



**Some biological aspects of Indian mackerel (*Rastrelliger kanagurta* Cuvier, 1816)
in Bali Strait waters**

I Nyoman Yoga Parawangsa^{1,*}, Prawira Atmaja Tampubolon²

¹Program Study of Aquatic Resources Management, Faculty of Agriculture, Warmadewa University
Jalan Terompong No. 24, Denpasar Bali, 80239, Indonesia

²Fisheries Research Center, National Research and Innovation Agency
Jalan Raya Jakarta-Bogor, Pakansari, Cibinong, Bogor, Jawa Barat, 16915, Indonesia

* Corresponding author: inymyparawangsa@gmail.com

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ABSTRACT

Indian mackerel (*Rastrelliger kanagurta* Cuvier, 1816) is a small pelagic fish species which is the main catch commodity in purse seiner and gillnetter in the Bali Strait waters. Sustainable management is urgently needed for Indian mackerel populations in Bali Strait waters to remain sustainable fishery. The availability of basic information such as biological aspects is very important as a fundamental resource in the management of Indian mackerel in Bali Strait waters. The aim of this study was to reveal several biological aspects of mackerel such as growth patterns, condition factors, sex ratio, and size at first maturity of Indian mackerel in Bali Strait waters. Sampling was carried out in May-September 2018. Samples of fish were taken from purse seiner and gillnetter. Fish sample was measured, weighed and dissected to observe the sex and the gonadal maturity stage. The total number of Indian mackerel samples was 167 individuals. Mackerel in the Bali Strait waters has a positive allometric growth pattern with fish in good condition. The sex ratio was in an unbalanced condition with the number of male fish being more than the female fish. The size at first maturity was 19.34 cm for male fish and 19.76 cm for female fish.

Keywords: good condition, Indian mackerel, positive allometric, unbalanced.

ABSTRAK

Ikan kembung (*Rastrelliger kanagurta* Cuvier, 1816) merupakan salah satu spesies ikan pelagis kecil yang menjadi komoditi tangkapan unggulan pada armada purse seine dan jukung di perairan Selat Bali. Pengelolaan yang berkelanjutan tentunya dibutuhkan untuk populasi ikan kembung di perairan Selat Bali agar tetap lestari. Tersedianya informasi mendasar seperti aspek biologis sangat penting sebagai data mendasar dalam pengelolaan ikan kembung di perairan Selat Bali. Tujuan dari penelitian ini adalah untuk mengungkapkan beberapa aspek biologis ikan kembung seperti, pola pertumbuhan, faktor kondisi, nisbah kelamin, dan ukuran kali pertama matang gonad ikan kembung di perairan Selat Bali. Pengambilan contoh ikan kembung dilaksanakan pada bulan Mei-September 2018. Contoh ikan diambil dari armada purse seine dan jukung yang menggunakan pukat cicin dan jaring insang. Setiap contoh ikan diukur, ditimbang dan dibedah untuk pengamatan jenis kelamin dan tingkat kematangan gonadnya. Jumlah total sampel ikan kembung adalah 167 ekor. Ikan kembung di perairan Selat Bali memiliki pola pertumbuhan allometrik positif dengan kondisi ikan berada dalam kondisi baik. Nisbah kelamin berada dalam kondisi tidak seimbang dengan jumlah ikan jantan lebih banyak daripada ikan betina. Ukuran kali pertama matang gonad adalah 19,34 cm untuk ikan jantan dan 19,76 cm untuk ikan betina.

Kata kunci: allometrik positif, ikan kembung, kondisi baik, tidak seimbang

1. Introduction

The Bali Straits waters is one of the ecosystems that has fish resources, especially small pelagic fish such as Bali sardinella (*Sardinella*

lemuru), scad fish (*Decapterus* spp.) and Indian mackerel (*Rastrelliger kanagurta*) which has been used intensively since 70's (Suniada & Susilo 2017). Indian mackerel is a small pelagic fish which is the main catch commodity in the Bali

Strait waters. The habitat of this fish is in the waters near the coast (neritic) and it is widely distributed in the central part of the Indo-Pacific (Utami et al. 2014; Saputra & Taufani 2021). These fish species in the Bali Strait are generally caught using purse seines and gill nets. Purse seines and gill nets are quite effective and selective fishing gear for catching fish (Aprilla et al. 2013; Wijayanti et al. 2021; Dharmawan et al. 2022).

