

# Population dynamics of anchovy pekto (*Stolephorus waitei*) in the waters of Malacca Strait, North Sumatra, Indonesia

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Manuscript received: 5 January 2021. Revision accepted: 14 June 2021.

**Abstract.** Mulya MB, Jhon AH, Harahap ZA. 2021. Population dynamics of anchovy pekto (*Stolephorus waitei*) in the waters of Malacca Strait, North Sumatra, Indonesia. *Biodiversitas* 22: 2693-2698. Anchovy pekto or *Stolephorus waitei* (Engraulidae: Clupeiformes) is one of the fish in the eastern coastal part of North Sumatra, occupying the waters of Malacca Strait. This research presents the population dynamics of *S. waitei* following its age, growth, mortality, and recruitment pattern based on the length-frequency data. Fork length (FL) and total weight (TW) data of *S. waitei* were collected at three sites from April to September 2018. A total of 1994 specimens with FL from 4.0 to 6.7 cm and TW from 0.2 to 2.3 g with the length-weight relationship of  $TW = 0.073FL^{3.0046}$  ( $R^2=0.765$ ) indicated a near isometric and positive allometric growth in the water region. The relative condition factor ( $K_n$ ) ranged from 1.01 to 1.02, indicating an estimate of good condition of the fishes. The growth parameters based on von Bertalanffy was 6.56 cm ( $L_\infty$ ) with the growth coefficient ( $K$ ) of  $0.34 \text{ yr}^{-1}$  and  $t_0$  (anchovy age at zero length) of 0.6506. The total mortality ( $Z$ ), natural mortality ( $F$ ), and catch mortality ( $M$ ) of *S. waitei* were 0.64, 1.39, and  $0.75 \text{ yr}^{-1}$  respectively, which suggest that the fishing activities of *S. waitei* are still in normal intensity. The recruitment pattern of *S. waitei* was stable between April and August with its peak in June by 14.21%. The fishing activities may then be limited during the spawning months (May to June) of *S. waitei* to maintain their population in the Strait of Malacca.

**Keywords:** Growth pattern, Malacca Strait, population dynamics, recruitment pattern, *Stolephorus waitei*

## INTRODUCTION

Anchovies are one of the important marine fishery resources in the Indo-Pacific region, including *Stolephorus* spp. or white baits, the most intensively harvested member of the groups commonly found in the tropical waters of Indonesia (Safurudin et al. 2018). Together with other small pelagics (sardines and herrings), anchovies provided the largest source of protein with annual productivity between 21% and 43% of the total marine commodities in the last 60 years (Cota et al. 2013). Anchovy pekto (*S. waitei*) or *ikan teri pekto* (Indonesian) is one of the relatively well harvested small fish species in North Sumatra among other 18 valid *Stolephorus* species from the family Engraulidae (Clupeiformes: Clupeoidei) distributed worldwide (Jordan and Seale 1926; Eschmeyer and Fricke 2008). The species is distinguishable by its uniformly pale brown body, a longitudinal silver band stretching from behind upper opercular margin to caudal-fin base, and a silver head with longer upper jaw (Whitehead et al. 1988; Wongratana et al. 1999; Hata et al. 2020). The distribution of this species is still reported only from Queensland, Australia (Hata et al. 2020) and Indo-Pacific: western Indian Ocean (from Cochin and southern tip of India to Myanmar) and western Pacific (Thailand, Java Sea, the Philippines, probably Irian Jaya, if not also Papua New Guinea, south to Queensland; perhaps even more widespread. A large population of anchovies was documented to dwell in the waters of Strait of Malacca, which is being harvested intensively following a high

market demand in North Sumatra for human consumption. Anchovies are rich in calcium, iron, omega-3 oils and proteins yet preserved as low-cost salted and dried products with a high nutrient content (Siriskar et al. 2013). Therefore, the availability of this species in the Indonesian waters is regarded as a natural blessing, one of high-quality fish in economical value with export priority. The monitoring of fish stocks in nature is urgently needed to assess its current state of sustainability in the face of intensive harvesting by fishermen, and the magnitude of industrial processing for fish products (Masse et al. 2016). High market demand may lead to overfishing by fishermen along with a consequence upon their population decline in nature. Although the availability of anchovies is regarded as abundant in certain provinces of Indonesia, some aspects of their biological parameters are still neglected. Research on this issue is limited especially for *S. waitei* populations regarding their recent conditions, growth, requirement patterns, and natural or catch mortalities (Milton et al. 1998; Gamawan et al. 2018; Irnawati et al. 2018).

