Diversity pattern and juvenile fish assemblage in the nearshore habitats of the Sumbawa Island, Indonesia

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Abstract. The coastal ecosystem plays a vital role as essential habitat for juvenile and small marine fishes. This study aimed to analyze juvenile and small-sized fish assemblage in the nearshore habitats of Sumbawa Island. Sampling was carried out in the morning at low tide when new and full moon from November 2020 to January 2021. Five sampling sites were selected based on habitats their adjacency to the river mouth. During the study period, 6349 individuals belonging to 74 species and 37 families were recorded. The number of *Ambassis vachellii* was the most significant, followed by *Hypoatherina temminckii*, and *Eubleekeria splendens*. The highest fish biomass was occupied by *E. splendens*, followed by *Plotosus lineatus*, and *Planiliza macrolepis*. Physico-chemical parameters were not varied between sampling sites, except salinity. Estuaries with vegetated areas have a higher species richness, diversity, and evenness index than the unvegetated area. Juvenile and small-sized fishes varied between sites but not varied between moon phases. Research findings confirm that the nearshore habitat of Sumbawa Island has a significant capacity to support the early life stage of many marine fish species.

1 Introduction

The coastal ecosystem plays an important role as essential habitat for juvenile and small-sized marine fishes. River mouths are part of an estuary ecosystem that is a transitional area for fish that migrate with various destinations from sea to the river or vice versa, and species that only use estuary [1]. The estuary has very high fish biodiversity due to nutrient input, which generally comes from river flows [2, 3].

River estuary ecosystems are significant for the survival of fish communities, especially juvenile fish. Fish takes benefit from the high availability of food in the form of

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phytoplankton, zooplankton, insects, and other prey in estuaries [4, 5]. Fish use estuary areas to find food and use space related to their protection and life cycle [6, 7].

Research conducted in estuarine ecosystems has provided information on the use of estuarine ecosystems by fish as foraging, protection, mating, spawning, nursery, and migration [6, 7, 8, 9]. Various fish species have also been grouped according to their use and life cycle in estuary ecosystems [1, 10]. Human activities are currently increasing, thus affecting the aquatic ecosystem. Current research has been carried out on Spatio-temporal distribution, relationships between habitats, environmental influences and threats, and conservation of fish in estuary ecosystems [11, 12, 13].

The change in environmental factors mostly worsens as there are also increasing human activities in the estuary and surrounding ecosystem. Water pollution from agricultural runoff, exploitation of natural resources, industry, cities, and waste disposal negatively impact freshwater or marine fishes [14, 15]. The low ability to manage the environment can pollute the aquatic ecosystem as the pollution in the waters spreads quickly. The ability of each species of fish is different in terms of adapting to changing environmental factors. A fish species that are not able to adapt to environmental changes can be lost from the waters. The existence of juvenile fish in the ecosystem continues to be threatened over time.

This study aimed to analyze juvenile and small-sized fish assemblage in the nearshore habitats of Sumbawa Island. The study was conducted to determine the fish that live in marine waters and fish that utilize the estuary area, both from marine and freshwater fishes.

2 Methods

2.1 Study site

The study site was located in five different sites, namely in the sandy beach, area of seagrass, and three areas of river mouth with mangrove of Sumbawa Island, West Nusa Tenggara, Indonesia (Fig. 1). The research was conducted for three months, from November 2020 to January 2021, representing the transition season, early rainy season, and the peak of the rainy season. A sampling of fish and environmental parameters was carried out in the morning when low tide and phase of the new moon and full moon.

2.2 Data collection

2.2.1 Juvenile and small-sized fish

Juvenile and small-sized fish samples were collected using a seine net with a dimension of 10 m x 1.2 m, 4 mm of mesh size, and 1 mm mesh size of cod-end. Two persons actively operate the Seine net. The net was operated in a shallow coastal area by pulling it to the shore. The catches were sorted directly in the field and preserved using formalin 5%. Fish was sorted based on the catch site. Preserved fish samples moved into ethanol 70% for species identification. Fishes were identified to the lowest taxon according to reference books [16], [17], [18], [19].
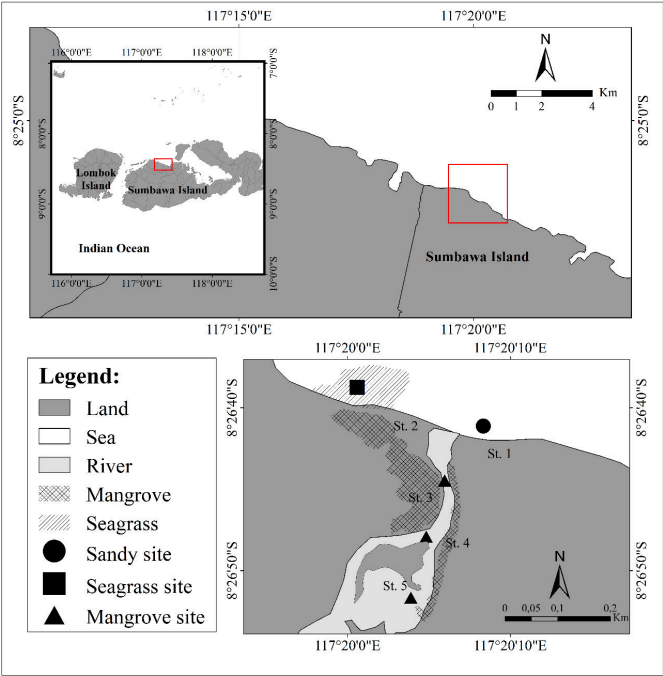
Fig. 1. Sampling locations in the nearshore habitat of Sumbawa Island.