Stock-based fisheries management requires information from various biological aspects (Susanti et al. 2019). One aspect that is important to know is morphoregression which includes the length-length relationship, the length-weight relationship and the condition factor of the fish. The length-length relationship and the length-weight relationship will provide an overview of the morphometry. That is important to know in the management of fisheries resources (Alam et al. 2013; Mahmoudi et al. 2014) in determining length measurement and standardizing length size characters in comparative studies of growth in different habitats (Kazemi et al. 2013; Parawangsa et al. 2021). Meanwhile, the fish condition factor indicates the condition of fish welfare in the habitat that supports its life (Ahmad et al. 2012; Ujjania et al. 2012; Gubiani, 2020). Sex ratio is the ratio between male and female fish that are ready to spawn (Maskill et al. 2017). Sex ratio can affect spawning success in fish (Weir 2013). The size of the first gonad maturity is important information in managing capture fisheries to avoid overfishing (Nunes et al. 2020).

Information regarding various aspects of Indian mackerel has been widely published. The reproductive biology of Indian mackerel has been published by (Kasmi et al. 2017; Susanti et al. 2019; Sudarno et al. 2020), utilization of Indian mackerel resources (Telleng, 2010; Aminah, 2011; Aprilia et al. 2021), gut content (Utami et al. 2014), Indian mackerel fishing gear selectivity (Tambunan, 2010), fishing grounds during the transitional season (Tarigan et al. 2020), exploitation rate (Faizun et al. 2021), biological aspect (Arrafi et al. 2016), growth and reproduction (Nasution et al. 2015), gonad maturity stage (Oktaviani et al. 2014), Indian mackerel stock indicator (Lubis et al. 2021), population parameters and bio-exploitation of Indian mackerel (Oktaviani et al. 2019), morphometric character (Roonjha et al. 2019; Hakim et al. 2020) and sustainable Indian mackerel population management (Bunyamin et al. 2016).

Although information regarding various aspects of mackerel has been published, information on mackerel in the waters of the Bali Strait has yet to be found. Basic information related to the biological aspects of mackerel in the Bali Strait waters is very important. This information can be used as a basis for management of this fish species which is one of the most important catchment commodities in the Bali Strait fisheries. The aims of this study were to reveal several biological aspects of mackerel such as growth patterns, condition factors, sex ratio, and size at first maturity of Indian mackerel in the Bali Strait waters.

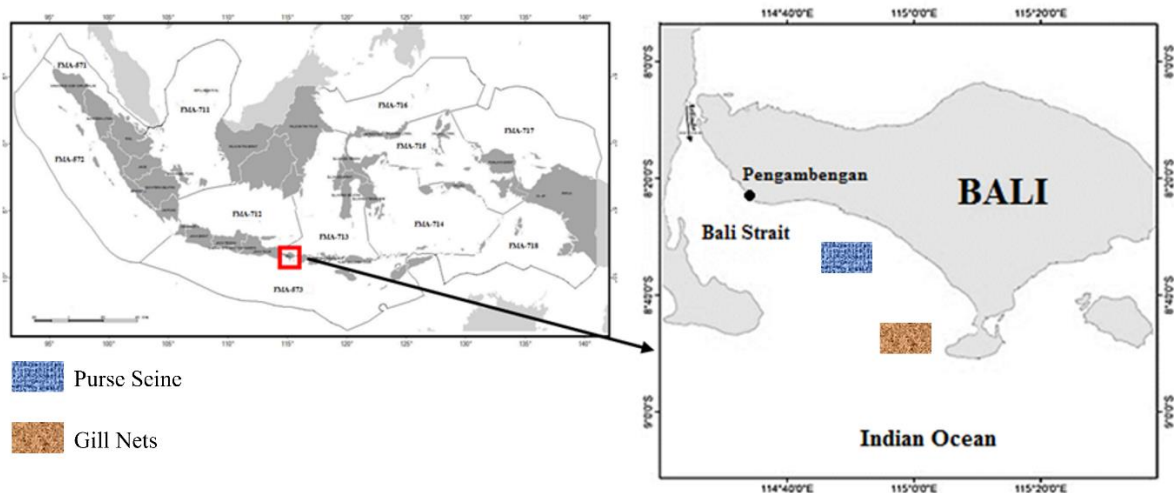


Figure 1. Locations for fishing ground of Indian mackerel with purse seiner and *jukung* fleets using gill nets in the Bali Strait waters.

