HAYATI
Journal of Biosciences

Vol. 32 No. 5, September 2025 1185-1198
DOI:10.4308/hjb.32.5.1185-1198
ISSN: 1978-3019
EISSN: 2086-4094

Research Article

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Juvenile Fish Composition and Their Growth Aspects on the East Coast of Banyuwangi, Bali Strait

Muhammad Faris Nazal[1], Charles P.H. Simanjuntak[2*], Jonson Lumban-Gaol[3], Fery Kurniawan[2], William W.L. Cheung[4], Gabriel Reygondeau[4], Lydia Teh[4], Ni Putu Asri Ratna Suhita[3]

[1]*Study Program of Aquatic Resources Management, Graduate School of IPB University, Bogor 16680, Indonesia*
[2]*Department of Aquatic Resources Management, Faculty of Fisheries and Marine Sciences, IPB University, Bogor 16680, Indonesia*
[3]*Department of Marine Science and Technology, Faculty of Fisheries and Marine Science, IPB University, Bogor 16680, Indonesia*
[4]*Institute for the Oceans and Fisheries, The University of British Columbia, Canada*

ARTICLE INFO

Article history:
Received January 24, 2025
Received in revised form March 27, 2025
Accepted April 15, 2025

KEYWORDS:
Bali Strait,
condition factor,
fish juvenile,
growth pattern,
small pelagic fish

ABSTRACT

The east coast of Banyuwangi, Bali Strait, has the potential to function as a nursery area for juvenile fish. Therefore, it is essential to research the ecology of juvenile fish resources. This study aimed to uncover the composition of juvenile fishes and their growth aspects through length-weight relationships and condition factors. We collected 9748 fish specimens from floating lift nets during April, September, December 2023, and February 2024. Identification and morphometric analysis were conducted to calculate fish juvenile assemblage composition, growth patterns from length-weight relationships, and condition factors. The study found 48 species from 26 families and 17 orders. The small pelagic fish group was the most common, including species from the Carangidae, Dorosomatidae, Spratelloididae, Engraulidae, Atherinidae, and Scombridae families in terms of the number of individuals and overall biomass. The fish growth on the east coast of Banyuwangi is optimal, with most fish species exhibiting positive allometric and isometric growth patterns. The overall condition factor of the juvenile fish is above 1.00, indicating that the health of fish resources is good. This suggests that the east coast of Banyuwangi, Bali Strait, can support the growth of fish juveniles and maintain the sustainability of fish resources.

1. Introduction

The Bali Strait is an important region in Indonesia. Its oceanographic characteristics are unique, as it is the meeting point of two oceans: the Indian Ocean to the south and the Bali Sea to the north (Wijaya *et al*. 2020). Bali Strait waters contribute substantial socio-economic benefits to Java and Bali through shipping and fisheries (Sah'ro *et al*. 2023). The Bali Strait is part of the Indonesian Fisheries Management Area (FMA) 573, which has high fisheries production potential (Harlyan *et al*. 2022a; Harlyan *et al*. 2022b). In the Bali Strait, 50 extant species from 26 families have been recorded, with the dominant species belonging to Clupeidae, Carangidae, and Scombridae (Pertami *et al*. 2022). Small pelagic fishes are the main catch in the Bali Strait and FMA 573 with a potential value of 624.336 tons/year based on the Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 19 of 2022. The principal catches consist of high-value pelagic fish such as Bali

* Corresponding Author
E-mail Address: charles_phs@apps.ipb.ac.id

sardinella (*Sardinella lemuru*), frigate tuna (*Auxis thazard*), Indian mackerel (*Rastrelliger kanagurta*), and mackerel scad (*Decapterus* spp.) (Andriyono 2018; Sartimbul *et al*. 2018).

The main fisheries activity sites in the Bali Strait are located at the Muncar Coastal Fishing Port, Banyuwangi, and the Pengambengan Fishing Port, Jembrana (Satyawan *et al*. 2023). Muncar, located in Banyuwangi Regency, East Java, is a pivotal fisheries area in Java for catching, landing, and trading catches (Simbolon *et al*. 2017; Warren and Steenbergen 2021). Fishing activities in Muncar, Banyuwangi, are known to use multi-fishing gears such as purse seines, mine purse seines, seine nets, drift gillnets, and lift nets (Ihsan *et al*. 2020). Purse seine (locally known as "slerek") is the main gear operated by many Muncar and Bali Strait fishermen to catch economically important pelagic fish (Puspasari *et al*. 2019). In parallel to active fishing gear, lift net, a passive fishing gear, is widely operated in the eastern part of Banyuwangi. The fixed lift net is concentrated in the waters of Pangpang Bay, while the floating lift net is scattered around Biru Bay (Senggrong Bay) and its north coast (Sukresno *et al*. 2021). The catches by different gears vary substantially by species, with floating lift net catching mainly mackerel scad, anchovy, Bali sardinella, toothpony fish, and squid, particularly those that are small in size and immature stages (Aliyubi *et al*. 2015; Khumaera *et al*. 2019). The high proportion of young fish found in eastern Java waters indicates the region's importance as a nursery area for fish in the Bali Strait.