In addition, the biomass dynamics of *S. waitei* may be strongly dependent on recruitment which remains a question especially for the population occupying the waters of Strait of Malacca in North Sumatra, Indonesia. For years, Strait of Malacca has been studied for its major problems and issues of development in the coastal and marine resources with the gaps on some neglected fish species (Burbridge 1988). No information is currently available from the monitoring of *S. waitei* within the water region of the Strait of Malacca. Therefore, the present

study reveals the significance of applied biology in fishery science to provide the biological data of *S. waitei* for the assessment of its stock and monthly population dynamics.

## MATERIALS AND METHODS

### Study area and sampling sites

This research was conducted in the water region of the Strait of Malacca, North Sumatra from April to September 2018. The fishing gears i.e. gill nets and trawls were provided by local fishermen. Monthly fork length (FL) data of *S. waitei* were collected from three representative sites in an area extending from west to east of the region i.e. station I (3° 29'N, 99° 18'E), station II (3° 29'N, 99° 18'E), and station III (03° 30'N, 99° 16'E).

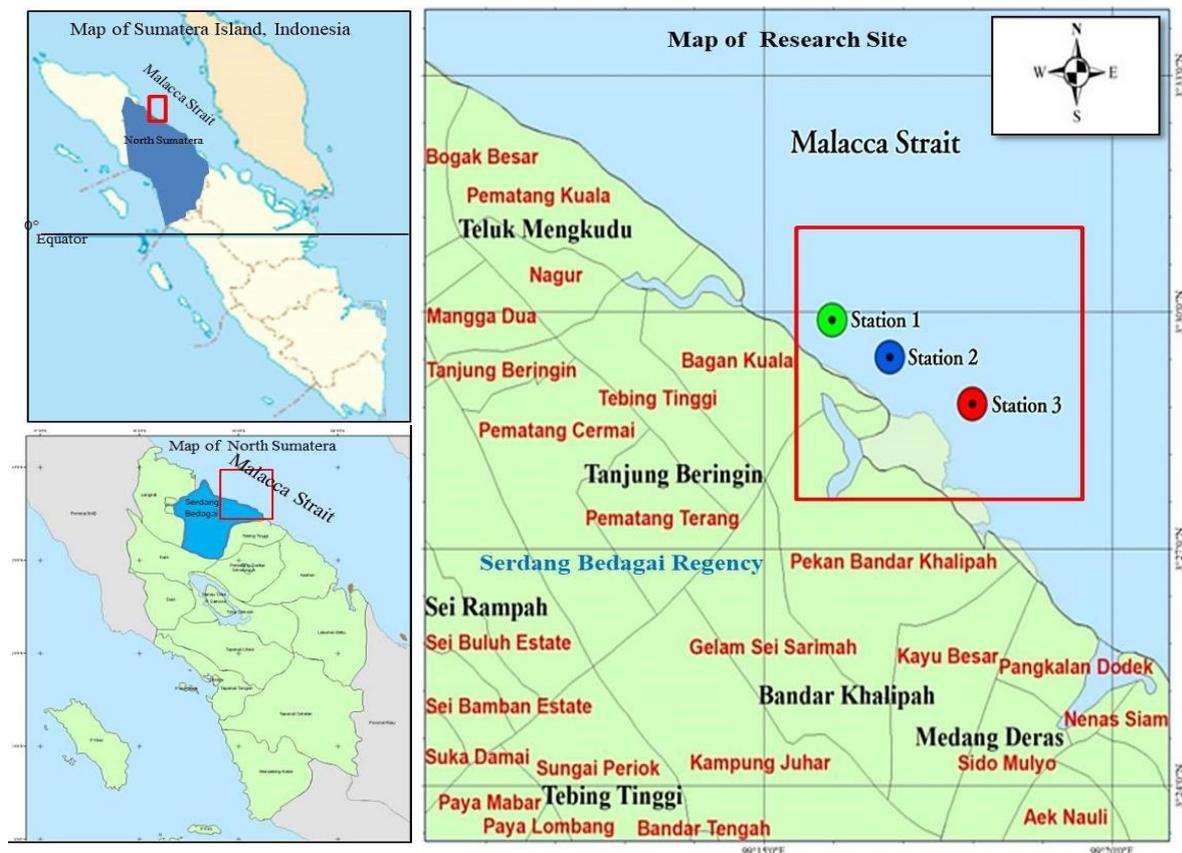
Fish sampling was collection at each location is carried out once a month, using a stocking net and nets with the help of the fisherman local. The fish samples obtained were put into a plastic bag containing 70% alcohol and labeled containing information about the data location and sample specifications. Fish-sized big, besides being soaked in alcohol, also injected formalin 4% (Harahap et al. 2018). Fish specimens before being preserved first photographed

