walbaum, 1792)

**Data Analysis**

The analyses included length-frequency distribution, sex ratio, length–weight relationship, and condition factor.

**1. Length-frequency distribution**

The distribution of total fish length was analyzed using class intervals in Microsoft Excel to identify the dominant size classes in each month. The length-class grouping procedure followed Humanica et al. (2024) and consisted of the following steps:

a. The range was calculated as: (R = Maximum value – Minimum value)
b. The number of classes was determined as: (B = 1+3,3 log n)
c. The class width was calculated as: (P = Range / Number of classes)
d. The lower and upper limits of each class interval were then determined.

**2. Sex ratio**

The sex ratio was evaluated by comparing the number of male and female individuals using the chi-square test ($X^2$) according to Sokal and Rohlf (1981):

$$X^2 = \sum[(\mathrm{obs_i} - \mathrm{exp_i})]^2 / \mathrm{exp_i} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Note:
$X^2$ : Chi-square statistic
Σ : Summation symbol
$Obs_i$ : Observed value for the (i)th category
$Exp_i$ : Expected value for the (i)th category
α : 0,05

The hypotheses were formulated as follows:
$H_0$: the sex ratio is balanced.
$H_1$: the sex ratio is unbalanced.
If the calculated ($X^2$) value exceeded the critical ($X^2$) value, ($H_0$) was rejected. Conversely, if the calculated ($X^2$) value was lower than the critical ($X^2$) value, ($H_0$) was accepted.

**3. Length-weight relationship**

The length–weight relationship was analyzed to determine the growth pattern of *A. sirm* using the model described by Sparre and Venema (1998):

$$W = a\, L^b \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Note:
W : body weight (g)
L : total length (cm)
a : intercept
b : slope

Equation (2) was then log-transformed into a linear form:

$$\log W = \log a + b \log L \quad \text{..... (3)}$$

A *t*-test was used to determine whether the estimated (b) value differed significantly from 3 (Walpole, 1993), using the following hypotheses:
$H_0$: b = 3, indicating isometric growth.
$H_1$: b ≠ 3, indicating allometric growth.

**4. Condition factor**

The condition factor was used to describe the relative body condition of the fish based on its length and weight relationship. The formula applied in this study was reported as Fulton's Condition Factor (K) following Effendie (2002):

$$K = \frac{W}{aL^b} \quad \text{..... (4)}$$

Note:
K : condition factor
W : mean body weight
L : mean total length
a : intercept
b : slope

## RESULTS AND DISCUSSION

### Length-Frequency Distribution

A total of 605 spotted sardinella (*Amblygaster sirm*) specimens were sampled at Pekalongan Nusantara Fishing Port (PPN Pekalongan), comprising 337 males and 268 females. The monthly length-frequency distributions recorded from July to October 2025 are presented in Figure 3.