2. Material and methods

Indian mackerel sampling was carried out in May - September 2018. Fish samples were taken 167 individuals from purse seine and *jukung* fleets in the Bali Strait waters which were then landed at Pengembangan Nusantara Fisheries Ports (Figure 1).

Each fish sample was measured for total length, fork length and standard length (Figure 2) using a ruler with an accuracy of 1 mm and weighed using a digital balance series ACIS Digital Compact Balance BC Series BC-5000 with an accuracy of 0.1 g. After being measured, each sample of indian mackerel was dissected to observe its sex and gonadal maturity stage. Data analysis was carried out on length-length relationship, length-weight relationship, condition factor, sex ratio and size at first maturity. The length-weight relationship was analyzed using the equation:

$$W = aL^b,$$

where W: weight (g); a dan b: regression constant (intercept and slope) length-weight; L: length of fish (mm).

The value of the regression constant b will describe the pattern of fish growth. The value $b=3$, describes the isometric growth pattern, and if the value $b \neq 3$, then the growth pattern is allometric. Fish conditions were analyzed with the condition factor equation as follows:

$$K = \frac{(100.000 \times W)}{L^3}$$

where K: condition factor; W: weighted weight (g); L: length of fish (mm).

The sex ratio of mackerel is calculated by comparing the number of male fish divided by the number of female fish. The size at first gonadal maturity was defined as the size for which 50% of the individuals in the sample size were at the gonadal maturity stage. This value was determined using a logistic model by adjusting the fraction of mature fish to the length of the interval using the nonlinear least squares regression method (King, 2007).

3. Results

The total number of mackerel samples were 167 individuals. The fork length size class of mackerel for gill nets ranges from 80 to 9 mm to 240 to 249 mm, while for purse seine gear it ranges from 200 to 209 mm to 260 to 269 mm. The size of mackerel caught in purse seines was smaller than that caught in gill nets (Figure 3). The most common fork length classes caught by purse seine and gill nets are 130 to 139 mm and 230 to 239 mm.

Analysis of the relationship between length characters found that the fork length-total length relationship had the highest closeness (Figure 4). Based on these results it was also found that the fork length character was the most precise length character in estimating Indian mackerel weight. The growth pattern of mackerel in the Bali Strait waters is positive allometric ($b > 3$) which indicates the rate of weight gain is faster than the rate of growth in body length.

Table 1 displays the value of the condition factor of Indian mackerel in the Bali Strait waters. Indian mackerel condition factor values ranged from 0.86 to 1.15. The highest value was found in

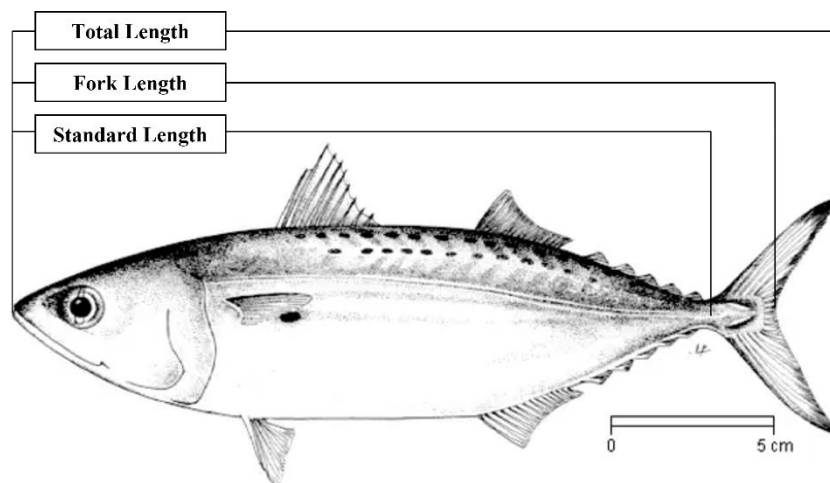


Figure 2. Measurement of total length, fork length and standard length of Indian mackerel in Bali Strait waters that landed at Pengembangan Nusantara Fisheries Ports (Picture modified form Khandaker et al. 2015)