Fishing, however, is exerting pressure on the sustainability of fish resources in the eastern coastal waters of Java, where lift net fisheries are located. Coastal waters along the east coast of Java to the west of Bali have the potential to be a nursery ground for fish juveniles based on the suitability of oceanographic factors, migratory activities of fish schools, and the number of young fish caught by lift nets in Biru Bay (Sambah *et al*. 2012; Syahputra *et al*. 2016). Nursery areas are essential for the long-term sustainability of fish stocks, evidenced by the presence of juvenile fisheries' target species (Mattone *et al*. 2022). However, fisheries activities for landings in Muncar, including the lift nets fishery, have increased since 2005 and fluctuated from 2013 to 2020s (Sukresno *et al*. 2021), increasing pressures on the exploited populations, community structure, and ecosystem functions (Pertami *et al*. 2018). Fishing in the nursery area can affect the recruitment of exploited populations, which are characterized by declining age structure and stock size (Somarakis *et al*. 2019).

New knowledge about fish resources in the Bali Strait is needed to support the sustainability of fisheries. Understanding fish growth is an instrument for fish biology research and fisheries management (Mehanna and Farouk 2021; Sheraliev *et al*. 2022; Li *et al*. 2023). Length-weight relationship analysis helps determine fish growth conditions at each life history stage, comparing fish growth between areas and complementary in studying reproduction and feeding habits (Froese *et al*. 2011; Falsone *et al*. 2022). For example, estimating condition factors can indicate fish's general health, well-being, and fitness (Cavraro *et al*. 2019) based on their condition or “fatness” relative to their length. It can reflect the nutritional health of fish, with higher values (high weight for its length) generally indicating good condition (Froese 2006; Azrita *et al*. 2024). The condition factor is mainly used to assess the health status of individual fish or fish populations as a biometric tool in fish ecology (Vuić *et al*. 2024).

Growth aspects of fish resources in the Bali Strait have been poorly studied only in essential species such as Bali sardinella, *Sardinella lemuru* (Aprianti *et al*. 2024), scad (*Decapterus* spp.) (Bintoro *et al*. 2021; Lelono *et al*. 2021; Tampubolon and Oh 2023), Indian mackerel, *Rastrelliger kanagurta* (Parawangsa and Tampubolon 2023), and bullet tuna, *Auxis rochei* (Bintoro *et al*. 2023). A comprehensive study of fish assemblages from growth and species composition has never been conducted on fish resources in these waters. This research is essential in elaborating basic information on the biology of fish resources in the Bali Strait waters. The study aimed to reveal fish juveniles' composition and growth patterns through length-weight relationships and condition factors.

2. Materials and Methods

2.1. Materials

Fish sampling was conducted using three floating lift nets in the eastern coastal waters of Banyuwangi, part of the Bali Strait. The dimensions of the floating lift net comprised a lift net size of 10×10 m^2 and a net frame size of 7×7 m^2 with a mesh size of approximately 3-5 mm in cuboid shape. The sampling took place overnight, from dusk until sunrise. A total of 9748 individuals were caught during the four months of sampling.

2.2. Methods

Data were collected over four months: April, September, December 2023, and February 2024 representing the east and west monsoon seasons. Sampling was conducted at night, following the operational schedule of the floating lift net gear, three times each month. The fish sampling location was in the western part of the Bali Strait, specifically in the eastern coastal waters of Banyuwangi, including Biru Bay (Banyu Biru) and its surrounding areas (see Figure 1). These waters are the fishing grounds of the floating lift net in the Bali Strait. Additionally, the fish samples were analyzed at the Macro Biology Laboratory, Department of Aquatic Resource Management, Faculty of Fisheries and Marine Science, IPB University.

Fresh specimens caught were immediately preserved in a 10% formalin-seawater solution for several hours. Subsequently, the fish samples were re-changed the preservation solution to ethanol 80%. Fish samples were rinsed in flowing freshwater to remove the formalin concentration and placed into sample bottles containing 80% ethanol (Simanjuntak *et al*. 2020). Fish samples were brought to the laboratory to be sorted and identified to the lowest taxa, specifically species, according to Carpenter and Niem (1998) and White *et al*. (2013). Fish morphometric characteristics such as total length were measured using a ruler (accuracy of 1 mm) and individual body weight using analytical digital balances (accuracy of 0.001 g).

2.3. Data Analysis

2.3.1. Fish Composition

The fish caught were counted in the number of individuals per species to calculate the fish species composition. Catch composition analysis was used to determine the proportion of fish assemblages caught, which were found at the research site each month. Fish species composition was calculated using the following formula (Odum 1971):

$$\text{Composition (\%)} = ni/N \times 100$$

Where:
Ni : Number of individuals from a species (i)
N : Total number of individuals from all species

2.3.2. Length-Weight Relationship

The growth patterns of the fish samples caught were analyzed using the length-weight relationship (LWR). The LWR calculations focused exclusively on the dominant fish species captured each month. The growth pattern of these fish species can be determined based on the b value, which represents the linear regression slope in the logarithmic form of the length-weight analysis