2.2.2 Physical and chemical parameters

Several physicochemical parameters were measured in situ before fish samplings, such as waters depth, transparency, total dissolved solids, temperature, salinity, pH, and dissolved oxygen to determine the condition of the waters.

2.3 Data analysis

2.3.1 Fish composition

All fish samples were grouped according to their life stages, namely juveniles and adults. The grouping is based on the ratio of the total length (TL) to the length at first maturity (LM) [20]. Data on the length at the first maturity of each species were sourced from Fishbase. If there is no data on the length at the first maturity of a fish species, it was assumed that one-third of the maximum length is the length at first maturity [21]. The fish were categorized as juveniles if their total length was less than a length at first maturity (TL < LM), while the adult stage if the total length was more than the length at first maturity (TL > LM).

2.3.2 Community structure

Analysis on community structure was analyzed using four attributes which are Shannon-Wiener diversity index (H'), species richness index (D), evenness index (E), and dominance index (C) [22]. The four attributes were determined by utilizing the formula (1), (2), (3), and (4):

$$H' = \Sigma \, p_i \, ln \, p_i \qquad (1)$$

$$D = S\text{-}1 \, / \, ln \, N \qquad (2)$$

$$E = H' \, / \, H'_{maks} \qquad (3)$$

$$C = \Sigma \, (n_i \, / \, N)^2 \qquad (4)$$

where p_i = the relative abundance of each species at each sampling site, H'_{maks} = ln S, n_i = number of individual fish, N = the total number of individual fish, S = number of species.

2.3.3 CPUE (Catch per Unit Effort)

CPUE calculation is based on the number of fish from one or various species caught per unit of area (number of fish per area of sweeping). The result from the CPUE calculation used as measurement represents fish relative richness in the research site during sampling. Each species was calculated its CPUE value in each sampling site using the formula [CPUE = C/f], CPUE: Catch per Unit Effort (g/100 m^2), C: Catch (g), f: Area of sweep area (m^2).

2.3.4 One-Way ANOVA and Two-Way ANOSIM

One-way analysis of variance (ANOVA) was used to test for significant differences in environmental variables (depth, transparency, total dissolved solids, temperature, salinity, pH, and dissolved oxygen) between different locations. While two-way analysis of similarity (ANOSIM) was used to test for site and moon condition effects for fish assemblages.

3 Results

3.1 Fish diversity

The fish caught during the study period was 74 species belonging to 37 families and 13 orders (Appendix 1). The most numerous fish species belong to the order Perciformes (41 species and 16 families). In contrast, order Atheriniformes, Batrachoidiformes, Beloniformes, Clupeiformes, Mugiliformes, Pleuronectiformes, Syngnathiformes, and Tetraodontiformes was only one to three families and one to six species (Fig. 2). The most numerous fish family caught during research was Gobiidae, represented by nine fish species, then followed by Carangidae (5 species), Syngnathidae, Tetraodontidae, and Zenarchopteridae (every four species) (Fig. 3). Other families that were found only constituted by one to three species (Fig. 2).
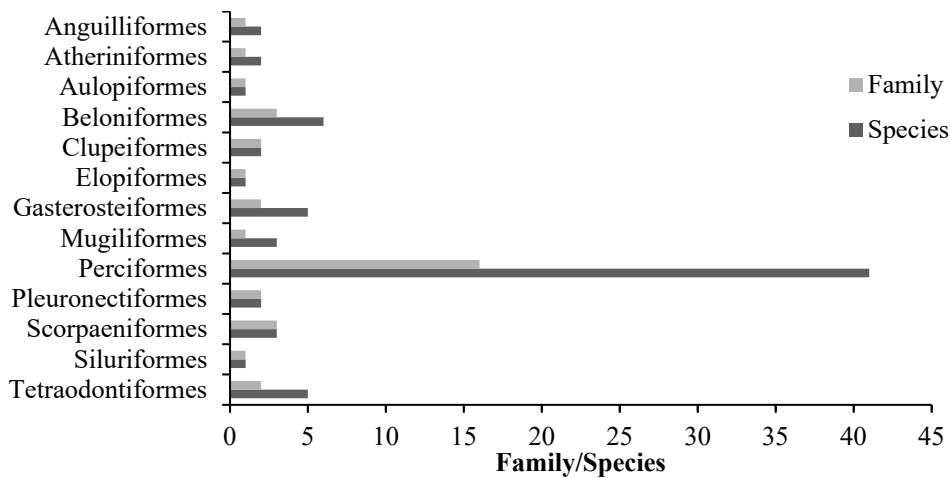
Fig. 2. The number of families and species for each fish order caught in the nearshore habitat of Sumbawa Island.
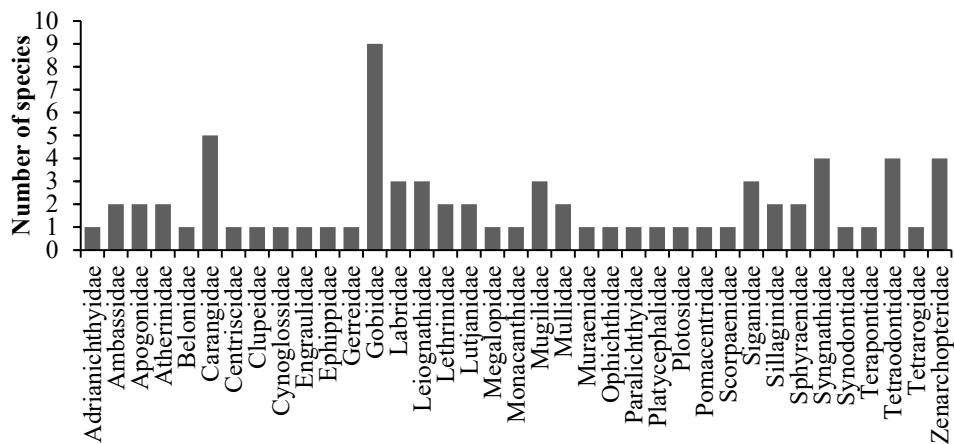