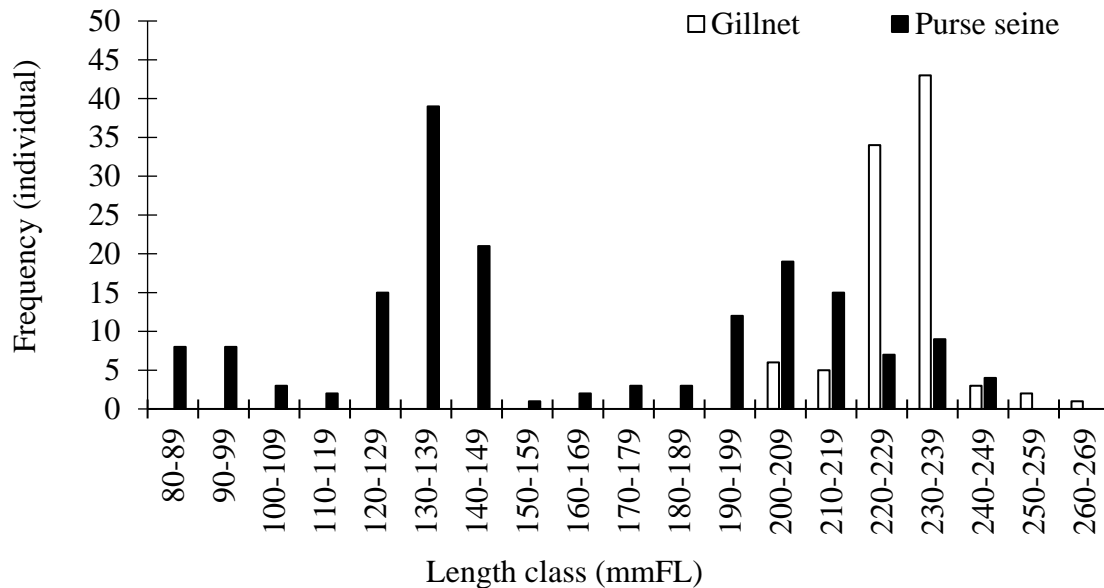


Figure 3. Length distribution of Indian mackerel caught using purse seines and gill nets in Bali Strait waters that landed at Pengambangan Nusantara Fisheries Ports.

Table 1. The value of factor condition of Indian mackerel in Bali Strait waters that landed at Pengambangan Nusantara Fisheries Ports during May – September 2018

Month	n	Condition factor	
		Range	Average
May	15	0.90 – 1.11	0.98
June	7	0.86 – 0.98	0.93
July	78	0.93 – 1.13	1.02
August	45	0.90 – 1.15	1.00
September	22	0.88 – 1.04	0.99

August and the lowest value was found in June. Based on the stage of gonadal maturity, the condition factor value of Indian mackerel increases with increasing gonadal maturity of indian mackerel (Table 2).

From 167 individuals, the number of male Indian mackerel (121 individual) was more than the number of female Indian mackerel (46 individual) for each of gonadal maturity stage (Figure 5). The sex ratio of Indian mackerel was

2.63:1.00. The size at first maturity for male and female mackerel was 19.34 cm and 19.76 cm (Figure 6).

4. Discussions

The waters of the Bali Strait are included in the 573 State Fisheries Management Area of the Republic of Indonesia which has high fishery productivity (Harlyan et al. 2022a). The Bali Strait fishery is very famous for its species *Sardinella*

Table 2. The value of condition factor of Indian mackerel in Bali Strait water that landed at Pengambangan Nusantara Fisheries Ports based on gonad maturity stage

Gonad maturity stage	n	Condition factor	
		Range	Average
I	6	0.91 – 1.01	0.96
II	9	0.88 – 1.11	0.95
III	25	0.86 – 1.08	0.99
IV	100	0.93 – 1.15	1.01
V	27	0.90 – 1.11	1.00