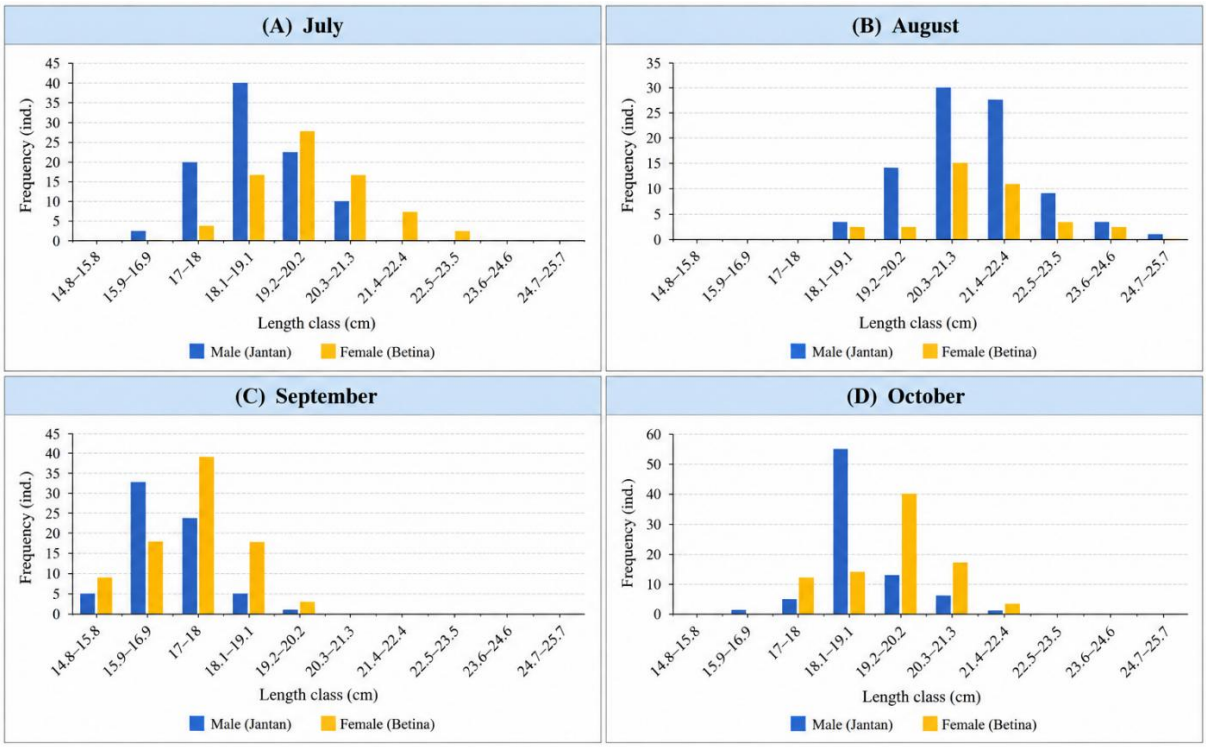


**Figure 3.** Length-frequency distribution of spotted sardinella (*Amblygaster sirm* Walbaum, 1792)

Male *A. sirm* ranged from 14.8 to 25.2 cm in total length, with a mean length of 19.08 cm, whereas females ranged from 14.8 to 25.2 cm, with a mean length of 19.2 cm. The length-frequency distribution of males fluctuated among months, with the highest frequency recorded in October at the 18.6 cm length class. A similar monthly fluctuation was observed in females, with the highest frequencies recorded in September and October at the 17.5 and 19.7 cm length classes, respectively.

Previous studies have reported differences in the size distribution of *A. sirm* among geographic areas. Kartini et al. (2017) recorded fork lengths of 10.0–18.9 cm in the Sunda Strait, whereas Purwoko et al. (2019) reported fork lengths of 14.1–24.5 cm for specimens landed at PPN Pekalongan. In the Java Sea, Sari et al. (2021) reported total lengths of 12.0–20.5 cm, while Fauzi et al. (2024) recorded fork lengths of 13.0–20.9 cm. Such variation in body size may be associated with differences in food availability, environmental conditions, fishing grounds, and fishing seasons (Mardlijah et al., 2022). Greater food availability may provide sufficient energy to support somatic growth (Rochman et al., 2015), while seasonal differences in fishing activity may also contribute to variation in observed size structure (Masyahoro et al., 2025). The fishing season for *A. sirm* occurs during the west monsoon, particularly around December, whereas sampling in the present study was conducted from July to October (Chodriyah & Hariati, 2010). This seasonal difference may partly explain why the sampled population was dominated by individuals smaller than 20 cm.

**Sex Ratio**

The 605 specimens examined consisted of 337 males and 268 females, corresponding to an overall male-to-female sex ratio of 1.3:1. Monthly variation in sex composition is shown in Figure 4.