and recorded local names, especially for fish species that already have local names.

### Observation of fish characteristic

#### Length-weight relationship and relative condition factor

Fork length (FL) of all specimens was measured using a digital caliper to the nearest 1 cm and total weight (TW) of specimens was measured to the nearest 1 g using a digital balance. The relationship between length and weight was estimated using the equation by Froese et al. (2006):  $TW = aFL^b$ , where  $a$  is the constant or linear intercept and  $b$  is the coefficient regression or slope when equal to 3. The  $a$  and  $b$  parameters were estimated using linear regression on the transformed equation:  $\log TW = \log a + b \log FL$  (Silaen and Mulya 2018). The  $b$  value may indicate the growth pattern of the fish, which falls into several categories i.e. isometric ( $b=3$ ) and allometric ( $b \neq 3$ ), which is further categorized as negative allometric ( $b < 3$ ) and positive allometric ( $b > 3$ ). Relative condition factor ( $K_n$ ) was estimated using the equation by Le Cren (1951):  $K_n = TW_{cal}/TW_{pred}$ , where  $TW_{cal}$  is the bodyweight of fish in g,  $TW_{pred}$  is the predicted body weight generated previously from the length-weight relationship.



**Figure 1.** Map of study area showing the sampling sites of *Stolephorus waitei* in the water region of Malacca Strait, North Sumatra, Indonesia

### Growth parameters

Fork length (FL) frequency data were used to calculate the von Bertalanffy growth rate ( $k$ ) using the equation by Sparre and Venema (1998):  $L_t = L_\infty (1 - e^{-k(t-t_0)})$ , where  $L_t$  is the length at  $t$  age,  $L_\infty$  is the asymptotic length calculated using the ELEFAN I menu from FiSAT II software (Pauly 1984; Gayanilo et al. 2005), and  $t_0$  is the anchovy age at zero length. The theoretical age ( $t_0$ ) was estimated using the equation by Pauly (1983):  $\log t_0 = -0.3922 - 0.2752 \log L_\infty - 1.0382 \log k$ .

### Mortality rate and recruitment pattern

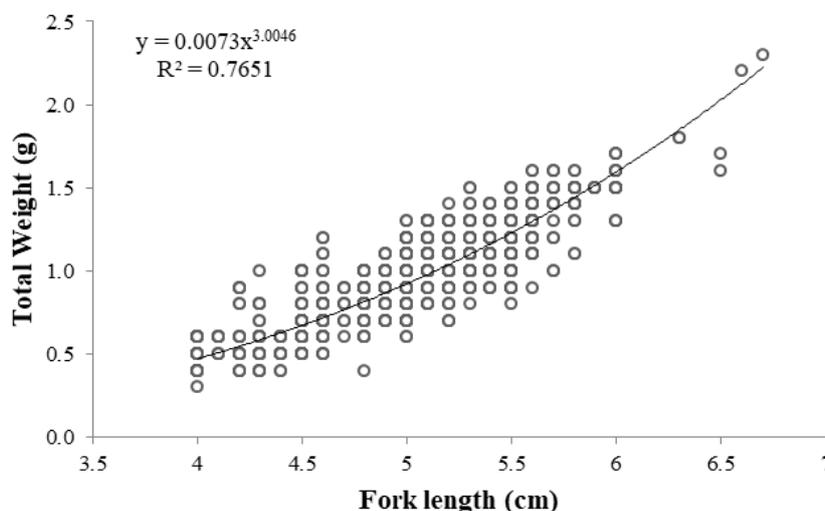
Natural mortality rate ( $M$ ) was estimated using an age-independent method by relating the data of annual water surface temperature ( $T$  °C) with von Bertalanffy growth parameters. The relationship between size (length-weight) and natural mortality was expressed into the equation by Pauly (1980):  $\log M = -0.0066 - 0.279 \log L_\infty + 0.6543 \log K + 0.4634 \log T$ . Total instantaneous mortality coefficient ( $Z$ ) was estimated using the catch curves of converted length size featured in the FiSAT II software (Gayanilo et al. 2005) along with the catch mortality ( $F$ ) and the exploitation rate ( $E$ ) using the equation by Pauly (1983):  $Z = F + M$ ,  $E = F/Z$ . Recruitment pattern of increasing *S. waitei* individuals was analyzed using FiSAT II software (Gayanilo et al. 2005).