Fig. 3. Number species for each fish family caught in the nearshore habitat of Sumbawa Island.

3.2 Fish assemblage structure

Every fish needs an essential habitat to grow and develop. The juvenile dominated habitat utilization by fish in the study area. The abundance of juveniles in all sites was 6,067 individuals (94%) of the 6,439 fish samples (Fig. 4). The predominant fish species based on the number of individuals and biomass was different (Fig.5). *Ambassis vachellii* was dominant based on the number of individuals (3242 individuals), followed by *Hypoatherina temminckii* and *Eubleekeria splendens*. The highest fish biomass was occupied by *Eubleekeria splendens* (1076.35 g), followed by *Plotosus lineatus* and *Planiliza macrolepis*.

The catch per unit effort (CPUE) represents the abundance of each species. Total CPUE in the nearshore habitat of Sumbawa Island was 89.43 Ind./100 m^2. The results showed that the CPUE of each fish species was varied (Appendix 1). The highest CPUE was *A. vachellii* (45.02 Ind./ 100 m^2), followed by *H. temminckii* (8.10 Ind./ 100 m^2), *E. splendens* (7.86 Ind./ 100 m^2), *P. lineatus* (7.85 Ind./100 m^2), and *Stolephorus commersonnii* (5.96 Ind./ 100 m^2).

Index of the community structure of fish shows the fluctuated value (Fig. 6). Station 4 (mangrove site) has the highest average of diversity and evenness index. Station 2 (seagrass

site) has the highest average species richness. Meanwhile, Station 1 (sandy beach) has the lowest fish diversity, evenness, and species richness.
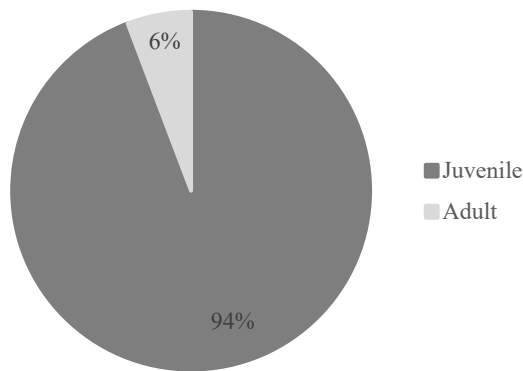

Fig. 4. Distribution of the number of a fish family caught in the nearshore habitat of Sumbawa Island.
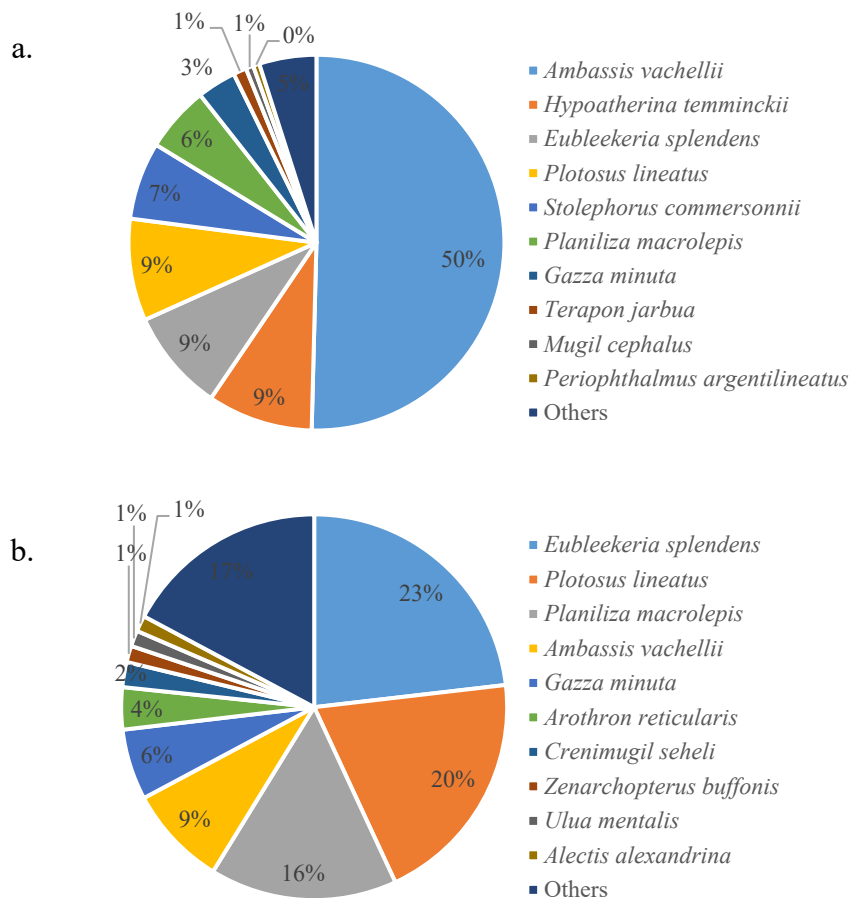