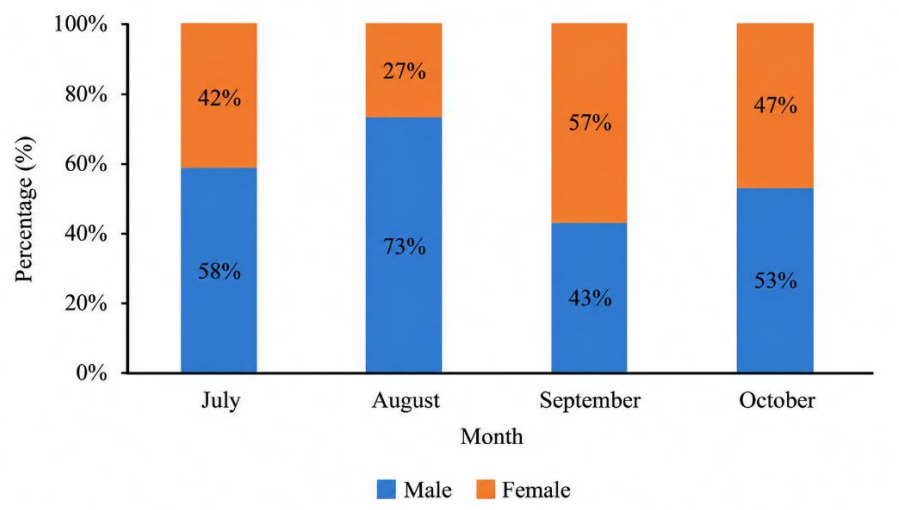


**Figure 4.** Sex ratio of spotted sardinella (*Amblygaster sirm* Walbaum, 1792)

Overall, males predominated during the four-month sampling period, although females were more abundant in September. The sex ratio of *A. sirm* caught in WPPNRI 713 was 1.3:1. The chi-square test yielded a calculated ($X^2$) value of 27.40, which exceeded the critical ($X^2$) value of 7.81, indicating that the observed sex ratio deviated from an equal male-to-female ratio.

Kartini et al. (2017) reported a sex ratio of 0.75:1 for *A. sirm* in the Sunda Strait, whereas Purwoko et al. (2019) recorded 381 males and 449 females. In the present study, the sex composition of *A. sirm* landed at PPN Pekalongan varied among months. The relatively high proportion of males observed in August may be associated

with reproductive migration, during which males may exhibit greater mobility, whereas females predominated in September. The higher proportion of females in September may be related to reproductive aggregation during the spawning period, when mature females may congregate in particular areas. Nevertheless, temporal and spatial variation in sex ratio may also be influenced by the relative abundance of juvenile and adult fish, reproductive behavior, and sex-specific growth patterns (Hasanah et al., 2022).

**Length–Weight Relationship**

The length–weight relationship provides an indication of fish growth patterns (Ragheb, 2023). The length–weight relationships of male and female *A. sirm* are presented in Figure 5.