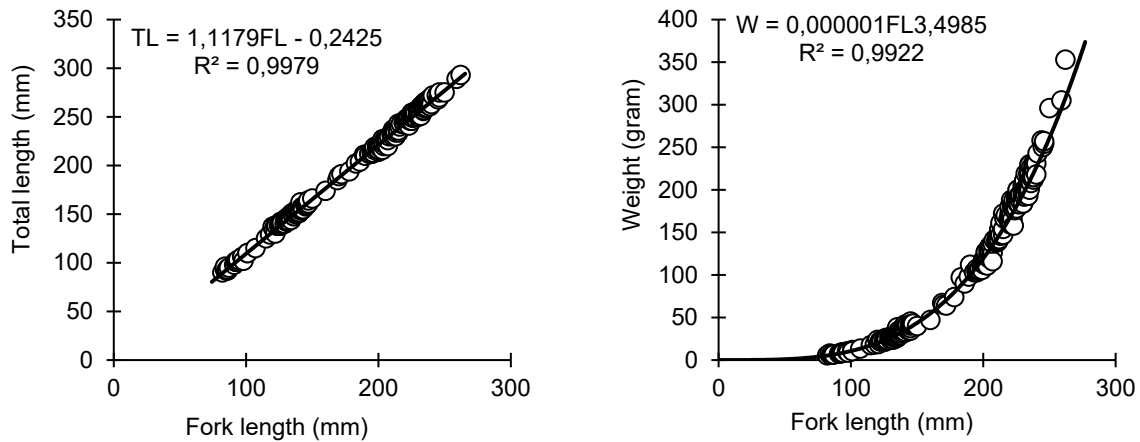


Figure 4. The fork length-total length relationship (left) and the length-weight relationship (right) of Indian mackerel that landed at Pengambangan Nusantara Fisheries Ports

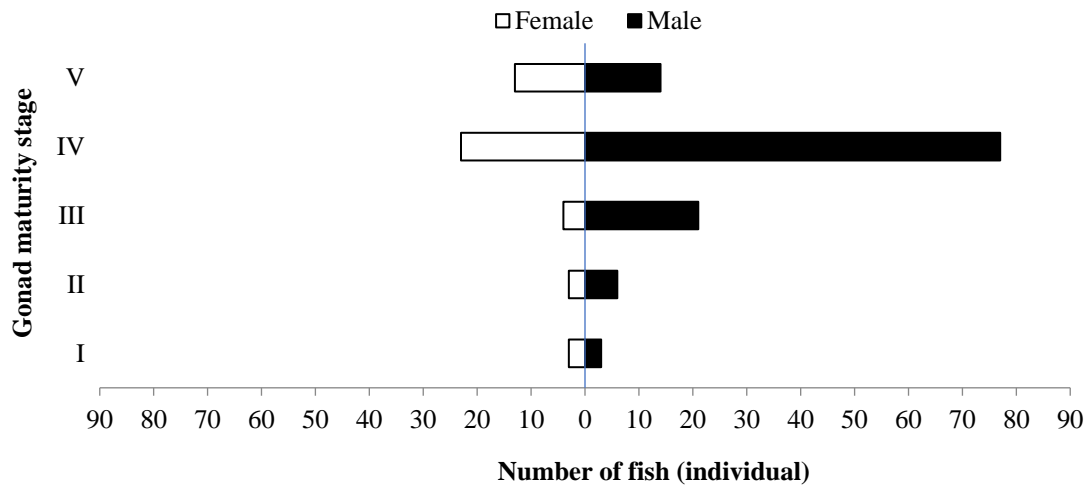


Figure 5. Sex ratio based on gonad maturity stage of indian mackerel in Bali Strait waters that landed at Pengambangan Nusantara Fisheries Ports

lemuru (Jatisworo et al. 2022), however, there are several types of small pelagic fish which are also superior catches besides *lemuru* such as scad fish, mackerel, and tuna (Harlyan et al. 2022b). Indian mackerel is a small pelagic fish that has a distribution area near the coast and it is found in almost all Indonesian waters because it has a wide migratory ability (Bunyamin et al. 2016; Susanti et al. 2019).

The length of Indian mackerel in the Bali Strait waters caught using purse seines ranges from 82 to 246 mmFL and weighs between 5.54 to 258.00 grams, while those caught in gill nets are larger, between 200 to 262 mmFL with a weight of 114.00 to 353.00 grams. It is suspected that the mesh size for gill nets is larger, namely

2.5 inches, while the mesh size for purse seines is $\frac{3}{4}$ –1 inch. Similar fishing gear is also used by fishermen in Sunda Strait waters to catch Indian mackerel (Tarigan et al. 2020). Both of fishing gears are indeed very effective in catching Indian mackerel which have aggregation characteristics, however, gill nets are a selective fishing gear (Lisna et al. 2018) while purse seine is a non-selective fishing gear (Sipahutar et al. 2022).