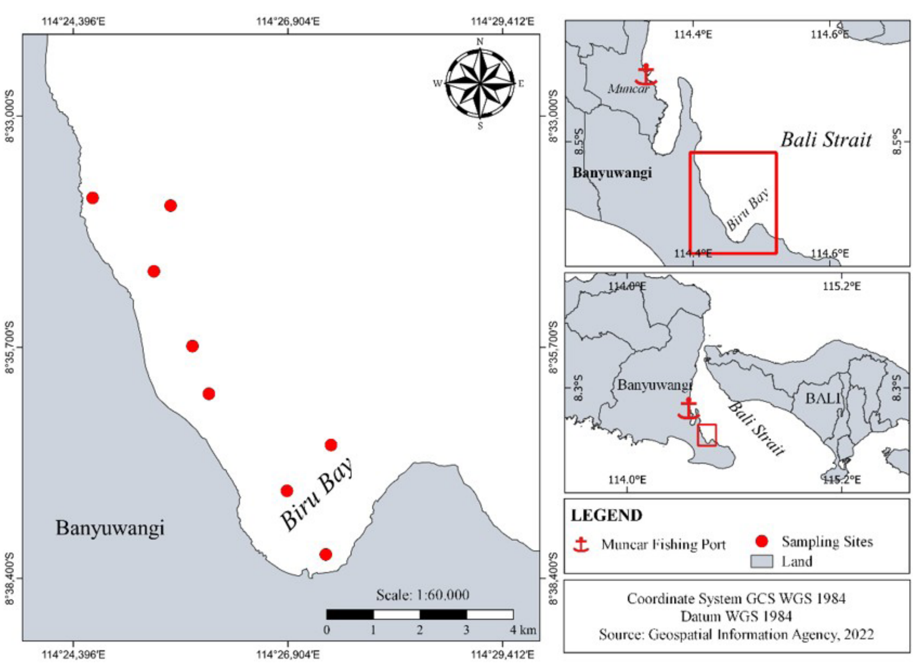

Figure 1. Fish sampling locations in the eastern coastal waters of Banyuwangi, Bali Strait

equation. The length-weight analysis calculation follows Keys (1928) and Froese (2006), outlined as follows:

$$W = aL^b$$

Where:
W : Body weight of individual fish (g)
L : Total length of fish (mm)
a : Intercept parameter
b : Slope parameter (logarithmic linear regression coefficient).

Fish growth is isometric if the value of b=3, allometric is positive if b>3, and allometric is negative if b<3.

A t-test is performed on the b value to verify the growth pattern. The null hypothesis value (H0: b=3, isometric) is compared against the alternative hypothesis (H1: b≠3, allometric) with a 95% confidence interval. If the value of t-test > t-table, then the decision is to reject H0, which means an allometric growth pattern, and vice versa. The equation for determining the t-test value is as follows:

$$t\text{-test} = (b-3) / S^b$$

Where:
b : Regression slope of the length-weight relationship (LWR)
Sb : Standard error of the b value.

2.3.3. Condition Factor

The calculation of the fish condition factor is determined based on its growth pattern. The fish condition factor in the isometric growth pattern refers to Fulton's condition factor formula. Fish condition factors in allometric growth patterns are determined by Le Cren (1951) Calculation of relative condition factors, as follows:

$$K = 10^5 / aL^b$$

$$K_{rel} = W / aL^b$$

Where:
K : Fulton condition factor
K_{rel} : Relative condition factor
W : Body weight of individual fish (g)
L : Total length of fish (mm)
a and b : LWR regression coefficient parameters.

3. Results

3.1. Juvenile Fish Composition

The fish samples caught during the study reached 9748 individuals, consisting of 48 species from 26 families and 17 orders (Supplementary Materials Table 1). Clupeiformes is the order with the highest taxa composition, composed of three families and 11 species. Meanwhile, Carangidae has the highest number of species, reaching seven species. The composition of fish taxa in each month changed over time. The lowest number of species and families was in September 2023, with 11 species from 9 families, while the highest was in February 2024, with 25 species from 15 families (Figure 2).

The leading fish families on Banyuwangi, Bali Strait's east coast, are primarily pelagic fishes,