## RESULTS AND DISCUSSION

This study investigated the population dynamics of *Stolephorus waitei* as one of the neglected fish species yet, but widely harvested and trade for commercials originating from the waters of the Strait of Malacca, North Sumatra, Indonesia. Some species of anchovies or whitebaits in the tropical waters between 60° N and 50° S have been studied (Whitehead et al. 1988). Based on the database of IUCN Red List of Threatened Species, *S. waitei* is still

categorized as data deficient with unknown information of their current population trend, either from its native habitat in Australia or Indonesia and Indo-Pacific: western Indian Ocean (from Cochin and southern tip of India to Myanmar) and western Pacific (Thailand, Java Sea, the Philippines, probably Irian Jaya, if not also Papua New Guinea, south to Queensland; perhaps even more widespread. Based on our study, we obtained 1994 specimens of *S. waitei* in total during the period of sampling. Fork length (FL) of 1994 specimens was ranged between 4.0 to 6.7 cm and the total weight (TW) ranged between 0.2 to 2.3 g.

The relationship was formulated as  $\log W = 0.073 + 3.0046 \log FL$  or exponentially as  $TW = 0.073FL^{3.0046}$  ( $R^2=0.765$ ) (Figure 2). Please bring this Figure 2 next to this para. The  $b$  value in most of the fish species generally ranged from 2.5 to 4.0 resulting in the dominant isometrical growth (Biswas 1993). The biometrical data simply described the mathematical correlation within two variables to predict the variation from the expected weight for length of the individual fish. In our study, the obtained  $b$  value was more than 3 ( $b>3.0$ ) which indicated a slight positive allometric or may be close to the isometric growth model for *S. waitei*. Our results also correspond to the previous study on *S. waitei* in Mangalore, India with  $b$  value of 3.156 showing the positive allometric growth (Rohit and Gupta 2008). Although the members of *Stolephorus* are generally small, different growth patterns may exist depending on their habitat conditions. A result was reported by Hazmadi et al. (2011) on *S. tri* in the coastal waters of Terengganu, Malaysia with the obtained  $b$  value of 3.038 indicating an isometric growth pattern. Another study by Nair et al. (2015) in Kerala Coast, India obtained the  $b$  value of 3.02 for *S. Commersonii*, which was determined as a positive allometric growth pattern by the species. In addition to that, a study of *S. indicus* in Thoothukudi coastal waters of India, revealed a negative allometric growth pattern ( $b=2.727$ ), which was different from the current findings (Patadiya et al. 2018).



