Fish Diversity in Mangrove Conservation Area of Labuhan, Bangkalan, East Java – Indonesia, with Emphasis on Important Fishery Species

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Abstract. Mangroves are one of the most productive ecosystems which support biodiversity of aquatic invertebrate and vertebrates. Many local fishermen in Labuhan village, Sepulu, Bangkalan – East Java depends on the existence of mangrove for fisheries production, including economically important species. This study aimed to determine the diversity of fish within mangrove (the inner mangrove/IM) and coastal water in front of mangrove (the outer mangrove/OM). Samplings with several active and passive fishing gears (scoop net, gill net, fish trap) were conducted three times during high tide periods in June 2021, October 2021 and July 2022. The fish diversity analyzed with the Shannon-Wiener (H') diversity index while similarity of fish communities was approached using the Sorensen similarity index. A total of 36 fish species were identified, with 23 species recorded from IM and 22 species from OM. The IM always has higher species richness and abundance, that is 20.33±0.58 species and 125.33±26.27 individuals compared to the OM with 13.33±3.06 species and 36.67±13.01 individuals. The IM also has a relatively higher value of H' (2.49±0.06) than OM (2.207±0.18). The value of Sorensen index was 0.419 with only 9 shared species in both areas. The most dominant species in the IM is Mozambique tilapia (*Oreochromis mossambicus*) while in OM there is Singapore glass perchlet (*Ambassis kopsii*). Sixteen species are considered having economic value; with most of high economic important species, e.g. Milkfish (*Chanos chanos*), Greenback mullet (*Planiliza subviridis*), Great barracuda (*Sphyraena barracuda*) and Barramundi (*Lates calcarifer*) were usually caught at juvenile and/or immature stages.

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1 Introduction

Among the nearshore coastal habitats, estuary and mangrove can be considered as the most productive ecosystem in the world, serving as nursery and breeding areas for various fish species therefore support fisheries production [1, 2]. Mangroves provide a high level of primary productivity which forms the base for food webs that support the wide range of commercial species [3]. The high abundance and species richness of benthic fauna in mangrove thus enhances the diversity of fish. Complex physical structure, including root system provide shelter for juveniles and small fish from predation especially during high tide [4, 5]. Mangrove is estimated to support 10-30% fisheries production in the world, as well as in small islands [6,7]. Fishery resources in mangroves include groups of species that live in the mangroves for all of their lifetime and groups of fauna that are present in mangroves only during spawning or early growth phase [8] or when foraging for food.

Despite having significant importance in supporting fisheries, mangroves in Labuhan, Sepulu, Bangkalan were damaged as a result of land conversion to aquaculture, especially shrimp ponds, which also the common driver of mangrove deforestation in East Java [9]. In the western part of the village, mangroves extend to 11.47 ha in 2019 and are estimated to be reduced to only 6.67 ha in 2022. From both ecological and economical perspectives, destruction of mangrove will directly reduce their habitat and ecosystem functions for supporting diversity of marine life [10], altering availability of habitat for fish population [11], as well as decrease their regulating functions (i.e. shoreline protection, climate regulation, sediment retention and carbon storage) [12].

In the area of Labuhan, Sepulu, Bangkalan, traditional fishing has generally been carried out around river mouths and coastal waters in front of mangrove forests. Given the importance of the vital role of mangroves for local fishery resources, damage to mangrove forests will certainly have a negative impact both ecologically and economically, where many local fishermen depend on the existence of mangroves. Concerning this, the mangrove in the area is now conserved and projected as an eco-tourism by the locals, aided by local government and a state enterprise (PHE-WMO) in the framework of corporate social responsibility (CSR). This study is aimed to determine the diversity of fish species in the mangrove and its surroundings while the data obtained is expected to be the basis of further planning for sustainable mangrove rehabilitation and management.

2 Materials and Method

2.1 Study site

The mangrove vegetation in which sampling of fish take place composed by 7 species of true mangrove, dominated by *Rhizophora stylosa*, *Avicennia marina*, *Lumnitzera racemosa* and *Excoecaria agallocha* with the total tree (trunk diameter >4 cm) density is 2366.67 individuals/ha. The mangrove is surrounded by active shrimp ponds and abandoned fishponds with several waterways and a small creek (width ±7-8 m), as depicted in Figure 1. In order to assess the fish community in two adjacent and continuous area, the sampling conducted in two areas: the inner mangrove (IM) and outer mangrove (OM) or coastal water in front of the mangrove.