Fig. 5. Species with the highest number of individuals (a) and biomass (b) in the nearshore habitat of Sumbawa Island.
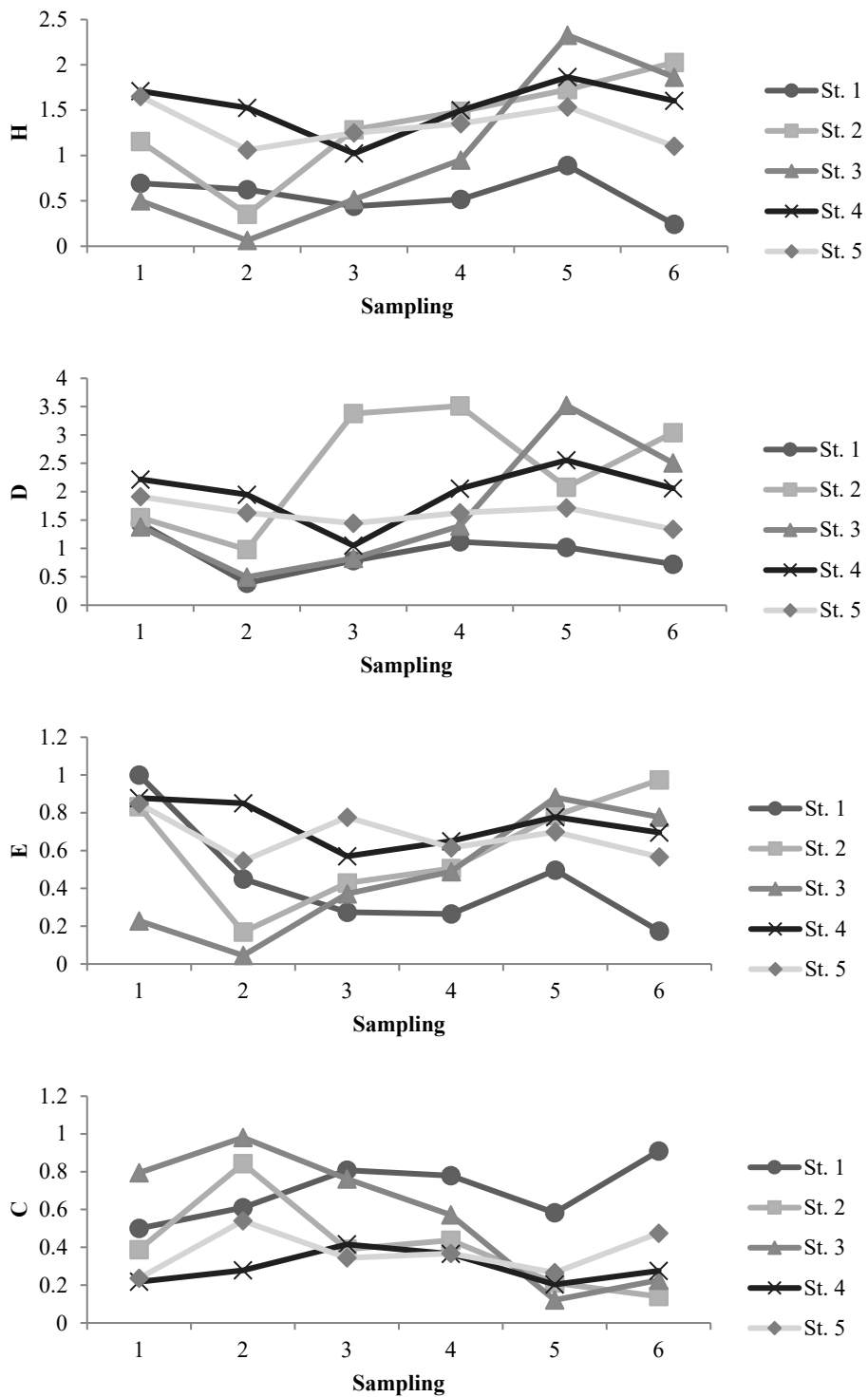
Fig. 6. Diversity index of fish assemblage in the nearshore habitat of Sumbawa Island.

3.4 Environmental factors

The environmental parameters of each site are presented in Table 2. Station 3 has the highest depth average value because it locates in the lowest river mouth. The highest average values of transparency, temperature, and dissolved oxygen were recorded at Station 1. The highest average salinity was documented at Station 2 and the lowest at Station 5. All environmental parameters were not varied between sites, except for salinity.