**Figure 2.** Length-weight relationship of *Stolephorus waitei* in study area

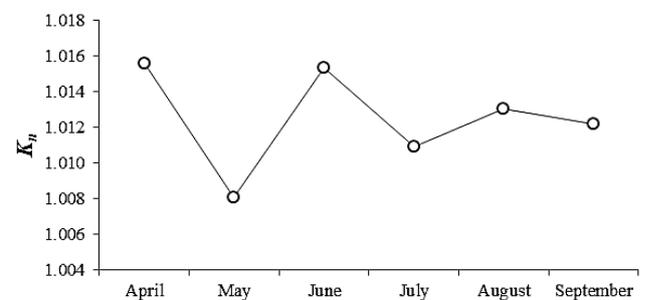
The differences of LWRs pattern may due to the seasonal timing of sampling, fish species, maturity state, and co-interaction between biological and abiotic factors (De Giosa et al. 2014; Zaher et al. 2015). Hence, the length-weight relationships (LWRs) analysis is one of the biometrical parameters used widespread to depict the growth of the fish, its general health, and fitness to thrive in its habitat (Froese 2006). The parameter may also show the condition of wellbeing of fish influenced by different biological and environmental factors (Morato et al. 2001). The relative condition factor ( $K_n$ ) was used to assess the condition of *S. waitei* population in our study. Based on the result,  $K_n$  was ranged between 1.01 and 1.02, with the peak in April and June (Figure 3).

In other species, the relative condition factor of Commerson's anchovy (*S. commersonii*) in the coastal waters of Kerala, India was reported within 0.78 to 1.95 with the lowest in June (0.78-0.88), which was contradictive and different to present results (Nair et al. 2015). Similar to the current finding, the relative condition factor of *S. indicus* in the coastal waters of India was found within 0.998 in January and 1.008 in June, while being categorized as suitable for the growth of fish population in the region (Patadiya et al. 2018). Condition factor represents the quality of fish individuals based on their physiological conditions as an adaptive result to the interaction between biotic and abiotic factors. In addition, the biometrical data may also represent the well-being status of the fish species. The relative condition factor ( $K_n$ ) may provide a valuable measure of different life cycle stages of fishes for the implementation of fishery resources management in an ecosystem. The slightly fluctuating result indicated a good and stable growth condition of *S. waitei* in the study area as denoted from  $K_n \geq 1$  (Le Cren 1951). Many factors are affecting the growth of a fish species including food availability, habitat or environmental conditions, and reproductive cycles (Morato et al. 2001). The estimates of growth parameters of *S. waitei* were 6.56 cm ( $L_\infty$ ) with the growth coefficient ( $K$ ) of 0.34 yr<sup>-1</sup> and  $t_0$  of 0.651. The results then showed that *S. waitei* may reach its maximum length of 6.56 cm at the age of 22 months. The population of *S. waitei* in the waters of Malacca Strait, consisted of a single age group (cohort), with a shift in the size modus during the month of

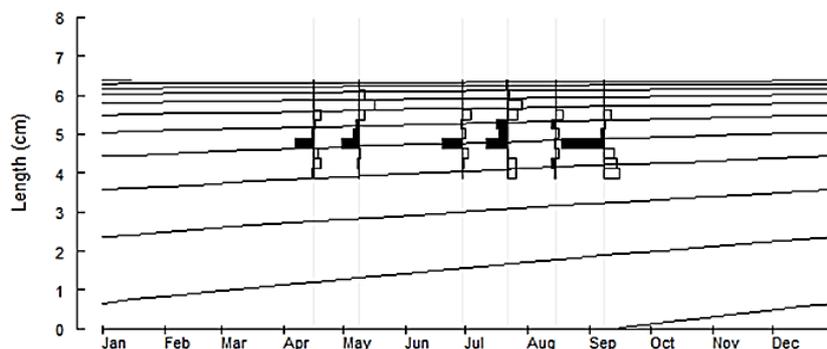
observation, which shows the monthly growth rate of the population (Figure 4).

Based on Figure 4, it can be seen that the spawning period of *S. waitei* occurs from May to June. Different from our results, a study on *S. waitei* in Belawan Sea, North Sumatra revealed three cohorts that emerged from a certain period in the same habitat (Yuanda et al. 2015). Other studies also reported four to five cohorts of *S. dubiosus* that existed in the Bay Hap and Cua Lon estuaries in Vietnam (Tran et al. 2020). In addition, the von Bertalanffy growth model of *S. waitei* was determined in the formula:  $L_t = 6.56(1 - e^{-0.34(t+0.6506)})$  (Figure 5).