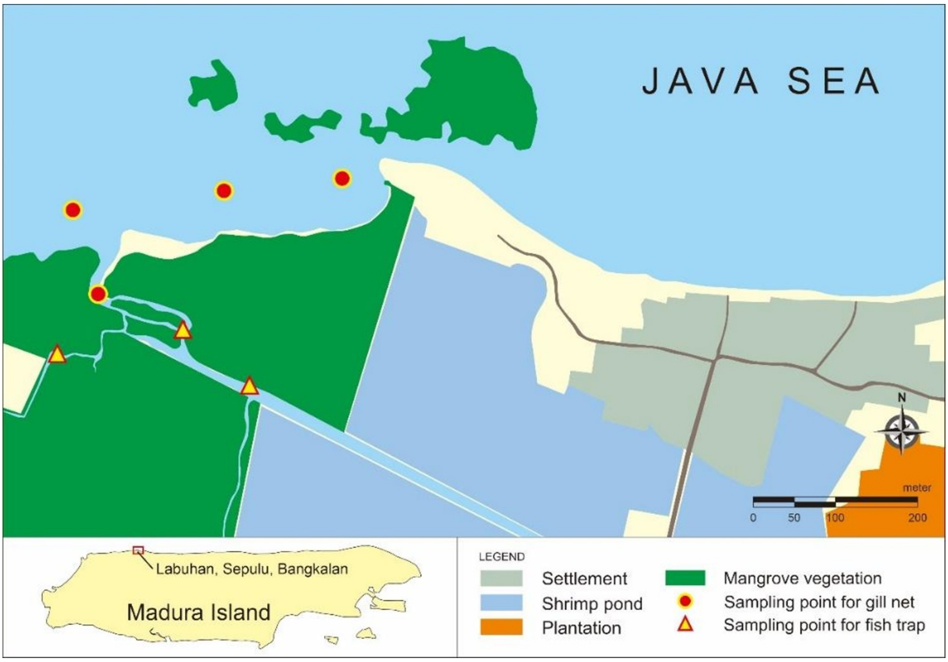

Fig. 1. Map showing sampling points in the mangrove and surrounding waters in Labuhan, Sepulu, Bangkalan, East Java.

2.2 Fish collection

Fish samples collected in June 2021, October 2021 and July 2022 during spring tide period using active (scoop net) and passive (centipede net, fish trap and gill net) fishing gears. In the IM area, centipede net (dimension of length, width and height is 200 x 60 x 40 cm, mesh size 1.5 cm) and hexagonal-shaped fish trap (90 cm in diameter, 6 openings) were used to sampling in waterways adjacent to mangrove root system. Both traps installed at high tide and later checked at low tide or ±6 hours post installment [5]. Scoop net used to catch juvenile and small-sized fish specimens in the riverbanks and waterways [5]; while gill net (length 10 m, width 1 m, mesh size 2 cm) was used to sampling in creek and OM area [13]. Similar to the fish trap and centipede net, the gill net was also installed during high tide and regularly checked at 30 minutes interval for ±6 hours duration. All collected specimens from both sampling areas were sorted by species, counted and photographed in situ; then preserved in 10% buffered-formaldehyde and further examined in the laboratory. Fish identification refers to [14, 15, 16, 17, 18]. Scientific nomenclature and taxonomic detail later checked online on the website of World Register of Marine Species (WoRMS).

2.3 Data analysis

This research is a descriptive quantitative study in which species diversity between periods and sampling areas was analyzed with the Shannon-Wiener (H') diversity index [5] using following formula:

$$H' = -\sum_{i=1}^{R} pi \ln pi \qquad (1)$$

 https://doi.org/10.1051/bioconf/20248905002

Similarities of fish communities between sampling areas (IM and OM) were approached using the Sorensen similarity index to determine habitat preferences [19]. The differences in fish abundance and value of H' from the two sampling areas at each period were analyzed with independent samples T-test while species richness parameters using the Wilcoxon Mann-Whitney test, since the data of species richness were not normally distributed. All statistical analyses were performed at p = 0.05.

3 Results and Discussion

3.1 Species richness, abundance and diversity index

During three sampling periods from the two areas, a total of 492 fish individuals from 36 species and 25 families were collected. The IM area has a much higher total abundance (376 individuals) compared to the OM (116 individuals). Total species richness from both sampling areas are relatively similar, that is 23 species in IM and 22 species in OM. Species richness and abundance of fish in this study is high, considering that the mangrove area is only 6.67 ha. Comparison of the results of this study are shown in Figure 2; explained that species richness and abundance of fish in this study were higher compared to other relatively similar studies. However, species richness obtained in this study was lower if compared to studies in much larger areas.