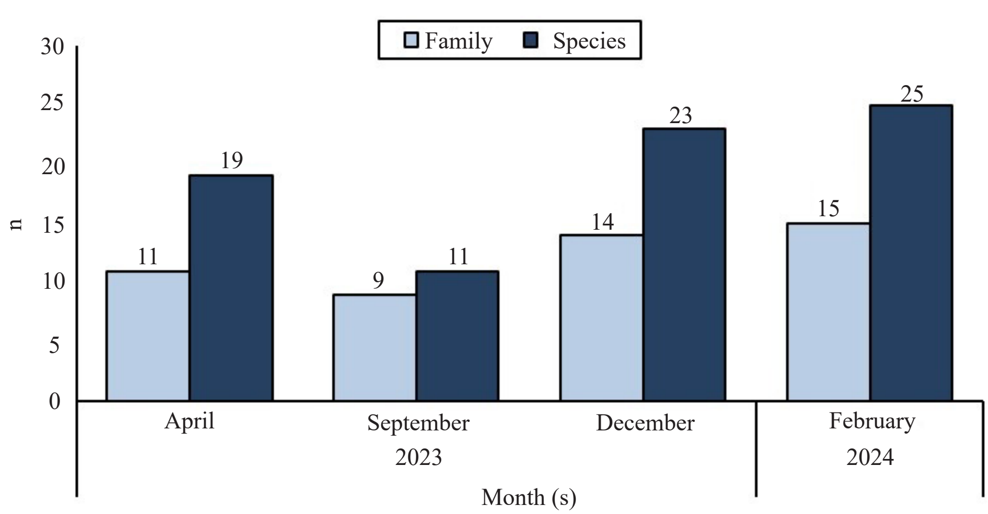

Figure 2. Monthly composition of juvenile fish assemblages on the east coast of Banyuwangi, Bali Strait

including Carangidae, Dorosomatidae, Engraulidae, and Spratelloididae (Figure 3). In April 2023, the Dorosomatidae family, specifically *Sardinella lemuru*, was the dominant family, constituting 79% of the catch biomass. In September 2023, most fish caught were from the Engraulidae and Spratelloididae families. In December 2023, the catch was dominated by the Carangidae and Spratelloididae. Moving to February 2024, the Carangidae and Dorosomatidae families represented the biomass caught, along with the addition of Scombridae, which began to be caught this month. The high abundance of the Carangidae family in February was due to the high numbers of *Megalaspis cordyla* and *Selar crumenophthalmus*, while Dorosomatidae was known from *Amblygaster sirm* and *Herklotsichthys quadrimaculatus*. The proportion of fish families caught based on the number of individuals shown in Figure 4 exhibited similar patterns. The dominant fish species, *Sardinella lemuru* (Dorosomatidae), was

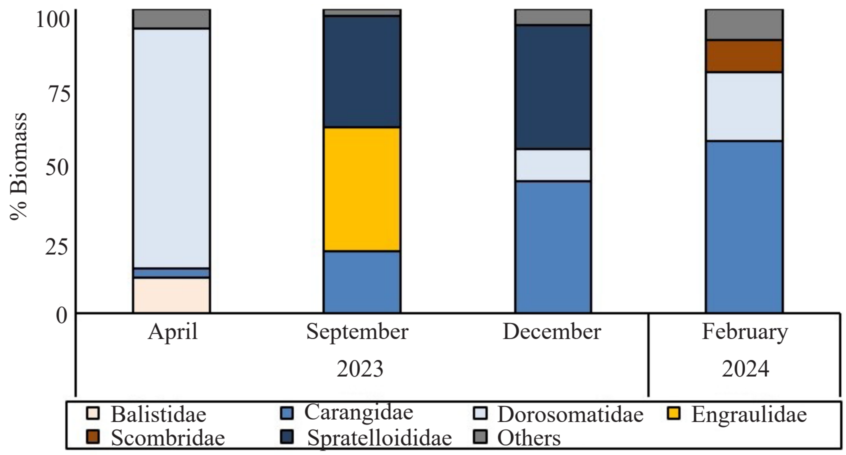

Figure 3. Biomass proportion of dominant families on the east coast of Banyuwangi, Bali Strait

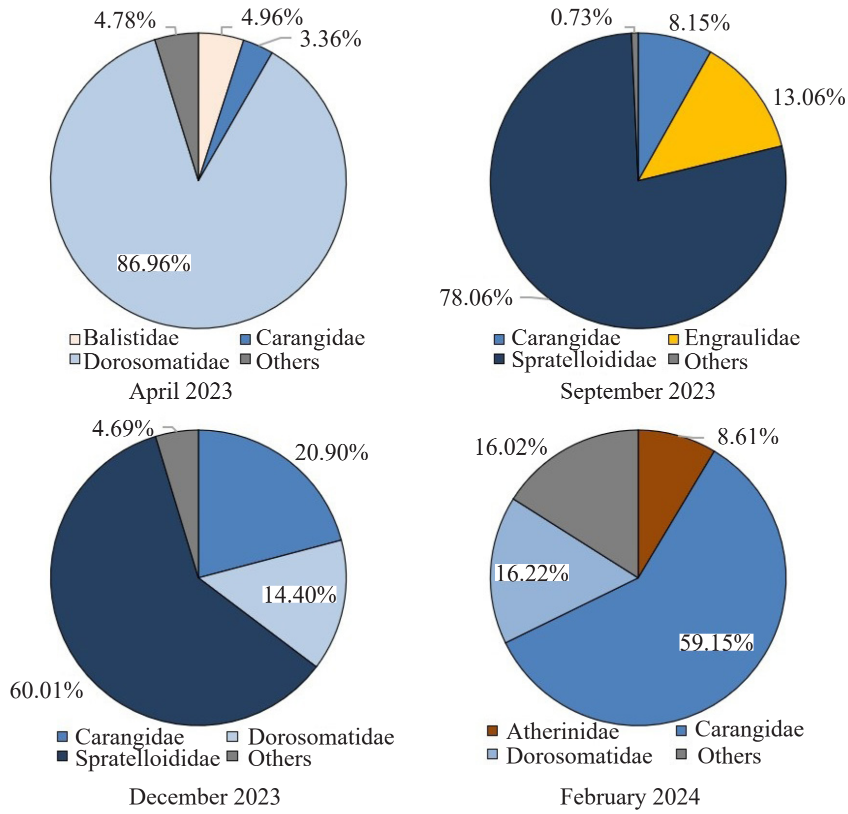

Figure 4. Individual proportion of dominant juvenile fish families on the east coast of Banyuwangi, Bali Strait

caught in large numbers, as was *Spratelloides delicatulus* (Spratelloididae) in September and December 2023.