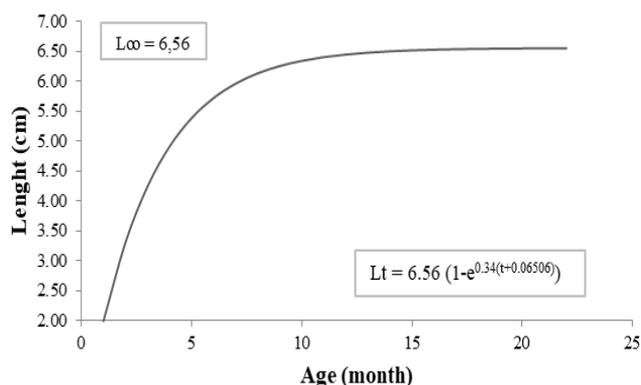
The annual  $K \geq 1.0$  may indicate the fast growth rate of a fish species in a water region. In current study, based on the growth parameters indicated the possible delayed growth of *S. waitei* in the Strait of Malacca, due to the intensive harvesting activity by fishermen. Meanwhile, the growth of *S. waitei* is considered as slow in the Malacca Strait. For comparison, the growth parameters of *S. waitei* in Mangalore were  $L_\infty = 122$  mm and  $K = 1.1$  yr<sup>-1</sup>, which showed higher results than our study (Rohit and Gupta 2008). The determination of mortality rate was then measured to support our assumption of the growth of *S. waitei*. The total mortality ( $Z$ ), natural mortality ( $F$ ), and catch mortality ( $M$ ) of *S. waitei* were 0.64, 1.39, and 0.75 yr<sup>-1</sup> respectively, which is lower than previous study (Luther et al. 1992; Rohit and Gupta 2008). In an ideal exploited stock, catch mortality and natural mortality should be equal to yield an exploitation rate of 0.5 (Gulland 1983).



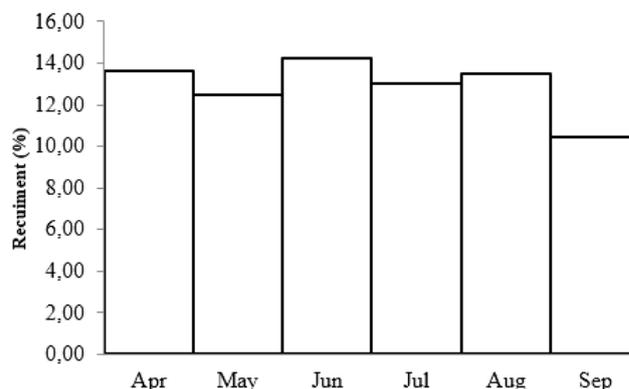
**Figure 3.** Relative condition factor ( $K_n$ ) of *Stolephorus waitei* during the study period



**Figure 4.** Length frequency distribution of *Stolephorus waitei* in monthly variation



**Figure 5.** Growth curve of *Stolephorus waitei* in the study area based on von Bertalanffy model



**Figure 6.** Recruitment pattern of *Stolephorus waitei* in the waters of Strait of Malacca from January to December 2020

However, the lower  $Z$  than  $F$  value indicates that the fishing activities by the fishermen are still considered as normal without any threats to the population decline. Different from our result, the Indian anchovy (*S. indicus*) in the Inner Ambon Bay experienced massive overfishing and exploitation leading to high mortality (Ongkers 2008). High natural mortality ( $F$ ) of a fish population in nature may be explained as the constant transfer of mass and energy of a population in an aquatic food web following the ecosystem consequences to prolong the successive future generations (Jorgensen and Holt 2013). The addition of new individuals or recruitment is closely related to population stability and sustainability in nature. The unimodal recruitment and wide distribution pattern for *S. waitei* were observed from its peak in June by 14.21% with a flat curve from April to August (Figure 6).

*Stolephorus waitei* population in the waters of the Strait of Malacca, North Sumatra was then categorized in a considerably high  $K$  value of population recruitment, showing a good and stable growth condition, and revealing future prospects for aquaculture. Therefore, it is suggested that the fishing activities should be controlled and maintained during the spawning period of *S. waitei* to achieve the sustainability of the population in the future.

#### ACKNOWLEDGEMENTS

This research was funded by Ministry of Research Technology and Higher Education, Republic of Indonesia under the scheme of DRPM Research Grant (Contract number 1140A/UN5.1.R/PPM/2018).

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