3.5 Correlation of environmental factors and fish composition

ANOSIM results show that there was a significant difference between fish assemblages and sites (Table 3). The composition of fish can be affected by the different salinity at each station. Pairwise testing of fish assemblages at each station showed that the sandy beach station and the seagrass station were significantly different from all stations leading to the upstream part of the river (Stations 3, 4, and 5). The seagrass site and the sandy site did not show a significant difference.

Table 2. Summary of one-way ANOVA for environmental factors in the nearshore habitat of Sumbawa Island.

Sites	Depth (cm)	Trans. (cm)	TDS (‰)	Temp. (°C)	Sal. (‰)	pH	DO (mg/L)
St. 1	61.1±18.4	47.7±22.7	771.5±478.8	30.5±2.6	27.3±5.2	7.3±0.3	9.7±1.6
St. 2	55.1±13.1	35.6±10.8	740.1±284.3	29±1.2	35.1±0.4	7.5±0.4	8.9±2.0
St. 3	72.1±18.4	37.0±17.2	699±426.2	29±3.0	10.6±13.4	7.3±0.3	7.3±2.1
St. 4	50.8±13.9	31.3±10.9	687±353.2	28.1±3.0	10±12.8	7.3±0.3	9.3±1.3
St. 5	42.6±19.6	30.3±11.5	700.8±409.6	28±3.2	9.6±12.6	7.3±0.2	8±2
F	2.580	1.213	0.047	0.773	7.955	0.225	1.722
P	0.062	0.330	0.995	0.553	0.00*	0.922	0.177

*: p-value <0.05.

Table 3. Summary of one-way ANOVA for environmental factors in the nearshore habitat of Sumbawa Island.

Global test		
Spatio-temporal	*R*	*P*
Moon condition	-0.0925	0.8529
Sites	0.2507	0.0018*
Pairwise test		
Pairs of site	*R*	*P*
St. 1 vs St. 2	0.0305	0.3434
St. 1 vs St. 3	0.1630	0.0523**
St. 1 vs St. 4	0.4139	0.0083*
St. 1 vs St. 5	0.4167	0.0048*
St. 2 vs St. 3	0.2343	0.0441*
St. 2 vs St. 4	0.6037	0.0024*
St. 2 vs St. 5	0.5963	0.0026*
St. 3 vs St. 4	0.1509	0.0499*
St. 3 vs St. 5	0.3361	0.0054*
St. 4 vs St. 5	-0.0833	0.8597
Pairs of moon condition	*R*	*P*
New moon vs Full moon	-0.0258	0.7531

*: p-value <0.05; **: p-value <0.1.

4 Discussion

The diversity of fish caught during research is relatively high. However, it is still considered low compared with the number of species found in the Estuary of Musi River (32 species) [23] and Poigar River Mouth (40 species) [24]. It is also different from the number of species found in other areas, which are higher in the estuary of Segara Anakan (87 species) [25] and the Estuary of Mayangan (105 species) [8]. The higher fish diversity in the nearshore habitat of Sumbawa Island is influenced by the surrounding three types of habitats and sampling, including the transitional season, the beginning of the rainy season, and the peak of the rainy season. The difference in the number of species is the consequence of various essential habitats that affect the high diversity of fish [26]. Besides, the different numbers of fish can also be caused by their habitat [27]. According to [28], the adjacent ecosystem can also affect the amount of fish diversity.

In this research, Perciformes play a significant role in nearshore habitats. Research from [29] in Cimanuk River Mouth found that the number of families from Perciformes is higher than other families. Similar research from [30] in Bintuni Bay, West Papua, found that Perciformes are higher than any other orders. Perciformes amount to more than a third of all fishes (160 families and over 10000 species) [31]. This particular family of fish from this order is distributed almost throughout the ocean [32, 33, 34, 35].

Gobiidae is the fish family with the highest number of species in the world. This family was also found to have the highest number of species in all study sites. Its ability to utilize various habitats is also a factor in the number of these species in the research location. Gobiidae is generally distributed in a wide range of coral reef habitats or areas of sandy, rubble, and muddy areas ranging from tidal pools to offshore coral reefs [19, 36].

Fish juveniles utilize all the habitats of sandy beaches, seagrasses, and mangroves in the estuary ecosystem. More than half of the species in estuary ecosystems are juveniles only [37]. [38] support this statement by stating that more than half (57%) of the total fish species in the estuary ecosystem are only juveniles. The highest number of juveniles shows that the estuary ecosystem is essential habitat for fish juveniles [39]. Habitat utilization by fish juveniles indicates that the area is used as a nursery area and can also be used as a feeding or breeding route [1, 10]. However, based on the high abundance and frequency of juveniles of each species, it is strongly suspected that juveniles of fishes utilize various habitats in the estuary of the study area as a nursery ground.

The total CPUE of all fish catches was 89.43 individuals/ 100 m^2. The value was higher than in Kema, North Minahasa (15.03 individuals/ 100 m^2) [40]. Environmental factors, population dynamics have a major influence on catches [41]. Currents, sea level, surface temperature, chlorophyll-a concentration, and total suspended solids affect CPUE [42]. The mangrove habitat, seagrass habitat, and sandy beach in the research location support the estuary ecosystem.