Based on the analysis of the length-weight relationship, mackerel in the Bali Strait has a positive allometric growth pattern. Aisyah et al. (2017) states that the allometric growth pattern is only temporary. In line with its growth pattern, the condition of Indian mackerel in the Bali Strait waters was in good condition. These conditions

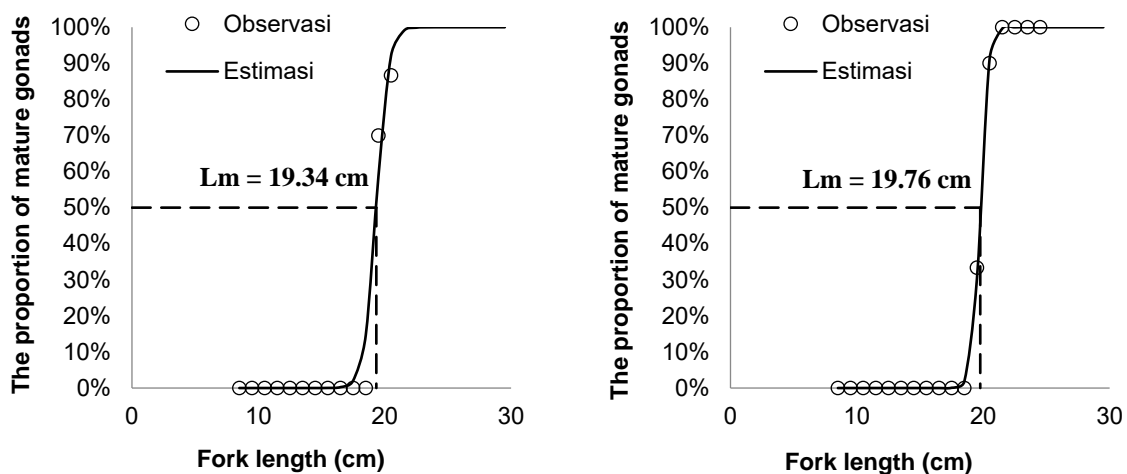


Figure 6. The length maturity of male Indian mackerel (left) and female indian mackerel (right) in Bali Strait waters that landed at Pengambangan Nusantara Fisheries Ports

indicate that the Bali Strait waters are suitable habitats and can support the life of Indian mackerel. The growth patterns and conditions of mackerel in several other habitats are presented in Table 3.

The differences in fish growth patterns can be influenced by several factors, such as the geographical location of the waters (Caesario et

al. 2022), season (Hulkoti et al. 2013), fishing gear (Liang et al. 2014), and fullness of gut content (Arrafi et al. 2016). In some fish species, the type of body is also a factor that can affect growth patterns, but this factor does not seem to affect growth patterns in Indian mackerel (Table 3). Condition factors can provide an overview regarding fish welfare and fish compatibility with

Table 3. Growth pattern and condition of indian mackerel in others ecosystem

No.	Location	Sex	Growth pattern	Value of condition factor	Reference
1.	Bali Strait waters	Pooled	Allometric (+)	0.86 – 1.15	This research
2.	Sorong waters	Pooled	Allometric (–)	–	Suruwaky & Gunaisah 2013
3.	South Coast of Maharashtra, India	Male	Allometric (+)	–	Brendarkar et al. 2014
4.	Suez Bay, Mesir	Female	Allometric (+)	–	Amin et al. 2015
		Male	Allometric (+)	–	
5.	PPN Pelabuhan Ratu	Female	Allometric (+)	–	Nasution et al. 2015
6.	West Aceh waters	Pooled	Allometric (+)	0.92 – 1.45	Arrafi et al. 2016
7.	Lombok Strait	Male	Allometric (–)	–	Bunyamin et al. 2016
		Female	Allometric (–)	–	
8.	Mayalibit Bay, Raja Ampat	Male	Allometric (+)	0.90 – 1.96	Oktaviani et al. 2019
		Female	Allometric (+)	1.01 – 1.90	
9.	East Coast of Biak	Male	Allometric (–)	0.10 – 1.75	Marasabessy 2020
		Female	Allometric (–)	0.03 – 2.28	
10.	PPP Tasikagung Rembang	Pooled	Isometric	–	Faizun et al. 2021
11.	North Coast of Java	Pooled	Allometric (+)	1.10	Saputra & Taufani 2021
12.	PPP Labuan Banten	Male	Allometric (–)	–	Sari et al. 2022
		Female	Allometric (–)	–	
13.	PPP Lempasing, Lampung	Pooled	Allometric (–)	0.93 – 1.14	Caesario et al. 2022
14.	Serdang Berdagai, North Sumatera	Male	Allometric (–)	0.61 – 1.30	Hasibuan et al. 2022
		Female	Allometric (–)	0.48 – 2.21	