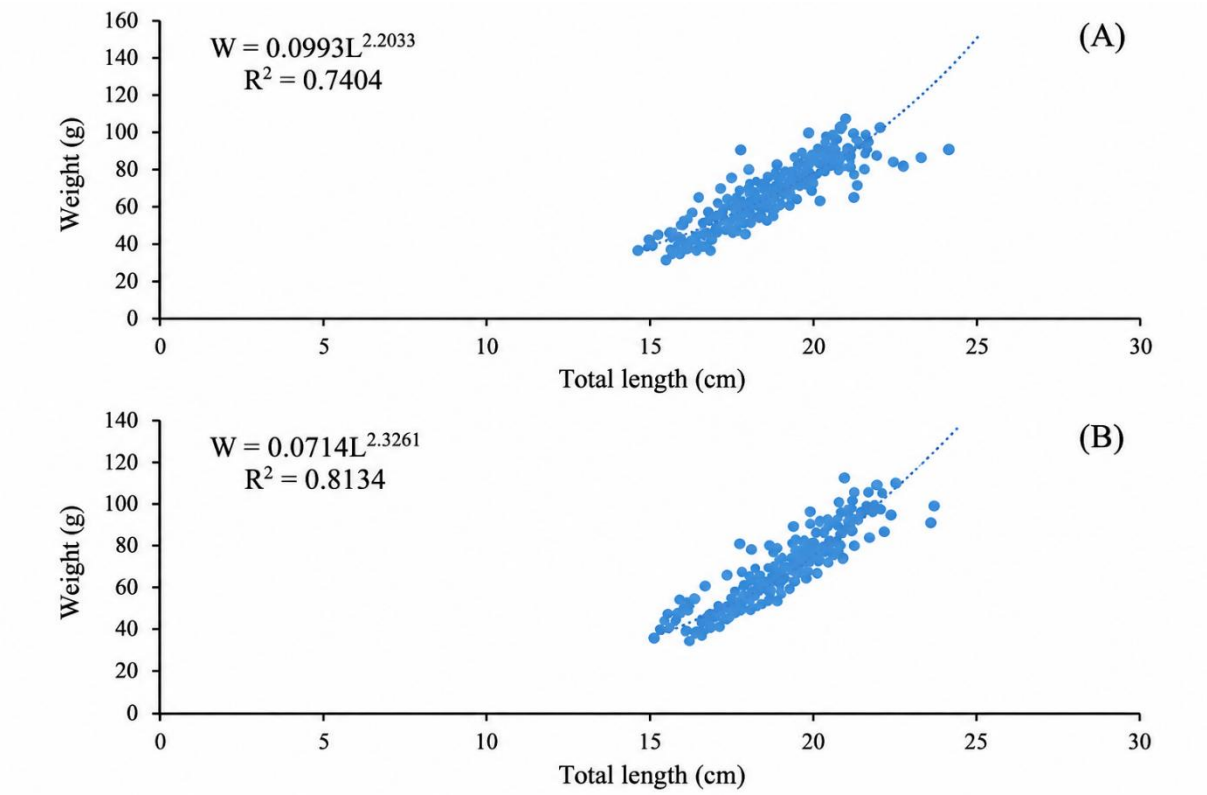


**Figure 5.** Length–weight relationships of male (A) and female (B) spotted sardinella (*Amblygaster sirm*)

The length–weight relationship differed between sexes. For males, the relationship was expressed as: $W=0{,}0993L^{2{,}2033}$, whereas for females, it was: $W=0{,}0714L^{2{,}3261}$.

The *t*-test indicated that both males and females exhibited negative allometric growth, meaning that body length increased proportionally faster than body weight. A comparison of growth patterns reported for *A. sirm* from different geographic areas is presented in Table 1.

**Table 1.** Growth patterns of spotted sardinella (*Amblygaster sirm*) in different study areas

| Location | (b) value | Growth pattern | Reference |
|---|---|---|---|
| Sunda Strait | 2.92 (male); 2.80 (female) | Isometric | Kartini et al. (2017) |
| Java Sea | 2.2598 | Negative allometric | Purwoko et al. (2019) |

| Location | (b) value | Growth pattern | Reference |
|---|---|---|---|
| Java Sea | 3.54 | Positive allometric | Sari et al. (2021) |
| Natuna Sea | 3.2324 | Positive allometric | Fauzi et al. (2024) |
| Flores Sea (WPPNRI 713) | 2.2033 (male); 2.3261 (female) | Negative allometric | Present study |

Previous studies have reported variation in the slope coefficient (\(b\)) of the length–weight relationship among populations of *A. sirm*, even when similar growth patterns were observed. Differences in \(b\) values within the same species may reflect variation in growth rate, age structure, gonadal development, food availability, environmental conditions, and the size range of the sampled fish (Pradeep et al., 2014).

The negative allometric growth observed in the present study is consistent with the findings of Purwoko et al. (2019). This similarity may be related to several shared characteristics, including the same landing location at PPN Pekalongan, comparable environmental conditions in the Java Sea, and the use of mini purse seines. These similarities may have resulted in the capture of fish with relatively comparable physiological conditions and access to food resources. By contrast, positive allometric growth has been reported for *A. sirm* in the Natuna Sea (Fauzi et al., 2024) and the Java Sea (Sari et al., 2021). Such differences may be associated with variation in food availability and environmental conditions among fishing areas (Jisr et al., 2018).