3.2. Length-Weight Relationship

The growth pattern of fish based on the length-weight relationship in the dominant fish caught is detailed in Table 1 (April 2023), Table 2 (September 2023), Table 3 (December 2023), and Table 4 (February 2024). According to the T-test results, juvenile fishes in April 2023 exhibited more isometric growth patterns. Fish species such as *Pseudobalistes flavimarginatus* and *Thryssa encrasicholoides* showed isometric growth patterns, while *Sardinella lemuru* exhibited a positive allometric pattern. The results of the length-weight relationship analysis in September 2023 (Table 2) indicated that most fish caught had a positive allometric growth type. Specifically, some fish species, such as *Decapterus russelli* (Carangidae family) and *Sardinella lemuru* (Dorosomatidae family), had an isometric pattern.

The length-weight relationship for the most dominant fish species in December 2023 (Table 3) exhibited a growth pattern similar to that observed in April 2023, which was isometric. Some species showed positive allometric growth patterns, for example, *Amblygaster sirm* and *Decapterus macrosoma*, while others exhibited isometric growth patterns, such as *Selar crumenophthalmus* and *Spratelloides delicatulus*. In February 2024, the T-test results (Table 4) showed that fish growth patterns were

Table 1. Length-weight relationship of dominant fishes on the east coast of Banyuwangi, Bali Strait in April 2023

Species	a	b	t-test		Growth types
			t_{hit}	t_{tab}	
Pseudobalistes flavimarginatus	0.000085	2.7329	1.8200	2.5326	Isometric
Sardinella lemuru	0.000003	3.2339	3.8132	2.2753	Positive allometric
Thryssa encrasicholoides	0.000004	3.0736	0.3883	2.4899	Isometric

Table 2. Length-weight relationship of dominant fishes on the east coast of Banyuwangi, Bali Strait in September 2023

Species	a	b	t-test		Growth types
			t_{hit}	t_{tab}	
Decapterus macrosoma	0.000003	3.1340	2.3471	2.2586	Positive allometric
Decapterus russelli	0.000008	2.9842	0.5177	2.2515	Isometric
Encrasicholina punctifer	0.000001	3.3457	2.4784	2.2764	Positive allometric
Sardinella lemuru	0.000002	3.2941	2.2501	2.4581	Isometric
Spratelloides delicatulus	0.000003	3.2190	7.3406	2.2457	Positive allometric

Table 3. Length-weight relationship of dominant fishes on the east coast of Banyuwangi, Bali Strait in December 2023

Species	a	b	t-test		Growth types
			t_{hit}	t_{tab}	
Amblygaster sirm	0.000002	3.3120	6.5983	2.3337	Positive allometric
Decapterus macrosoma	0.000003	3.2226	3.1390	2.2929	Positive allometric
Decapterus russelli	0.000007	3.0434	0.8543	2.3313	Isometric
Herklotsichthys quadrimaculatus	0.000001	3.5639	8.5438	2.2638	Positive allometric
Selar crumenophthalmus	0.000005	3.1494	2.2220	2.2590	Isometric
Spratelloides delicatulus	0.000007	3.0054	0.1326	2.2711	Isometric
Upeneus sp.	0.000018	2.7516	1.6648	2.3391	Isometric

Table 4. Length-weight relationship of dominant fishes on the east coast of Banyuwangi, Bali Strait in February 2024

Species	a	b	t-test		Growth types
			t_{hit}	t_{tab}	
Doboatherina duodecimalis	0.000001	3.5030	10.3587	2.2795	Positive allometric
Herklotsichthys quadrimaculatus	0.000003	3.2162	8.6032	2.2582	Positive allometric
Megalaspis cordyla	0.000065	2.5944	9.4370	2.2506	Negative allometric
Rastrelliger kanagurta	0.000001	3.5800	4.6815	2.3172	Positive allometric
Selar boops	0.000003	3.2930	1.6553	2.3313	Isometric
Selar crumenophthalmus	0.000002	3.3863	10.5277	2.2620	Positive allometric
Spratelloides delicatulus	0.000012	2.8208	1.0920	2.2921	Isometric

mostly positive allometric. Juveniles of the Carangidae family, such as *Selar crumenophthalmus*, and Scombridae, such as *Rastrelliger kanagurta*, exhibited positive allometric growth. However, only one species displayed negative growth patterns, *Megalaspis cordyla*.