The high abundance of *Ambassis vachellii* is due to its ability to utilize different habitats in the estuary and surrounding ecosystems. This species was found in a large number in seagrass, sandy, and mangrove habitats. Previous studies showed that *A. vachellii* is widely spread from coastal estuaries to upper river areas or upstream rivers [43] and includes areas around bays where seagrass meadows are found [44]. The high abundance of *A. vachellii* in estuary locations was also found by [45]. They found that juveniles of *A. vachellii* were abundant in waters with mangrove habitats and could even be grouped as species that use mangrove as its habitat. The habitat of this species includes the bay area with brackish waters, estuaries, and tidal areas where mangroves are found [19, 38]. In addition, *A. vachellii* can spawn many times during its life cycle due to its long lifespan compared to other species in estuaries [46].

E. splendens has a greater ability to utilize various habitats. Therefore it was often found in diverse habitats. Certain species may occupy more than one type of habitat, and this is due to their excellent tolerance level to various environmental factors, habitat proximity factors, and connectivity with other habitats [10, 47].

A total of 10 species that dominate based on the number of individuals (95.09%) was more significant than the total biomass (82.82%). The dominance that occurs based on the number of individuals was more visible than the total biomass. The dominant fish species are generally smaller compared with other fish and forms schooling in the waters. Small-sized fishes and juveniles are more dominant than large fish in utilizing estuaries in tropical waters [25, 38, 48]. This result was shown by the abundance of juveniles *A. vachellii* (1,740 individuals, mean SL = 9 mm) and *H. temmickii* (580 individuals, mean SL = 15.53 mm) in sandy site and seagrass site. The abundance of the juvenile *A. vachellii is* presumably because the juvenile of *A. vachellii* were just about to enter the estuary area, which is their habitat. The abundance of this species was always found in high numbers in estuaries, both in areas with sand and mud substrates [49]. Appearance at one location and abundantly indicates *H. temminckii* forms schooling in the sandy site. According to [34], *H. temminckii* was commonly found in coastal waters and ports.

The higher fish diversity is mostly recorded in the vegetated areas, such as seagrass and mangrove [45, 50]. The diversity value is used as an indicator for monitoring environmental changes [51] because each fish species has a different tolerance to water quality, habitat, and other environmental parameters [52].

The seagrass site is farthest from the river mouth, so it has high salinity. The more towards the upstream of the river, salinity is lower. The salinity distribution can also be affected by water circulation, evaporation, and rainfall [53]. The fish that occupy estuary waters are estuarine residents, euryhaline marine migrants, stenohaline marine, freshwater migrants, catadromous migrants, and anadromous migrants [54]. High salinity at the seagrass and sandy sites were utilized by juveniles of marine fish belonging to the stenohaline groups. This group has a large number of species, including various types of marine fish. However, species richness is higher in high salinity coastal areas than in estuarine areas due to the influence of the high number of taxa in the marine environment compared with the estuary, the low ability for freshwater fish species to enter high salinity areas, or the low ability for marine fish species to enter low salinity areas [55].

Increasing salinity in estuaries can provide greater opportunities for marine species to utilize habitats in estuaries [56]. Increases in salinity can happen especially during the dry season, when the volume of river water is small, or at the farthest tide when the new moon and full moon. The study was conducted during the transitional and rainy seasons when the volume of river water increases, resulting in a decrease in salinity in the estuary. The decrease causes the stenohaline fish only to occupy seagrass and sandy beaches. Meanwhile, the estuary area was inhabited mostly by permanent resident fish of the estuary such as *Amblygobius linki*, *Zenarchopterus buffonis*, *Periophthalmus argentilineatus*, *Chelonodon patoca*, and *Favonigobius reichei* and marine euryhaline fish like *Ambassis vachellii*, *Eubleekeria splendens*, *Planiliza macrolepis*, *Terapon jarbua*, *Mugil cephalus*, and *Stolephorus commersonnii*. This group has a high diversity and large numbers due to their tolerance to various water salinities [54].

There was no significant difference in fish assemblages between Station 4 and Station 5 in the mangrove area upstream of the estuary. This similarity is strongly suspected because of the increase in salinity due to high tides that is relatively low at that two stations. Therefore, marine stenohaline species do not take advantage of this habitat, unlike the case at station 3 in the mangrove area, which is the main entrance of seawater to the estuary area. Tidal currents carry water masses along with marine fish to enter the lower reaches of the estuary.

Marine fish utilize the increase in salinity of the waters downstream to serve as their essential habitat temporarily [56].

Each species has a different ability to adapt to environmental factors. Specific habitats will continue to be utilized by several species of fish despite changes in environmental factors. Therefore, various ecosystems' habitats can significantly affect the diversity and abundance of fish shown by the sandy site, an essential habitat for *H. temminckii*. This species is found abundantly on the coast and from schooling [33]. *Cheilio inermis* was only found in seagrass areas. This species is a stenohaline character fish and utilizes seagrass habitat in the juvenile stage [57]. Although it is not significantly different in species composition, there were 32 species found in seagrass but not in sandy beach areas. The high number of species is due to various species using seagrass areas for camouflage between the leaves and stems of the seagrass [31] to avoid predators so that the sustainability of the population is maintained. Families such as Siganidae, Atherinidae, Labridae, Nemipteridae, and various reef fish families are interested in seagrass ecosystems, especially in the juvenile phase [58, 59, 60, 61].