## Condition Factor

The condition factor of male and female *A. sirm* was derived from their respective length–weight relationships. Monthly condition-factor values for both sexes are presented in Table 2.

**Table 2.** Condition factor of spotted sardinella (*Amblygaster sirm* Walbaum, 1792)

| Month | Male Range | Male Mean | Male SD | Female Range | Female Mean | Female SD |
|---|---|---|---|---|---|---|
| July | 0.7954–1.5222 | 1.0202 | 0.1163 | 0.8345–1.3748 | 1.0037 | 0.1079 |
| August | 0.7205–1.2825 | 1.0206 | 0.1151 | 0.7558–1.2480 | 1.0187 | 0.1012 |
| September | 0.7399–1.1345 | 0.9211 | 0.0800 | 0.7969–1.2393 | 0.9491 | 0.0939 |
| October | 0.7701–1.1285 | 0.9643 | 0.0738 | 0.8098–1.1331 | 0.9450 | 0.0679 |

Condition-factor values were highest in July and August, declined in September, and increased slightly in October. Across the four-month sampling period, the overall mean condition factor was 0.9803, a value close to 1. This suggests that the sampled fish generally maintained a relatively stable body condition. A condition-factor value below or close to 1 does not necessarily indicate poor physical condition. The naturally elongated, fusiform, and laterally compressed morphology of clupeid fishes may result in relatively low weight-to-length ratios and, consequently, lower condition-factor values (Effendie, 2002).

The condition factor of males ranged from 0.7204 to 1.5222, while that of females was reported to range from 0.9779 to 1.3748. Tampubolon et al. (2002) reported condition-factor ranges of 0.57–1.40 for males and 0.53–1.46 for females in Sibolga Bay. In the Sunda Strait, Kartini et al. (2017) reported values of 0.9346–1.0294 for males and 0.9401–1.0738 for females.

Condition-factor values can vary among geographic areas and may be influenced by age, sex, food availability, and gonadal maturity stage (Effendie, 2002). Temporal fluctuations in condition factor may also reflect variation in the quantity and quality of available food resources (Kartini et al., 2017). Condition factor can therefore provide

useful information on changes in fish condition over time, including potential responses to fishing pressure and environmental degradation (Wujdi et al., 2012).

Purwoko et al. (2019) reported indications of growth overfishing in *A. sirm* populations in the Java Sea, with production reported to be below the maximum yield-per-recruit level. These findings highlight the importance of management measures aimed at improving gear selectivity and promoting the use of environmentally responsible fishing practices. In addition, catch-based management measures and protection of spawning seasons and spawning habitats may contribute to the long-term sustainability of *A. sirm* resources.

## CONCLUSION

Based on the results of this study, spotted sardinella (*Amblygaster sirm* Walbaum, 1792) caught in WPPNRI 713 and landed at Pekalongan Nusantara Fishing Port between July and October 2025 had total lengths ranging from 14.8 to 25.7 cm. The sample comprised 337 males and 268 females, corresponding to a male-to-female sex ratio of 1.3:1. The length–weight relationship was described by the equation $W = 0.0993L^{2.2033}$ for males and $W = 0.0714L^{2.3261}$ for females. Both sexes exhibited negative allometric growth, indicating that body length increased proportionally faster than body weight. The mean relative condition factor was 0.9803, indicating that the observed body weight was generally close to the expected weight predicted from the length–weight relationship. Overall, this study provides baseline information on the size structure, sex ratio, length–weight relationship, growth pattern, and condition factor of *A. sirm* in WPPNRI 713.

## RECOMMENDATION

Further studies are recommended to update and expand information on the growth rate, mortality rate, and reproductive biology of *A. sirm*. Such data are needed to provide a more comprehensive understanding of the species' biological characteristics and to strengthen the scientific basis for sustainable fisheries management.

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The authors used AI-assisted technologies solely to improve the readability and language quality of the manuscript. The authors reviewed and edited the final content and take full responsibility for the manuscript.

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