3.3. Condition Factor

Fish condition factors in the eastern waters of the Banyuwangi, Bali Strait are presented monthly in Table 5 (April 2023), Table 6 (September 2023), Table 7 (December 2023), and Table 8 (February 2024). Most species' average condition factor values were above 1.00 monthly, except for dominant fishes in December 2023. The highest mean fish condition factor was in February 2024, as shown by most species with condition factor values greater than 1.0025.

Table 5. Condition factor of dominant fishes on the east coast of Banyuwangi, Bali Strait in April 2023

Species	Condition factor	
	Range	Mean ± SD
Pseudobalistes flavimarginatus	0.8554-1.1580	3.1360 ± 0.1656
Sardinella lemuru	0.8316-1.3288	1.0041 ± 0.0920
Thryssa encrasicholoides	2.8357-3.4613	0.5507 ± 0.0981

Table 6. Condition factor of dominant fishes on the east coast of Banyuwangi, Bali Strait in September 2023

Species	Condition factor	
	Range	Mean ± SD
Decapterus macrosoma	0.6683-1.3556	1.0049 ± 0.0994
Decapterus russelli	0.6118-1.3339	0.7905 ± 0.0763
Encrasicholina punctifer	0.8280-1.2694	1.0038 ± 0.0883
Sardinella lemuru	0.5480-0.6673	0.6061 ± 0.0340
Spratelloides delicatulus	0.1061-3.9785	1.0153 ± 0.2117

Table 7. Condition factor of dominant fishes on the east coast of Banyuwangi, Bali Strait in December 2023

Species	Condition factor	
	Range	Mean ± SD
Amblygaster sirm	0.8405-1.1935	1.0019 ± 0.0626
Decapterus macrosoma	0.8683-1.0991	1.0011 ± 0.0458
Decapterus russelli	0.7927-1.1028	0.8864 ± 0.0534
Herklotsichthys quadrimaculatus	0.7190-1.8298	1.0085 ± 0.1342
Selar crumenophthalmus	0.6868-1.1765	0.9091 ± 0.0583
Spratelloides delicatulus	0.5611-1.1739	0.6889 ± 0.0674
Upeneus sp.	0.5642-1.0150	0.7796 ± 0.0990

Table 8. Condition factor of dominant fishes on the east coast of Banyuwangi, Bali Strait in February 2024

Species	Condition factor	
	Range	Mean ± SD
Doboatherina duodecimalis	0.7791-1.6027	1.0077 ± 0.1348
Herklotsichthys quadrimaculatus	0.6832-1.5502	1.0089 ± 0.1373
Megalaspis cordyla	0.4337-1.7313	1.0052 ± 0.1039
Rastrelliger kanagurta	0.8817-1.7461	1.0055 ± 0.1227
Selar boops	0.7813-1.1204	0.9645 ± 0.0742
Selar crumenophthalmus	0.7986-1.3596	1.0026 ± 0.0729
Spratelloides delicatulus	0.4811-1.0574	0.6427 ± 0.0824

4. Discussion

The number of species caught in this survey indicates a diversity of fish species in the Bali Strait. In previous research on the ichthyofauna in the Bali Strait on the southwest coast of Bali there were more species, up to 50 species from 26 families and 13 orders (Pertami *et al*. 2022). Some species were young fishes of commercially essential resources in the Bali Strait. This is related to the catches landed at the Muncar Port based on Lubis *et al*. (2013), which were 34 species, including economically important species such as Bali sardinella (*Sardinella lemuru*), mackerel scads (*Decapterus* spp.), Indian mackerel (R*astrelliger kanagurta*), and frigate tuna (*Auxis thazard*). The most economic fish species in Muncar is Bali sardinella (*Sardinella lemuru*), an essential catch species in the Bali Strait, with total production reaching 80-90% of the total pelagic fish catch. (Sartimbul *et al*. 2010; Wijaya *et al*. 2021). Another economic species is mackerel scads (*Decapterus* spp.), which also have high catch production in the Bali Strait (Lelono *et al*. 2021; Tampubolon and Oh 2023).

Fish assemblages in aquatic ecosystems often have temporal variations in species diversity due to seasonal differences related to variations in environmental parameter conditions (Sreekanth *et al*. 2016). Two fish species are observed in all sampled months: *Decapterus macrosoma* and *Decapterus russelli*. Both species belong to Carangidae, which contributed predominately to the pelagic fish catches in Bali Strait. Scad (*Decapterus* spp.) is an economically valuable fish caught throughout the year in the eastern waters of Java and the Bali Strait, indicating that these waters are essential habitats for scad (Bintoro *et al*. 2021; Lelono *et al*. 2021). Several species from the Clupeiformes, such as *Sardinella lemuru* and *Herklotsichthys quadrimaculatus* (Dorosomatidae), *Spratelloides delicatulus* (Spratelloididae), and fish from the Carangiformes order represented by *Selar boops* and *S. crumenophthalmus* (Carangidae), were observed almost every month. However, despite being commonly found in the waters of the Bali Strait, their presence was not consistently found at certain times.