their habitat (Gubiani et al. 2020). Fish condition factors can be influenced by the season (Oktaviani et al. 2019), oceanographic conditions (Suniada & Susilo 2017), and gonad maturity stage (Rachmanto et al. 2020). In this study, it was found that the average value of the condition factor for mackerel was in the mature stage (III & IV) higher when compared to mackerel in the immature stage (I, II, & V). Indian mackerel has been known to have good condition factor values in several aquatic ecosystems, including in the Bali Strait waters. This indicates that Indian mackerel has a good adaptation pattern and compatibility with many aquatic ecosystems.

The sex ratio is one of the important information in the management of proportional capture fisheries in order to ensure the sustainability of the population (Jega et al. 2017). The sex ratio of Indian mackerel in the Bali Strait waters was in an unbalanced condition. An unbalanced sex ratio was also found in Indian mackerel populations in Demak waters (Rachmanto et al. 2020) and in Madura Strait waters (Susanti et al. 2019). The different conditions were found in Indian mackerel populations in Serdang Bedagai waters, North Sumatera (Hasibuan et al. 2022). The sex ratio of small pelagic fish is strongly influenced by pressure on habitat and food availability (Rachmanto et al. 2020). When food resources are available in sufficient quantities and environmental pressures are low, the sex ratio will be balanced. The sex ratio of fish can fluctuate, especially during the phase before and during spawning (Susanti et al. 2019). When the fish are swarming to spawn, generally the number of male fish will be more, then it will be balanced during spawning and followed by the number of female fish that will dominate thereafter (Sulistiono et al. 2001; Zamroni & Suwarso 2011).

Indian mackerel fish caught in the Bali Strait waters are dominated by mature fish. The size of the first gonad maturity of Indian mackerel in the Bali Strait waters was 19,34 cmFL for male and 19,76 cmFL for female. This size is shorter than the Indian mackerel population in Aru waters (Fauzi et al. 2020), Coast of Takalar, South Sulawesi (Kasmi et al. 2017), Mayalibit Bay, Raja Ampat (Oktaviani et al. 2014), and Coast of North Java (Saputra & Taufani 2021). However, it is longer than the Indian mackerel that lives in Sunda Strait waters (Lubis et al. 2019). Rachmanto et al. (2020) states that fish populations that are under high fishing pressure will respond by maturing their gonads quickly at small fish sizes. This condition is an adaptation of fish so that the population can return to balance

(Zamroni & Ernawati 2019). The differences in size at first maturity can also be influenced by oceanographic conditions (Ghosh et al. 2016), especially water temperature (Karna & Panda 2011).

The management of mackerel based on a biological aspect approach in the waters of the Bali Strait waters must be started. So far, capture fisheries in the waters of the Bali Strait have only focused on single species. This of course has an unfavorable impact on other fish commodities. Indian mackerel resources in the Bali Strait waters have very good potential (Zulbainarni et al. 2011). The management of this fish species should start to become a concern for fisheries stakeholders in the Bali Strait waters, especially the fishing gear used. Purse seine is known to catch more Indian mackerel which is below the size at first maturity. This of course will have a negative impact on the Indian mackerel population. Gill nets with mesh sizes that have been used by fishermen in the Bali Strait waters is more recommended because they are more selective.

5. Conclusions

Indian mackerel in the Bali Strait waters caught in purse seines are smaller in size than those caught in gill nets. This fish species has a positive allometric growth pattern under good conditions. The sex ratio of Indian mackerel is in an unbalanced condition with the number of male fish being more than the female fish. The size of the first gonadal maturity for male and female fish is 19.34 cmFL dan 19.76 cmFL. Special attention is needed for the management of Indian mackerel in the Bali Strait waters because catches are found that are below the size at first maturity, especially in fishing fleets using purse seine

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