5 Conclusion

A total of 74 fish species from 37 families and 13 orders dwelled in the nearshore habitat of Sumbawa Island. The fish assemblage is dominated by fish juveniles (94%), and they occupy various habitats such as mangroves, seagrass, and sandy beach. Estuaries with vegetated areas have a higher species richness, diversity, and evenness index than the unvegetated area. Moreover, salinity is an environmental parameter that significantly varies between sampling sites and affects the fish assemblages. The nearshore habitat of Sumbawa Island has a significant capacity to support the early stage of many marine fish species.

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6 Appendix

Appendix 1. Number of individuals (N), total of weight (W), CPUE (Ind./100 m^2), standard length (SL), and life stages (LS: J, juveniles; A, adults) of fish collected by sampling sites in the nearshore habitat of Sumbawa Island

No.	Order/ Family	Species	Sampling sites					N	W (g)	CPUE	SL (cm)	LS
			St. 1	St. 2	St. 3	St. 4	St. 5					
	ANGUILLIFORMES											
1.	Muraenidae	*Echidna rhodochilus*	0	0	1	0	0	1	13.3	0.01	172-172	A
2.	Ophichthidae	*Ophichthus altipennis*	0	2	0	0	0	2	26.9	0.03	235-338	J
	ATHERINIFORMES											
3.	Atherinidae	*Doboatherina duodecimalis*	0	3	0	0	0	3	0.13	0.04	19-20	J
4.		*Hypoatherina temminckii*	582	1	0	0	0	583	11.66	8.10	4-41	J, A
	AULOPIFORMES											
5.	Synodontidae	*Saurida nebulosa*	0	1	0	0	0	1	53.52	0.01	156-156	A
	BELONIFORMES											
6.	Adrianichthyidae	*Oryzias javanicus*	0	0	0	0	1	1	0.14	0.01	20-20	A
7.	Belonidae	*Platybelone argalus platyura*	0	0	0	3	1	4	3.56	0.06	64-96	J
8.	Zenarchopteridae	*Zenarchopterus buffonis*	0	1	4	10	3	18	63.99	0.25	27-152	J
9.		*Zenarchopterus dispar*	0	0	2	3	0	5	21.66	0.07	59-105	A
10.		*Zenarchopterus dunckeri*	0	0	1	0	0	1	8.2	0.01	88-88	A
11.		*Zenarchopterus rasori*	0	0	2	0	5	7	12.26	0.10	45-112	J, A
	CLUPEIFORMES											
12.	Clupeidae	*Herklotsichthys quadrimaculatus*	1	0	0	0	0	1	0.26	0.01	25-25	J
13.	Engraulidae	*Stolephorus commersonnii*	179	246	2	0	2	429	55.77	5.96	15-66	J
	ELOPIFORMES											
14.	Megalopidae	*Megalops cyprinoides*	1	9	0	0	0	10	0.67	0.14	18-32	J
	GASTEROSTEIFORMES											
15.	Centriscidae	*Aeoliscus strigatus*	0	1	0	0	0	1	0.08	0.01	36-36	J
16.	Syngnathidae	*Hippichthys cyanospilos*	0	1	0	0	0	1	0.8	0.01	96-96	A

No.	Order/ Family	Species	St. 1	St. 2	St. 3	St. 4	St. 5	N	W (g)	CPUE	SL (cm)	LS
			Sampling sites									
17.		*Hippocampus kuda*	1	0	0	0	0	1	3.2	0.01	80-80	J
18.		*Microphis leiaspis*	0	0	1	1	1	3	0.21	0.04	54-60	J
19.		*Syngnathoides biaculeatus*	0	1	0	0	0	1	4.31	0.01	175-175	A
	MUGILIFORMES											
20.	Mugilidae	*Crenimugil seheli*	0	0	0	9	12	21	97.54	0.29	44-83	J
21.		*Mugil cephalus*	16	1	3	6	16	42	0.97	0.58	8-12	J
22.		*Planiliza macrolepis*	1	0	5	150	208	364	729.2	5.06	10-84	J
	PERCIFORMES											
23.	Ambassidae	*Ambassis interrupta*	0	0	0	1	0	1	1.47	0.01	35-35	J
24.		*Ambassis vachellii*	1751	1165	141	112	73	3242	391.41	45.03	7-56	J, A
25.	Apogonidae	*Fibramia amboinensis*	0	2	2	0	1	5	11.17	0.07	15-54	J, A
26.		*Fibramia lateralis*	0	3	0	0	0	3	0.12	0.04	13-16	J
27.	Carangidae	*Alectis indica*	0	1	0	0	0	1	8.7	0.01	64-64	J
28.	Carangidae	*Alectis alexandrina*	0	4	0	0	0	4	62.15	0.06	62-91	J
29.		*Caranx ignobilis*	0	0	0	0	1	1	9.85	0.01	77-77	J
30.		*Selar crumenophthalmus*	0	0	0	3	0	3	0.82	0.04	24-26	J
31.		*Ulua mentalis*	5	0	0	0	0	5	62.2	0.07	61-80	J
32.	Ephippidae	*Platax orbicularis*	0	3	0	0	1	4	22.02	0.06	14-59	J
33.	Gerreidae	*Gerres oyena*	0	0	0	3	2	5	3.8	0.07	13-43	J
34.	Gobiidae	*Amblygobius linki*	0	0	20	6	0	26	21.24	0.36	27-54	J, A
35.		*Bathygobius cyclopterus*	0	1	0	0	0	1	0.21	0.01	21-21	A
36.		*Favonigobius reichei*	0	0	3	8	13	24	9.85	0.33	16-41	J, A
37.		*Glossogobius bicirrhosus*	0	0	0	1	0	1	0.2	0.01	25-25	J
38.		*Oligolepis acutipennis*	0	0	0	1	2	3	2.91	0.04	13-49	J, A
39.		*Oxyurichthys ophthalmonema*	0	0	6	0	0	6	1.22	0.08	12-33	J
40.		*Periophthalmus argentilineatus*	0	0	6	17	12	35	57.16	0.49	19-62	J, A
41.		*Psammogobius biocellatus*	0	0	0	1	0	1	3.9	0.01	63-63	A
42.		*Sicyopterus lagocephalus*	0	1	2	2	0	5	0.77	0.07	14-26	J
43.	Labridae	*Cheilio inermis*	0	6	0	0	0	6	24.6	0.08	30-141	J