Small pelagic fish such as sardines and anchovies support the majority of total fisheries catch, with energy flowing to top predators or harvested species at higher trophic levels (Pikitch *et al*. 2014). Small pelagic fish ecologically provide multiple roles, such as predator, prey, forage, and fisheries targets (Peck *et al*. 2021; Peck *et al*. 2024). The study of fish composition on the eastern coast of the Banyuwangi showed that Carangidae, Dorosomatidae, and Spratelloididae were the predominant fish species. Another study conducted by Syahputra *et al*. (2016) found that *Sardinella* spp., especially *S. lemuru*, comprised the highest proportion of fish caught in floating lift nets at different times. The dominant fish species caught in lift nets in other coastal waters, such as Banten Bay, Indonesia, belong to the Dorosomatidae family (e.g., *Sardinella* spp.) and the Engraulidae family (e.g., *Stolephorus* spp.) (Susanto *et al*. 2017). Lift net fisheries in Indonesia exploit small pelagic fish as target species, with the dominant species caught among scads (*Decapterus* spp.), sardines (*Sardinella* spp.), and Indian mackerel (*Rastrelliger* spp.) (Solomon and Ahmed 2016).

The dominant fish families, such as Dorosomatidae and Spratelloididae, were caught in large numbers. These group taxas are commonly caught using floating lift nets and are considered economically important fish in Muncar, Banyuwangi. *Spratelloides delicatulus*, belonging to the family Spratelloididae, are widely found in the coastal waters of the Indo-Pacific region. They are considered forage fishes for larger predators and economically valuable catches in several areas (Pham *et al*. 2020). The family Carangidae is also abundantly caught and can be found in the waters every month. Notable species of this family include mackerel scads (*Decapterus macrosoma*, *D. russelli*) and bigeye scads (*Selar crumenophthalmus*), which are essential catches for fishers using lift nets and other fishing gear such as purse seines. The fish caught in the floating lift net in Biru Bay, Bali Strait, are similar to those found in previous observations by Sukresno *et al*. (2021). These fish include many juveniles from the mackerel scads, sardines, anchovy, and ponyfish groups. Small pelagic fish, such as mackerel scads and Bali sardinella, are the dominant fish groups caught in Bali Strait and Makassar Strait (Puspasari *et al*. 2016).

Most juvenile fish on the east coast of Banyuwangi, Bali Strait, show positive allometric growth patterns, which indicate heavier fish and reflect optimum growth conditions (Jisr *et al*. 2018). Marine pelagic fish in some locations also reflect positive allometric growth patterns in most species, such as commercial pelagic fish on the Padang coast of Indonesia. (Kunzmann and Braitmaier 2018) and Southeastern Arabian Sea (Rajesh *et al*. 2020). The growth of some economically important fish species on the east coast of Banyuwangi is classified as positive allometric. This includes *Sardinella lemuru* (April 2023), *Spratelloides delicatulus* (September 2023), *Decapterus macrosoma* (September and December 2023), and *Rastrelliger kanagurta* (February 2024). These fish are in the juvenile stage, and their positive allometric growth pattern shows that juveniles can grow optimum on the eastern coast of Banyuwangi. This indicates that these areas support the sustainability of fish assemblages.

The following most common growth pattern observed in this study was isometric. Many species, especially fishes like *Decapterus russelli*, *Selar crumenophthalmus*, and *Spratelloides delicatulus*, exhibited isometric growth patterns in September and December 2023. Isometric growth refers to an increase in length and weight at the same rate, which is considered ideal growth (Froese *et al*. 2011). Only one fish species, *Megalaspis cordyla* (February 2024), experienced negative allometric growth. The different growth patterns observed in these fishes depend on body shape and internal factors such as maturity and life stage and can change with each seasonal or temporal variation (Froese 2006; De Giosa *et al*. 2014).

A critical finding from the study on fish growth on the east coast of Banyuwangi, Bali Strait, is that certain species exhibit a change in growth patterns over time. For instance, the growth pattern of *Sardinella lemuru* was positive allometric in April 2023 but became isometric by September 2023. *Spratelloides delicatulus* exhibits varying growth patterns each month. According to Radhi *et al*. (2018), these changes in growth patterns are often influenced by the body's physiological needs and alterations in body dimensions over time. Since the fish in this study are predominantly in the juvenile stage, they may likely display diverse growth patterns in the future. Factors such as changes in life stages and different sexes can influence the growth of the fish over a specific period (Possamai *et al*. 2020).

Condition factors are assessed to evaluate fish populations' general health, productivity, maturity, and physiological condition (Lederoun *et al*. 2016; Muthiadin *et al*. 2020). Overall, condition factor values of most species on the east coast of Banyuwangi were above 1.00. A condition factor equal to or greater than 1.00 indicates good growth conditions for the fish and that their nutritional requirements are well-provided (Ragheb 2023).

The condition factor values for each fish species varied over the month. It depends on sex, body size, season, and gonadal maturity (Froese 2006). Based on the average condition factor of fish each month, the health and growth of juvenile fishes on the east coast of Banyuwangi are relatively good. Environmental factors and diet can affect fish's growth patterns and condition factors (Mazumder *et al*. 2016). Additionally, the diverse condition factor values are caused by many aspects, including predation, water quality, and food availability (Muchlisin *et al*. 2017; Ragheb 2023) In short, the body condition of small pelagic fish, such as sardines and anchovies, largely depends on spatiotemporal local environmental factors. Trophic variables (prey abundance, composition, and quality) also contribute to their fitness (Lloret-Lloret *et al*. 2022).