No.	Order/ Family	Species	Sampling sites					N	W (g)	CPUE	SL (cm)	LS
			St. 1	St. 2	St. 3	St. 4	St. 5					
44.		*Halichoeres argus*	1	3	0	0	0	4	17.33	0.06	42-68	A
45.		*Halichoeres papilionaceus*	0	1	0	0	0	1	5.99	0.01	64-64	A
46.	Leiognathidae	*Deveximentum interruptum*	21	5	0	0	0	26	8.51	0.36	13-28	J, A
47.		*Eubleekeria splendens*	176	91	298	1	0	566	1076.35	7.86	8-68	J, A
48.	Leiognathidae	*Gazza minuta*	190	33	1	0	0	224	276.17	3.11	8-42	J
49.	Lethrinidae	*Lethrinus lentjan*	0	3	0	0	0	3	0.36	0.04	15-22	J
50.		*Lethrinus rubrioperculatus*	0	1	0	0	0	1	1.8	0.01	42-42	J
51.	Lutjanidae	*Lutjanus fulviflamma*	0	1	0	0	0	1	0.16	0.01	17-17	J
52.		*Lutjanus lutjanus*	0	1	0	0	0	1	0.7	0.01	29-29	J
53.	Mullidae	*Parupeneus indicus*	0	1	0	0	0	1	0.8	0.01	37-37	J
54.		*Upeneus vittatus*	0	1	3	0	0	4	57.87	0.06	67-105	J, A
55.	Pomacentridae	*Pomacentrus tripunctatus*	0	0	0	1	0	1	24.03	0.01	80-80	A
56.	Siganidae	*Siganus canaliculatus*	0	5	1	0	0	6	2.02	0.08	20-31	J
57.		*Siganus guttatus*	0	0	2	1	0	3	12.59	0.04	40-68	J
58.		*Siganus spinus*	0	14	6	0	0	20	3.43	0.28	15-20	J
59.	Sillaginidae	*Sillago aeolus*	0	0	10	1	0	11	3.16	0.15	16-30	J
60.		*Sillago sihama*	0	0	1	0	2	3	11.9	0.04	38-90	J
61.	Sphyraenidae	*Sphyraena barracuda*	3	1	0	0	0	4	3.71	0.06	23-80	J
62.		*Sphyraena flavicauda*	0	12	0	0	0	12	20.04	0.17	19-78	J
63.	Terapontidae	*Terapon jarbua*	1	3	11	9	49	73	31.77	1.01	9-60	J
	PLEURONECTIFORMES											
64.	Cynoglossidae	*Cynoglossus puncticeps*	1	2	0	0	0	3	28.56	0.04	89-110	J
65.	Paralichthyidae	*Pseudorhombus arsius*	1	1	1	0	0	3	39.73	0.04	37-113	J
	SCORPAENIFORMES											
66.	Platycephalidae	*Sorsogona tuberculata*	0	1	0	0	0	1	15.62	0.01	113-113	A
67.	Scorpaenidae	*Parascorpaena mcadamsi*	0	1	0	0	0	1	8	0.01	57-57	A
68.	Tetrarogidae	*Tetraroge barbata*	0	1	2	0	0	3	14.54	0.04	32-67	J, A
	SILURIFORMES											
69.	Plotosidae	*Plotosus lineatus*	0	146	419	0	0	565	927.25	7.85	22-74	J

No.	Order/ Family	Species	Sampling sites					N	W (g)	CPUE	SL (cm)	LS
			St. 1	St. 2	St. 3	St. 4	St. 5					
	TETRAODONTIFORMES											
70.	Monacanthidae	*Acreichthys tomentosus*	0	1	0	0	0	1	6.99	0.01	60-60	A
71.	Tetraodontidae	*Arothron manilensis*	0	1	1	0	1	3	24.89	0.04	41-63	J
72.		*Arothron reticularis*	0	0	0	1	1	2	164.5	0.03	35-120	J
73.		*Canthigaster margaritata*	0	1	0	0	0	1	13.2	0.01	61-61	J
74.		*Chelonodon patoca*	0	0	3	3	3	9	43.3	0.13	8-71	J
		Total	2931	1784	960	354	410	6439	4649.37	89.43		
		Number of species	18	46	31	26	23	74				