The results of this study provide a foundational benchmark for assessing the health of fish resources in the marine environment in Bali Strait. Economically important fish in the Bali Strait exhibited growth patterns and favorable conditions, indicating a healthy body condition and suitable habitat for nurseries, particularly in the eastern part of the Bali Strait, such as Biru Bay and its surrounding waters. It is essential to regulate fishing operations that use floating lift nets in this nursery area to ensure that the fish recruitment process occurs effectively. This regulation will help maintain sustainable fish populations and support sustainable fisheries in the waters of the Bali Strait.

Acknowledgement

This research was partially funded by grants from the David & Lucile Packard Foundation and the Indonesia Endowment Fund for Education (LPDP)-Ministry of Finance, Republic of Indonesia.

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Supplementary Materials

Supplementary Table 1. Composition and length-weight of fish assemblages on the east coast of Banyuwangi, Bali Strait

Ordo/families	Species	n	Length (mm)	Weight (g)
Acanthuriformes				
Acanthuridae	*Acanthurus olivaceus*	1	33	1.43
Leioghnathidae	*Gazza minuta*	3	16-49	0.13-1.37
Acropomatiformes				
Acropomatidae	*Acropoma argentistigma*	2	27-30	0.34-0.45
Pempheridae	*Parapriacanthus ransonneti*	7	33-47	0.76-2.99
Atheriniformes				
Atherinidae	*Doboatherina duodecimalis*	95	25-82	0.26-8.41
Beloniformes				
Belonidae	*Tylosurus crocodilus*	1	195	11.42
Exocoetidae	*Cheilopogon katoptron*	1	155	52.64
Blenniiformes				
Blenniidae	*Petroscirtes variabilis*	1	34	0.52
Carangaria				
Sphyraenidae	*Sphyraena barracuda*	1	80	3.89
	Sphyraena flavicauda	21	35-87	0.19-4.01
	Sphyraena obtusata	3	55-80	1.10-4.24
Carangiformes				
Carangidae	*Alectis ciliaris*	1	37	2.20
	Alepes melanoptera	1	55	2.66
	Decapterus macrosoma	285	29-95	0.23-9.70
	Decapterus russelli	392	17-93	0.07-10.73
	Megalaspis cordyla	377	24-91	0.30-11.37
	Selar boops	49	40-60	0.86-3.65
	Selar crumenophthalmus	364	24-94	0.23-17.92
Centrarchiformes				
Terapontidae	*Terapon theraps*	1	58	4.66
Clupeiformes				
Dorosomatidae	*Amblygaster sirm*	55	47-170	1.04-72.54
	Herklotsichthys quadrimaculatus	366	21-111	0.09-16.12
	Sardinella gibbosa	21	49-73	0.94-2.62
	Sardinella lemuru	506	22-80	0.10-6.07
Engraulidae	*Encrasicholina devisi*	5	58-81	1.92-5.03
	Encrasicholina heteroloba	11	58-76	1.68-3.91
	Encrasicholina punctifer	862	50-80	0.97-4.67
	Stolephorus commersonii	3	24-52	0.12-1.04
	Thryssa encrasicholoides	17	29-48	0.20-1.16
Spratelloididae	*Spratelloides delicatulus*	6116	18-62	0.03-2.90
	Spratelloides gracilis	1	22	0.11
Eupercaria				
Caesionidae	*Dipterygonotus balteatus*	8	22-57	0.19-2.54
Priacanthidae	*Priacanthus macracanthus*	1	75	11.38
Kurtiformes				
Apogonidae	*Rhabdamia gracilis*	2	34-39	0.70-0.96
Mugiliformes				
Mugilidae	*Mugil cephalus*	1	25	0.22
Mulliformes				
Mullidae	*Upeneus* sp.	51	19-39	0.08-0.59
Ovalentaria				
Pomacentridae	*Abudefduf vaigiensis*	1	90	34.34

Supplementary Materials

Supplementary Table 1. Continued

Ordo/families	Species	n	Length (mm)	Weight (g)
Scombriformes				
Scombridae	*Auxis thazard*	10	79-115	4.40-18.05
	Euthynnus affinis	8	90-109	7.42-16.24
	Rastrelliger kanagurta	50	74-94	2.08-11.14
	Sarda orientalis	1	87	8.03
Trichiuridae	*Tentoriceps cristatus*	1	352	11.03
Syngnathiformes				
Fistulariidae	*Fistularia commersonii*	1	150	1.35
Tetraodontiformes				
Balistidae	*Pseudobalistes flavimarginatus*	15	28-40	1.14-3.00
	Sufflamen bursa	4	30-36	1.21-2.55
	Sufflamen fraenatum	1	35	2.27
	Xanthichthys lineopunctatus	8	40-53	2.83-5.70
Ostraciidae	*Ostracion solorensis*	1	22	2.32
Tetraodontidae	*Lagocephalus sceleratus*	15	47-91	2.38-11.03