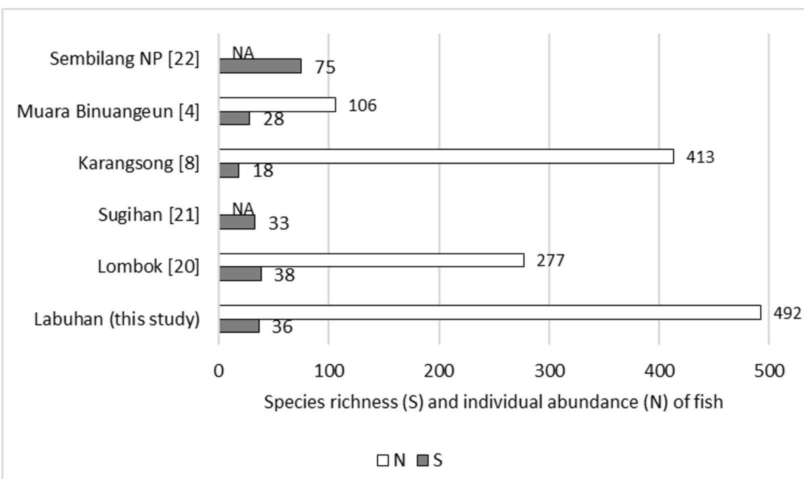

Fig. 2. Comparison of species richness and individual abundance of fish in this study (Labuhan) compared to other similar studies in Lombok [20], Sugihan in South Sumatera [21], Karangsong in West Java [8], Muara Binuangeun in Banten [4], and Sembilang National Park [22]. Note: data of individual abundance were not available in {21] and [22].

Although there appears to be no difference in terms of total species richness between areas, the result of the Wilcoxon Mann-Whitney test showed that species richness in the IM were significantly higher (significance value = 0.046 or <0.05) compared to the OM. In June 2021, October 2021 and July 2022 there were 20, 20 and 21 species identified in the IM; while 14, 9 and 15 species were recorded in the OM area, respectively. A similar trend also occurred for the variable of individual abundance, where the results of the two independent-samples T-test showed a significance value of 0.007 (<0.05). In each period, the IM area always obtained more abundant fish (115, 105 and 153 individuals) compared to the OM area

(38, 24 and 48 individuals). These findings are consistent with previous study by [5] in nearby study area di Sepulu where vegetated areas will support higher abundance of fish.

In contrast to species richness and individual abundance, the result of independent-samples T-test showed no significant difference of H' (Sig. = 0.059). However, the value of H' in IM ranged from 2.447 to 2.56 or 2.49±0.061 on average; slightly higher compared to the OM with the value of H' from 2.015-2.365 or 2.207±0.177. Values of H' in this study also higher compared to [8] which was recorded at 2.36 in mangrove and 1.82 in the seawater in front of the mangrove. However, it is lower than studies by [20] which ranged from 2.618 to 3.072; or by [4] with the value of 2.816. Figure 3 shows the dynamics of the species richness, individual abundance and the value of H' in each area and sampling period.

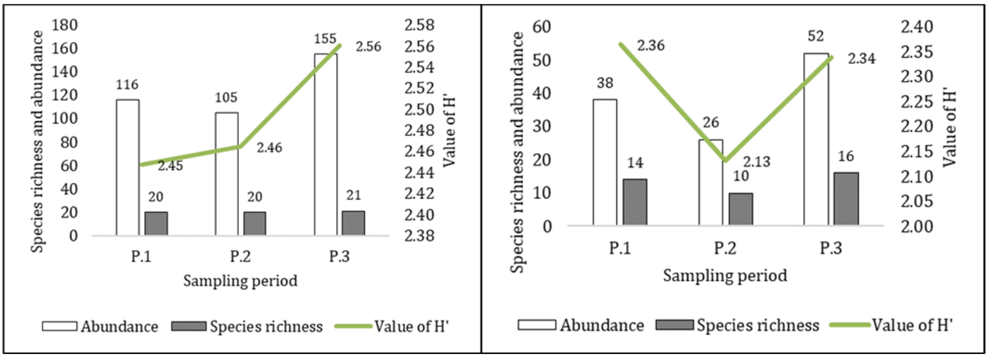

Fig. 3. The dynamics of species richness, abundance and value of Shannon-Weiner diversity index (H') of fish community in the inner (IM, left picture) and outer (OM, right picture) mangrove areas at each sampling period (P.1 June 2021, P.2 October 2021, P.3 July 2022).

3.2 Species composition and community similarity

Value of Sorensen similarity index between IM and OM is 0.419, showing that fish community similarity in two areas is low. There are only 9 shared species in both areas, namely Buru glass perchlet (*Ambassis buruensis*), Singapore glass perchlet (*A. kopsii*), Milkfish (*Chanos chanos*), Whipfin silver-biddy (*Gerres filamentosus*), Greenback mullet (*Planiliza subviridis*), Squaretail mullet (*Ellochelon vaigiensis*), Spotted scat (*Scatophagus argus*), Silver sillago (*Sillago sihama*) and Crescent gunter (*Terapon jarbua*). Singapore glass perchlet, Greenback mullet and Crescent gunter usually caught in higher abundance compared to the other 6 species.

Difference in community can also be seen from the list of dominant species (relative abundance >5%). In the IM, the most dominant species are Mozambique tilapia (*Oreochromis mossambicus*) with relative abundance 21.27% of total population from three sampling periods. Other dominant species including Javanese medaka (*Oryzias javanicus*), Singapore glass perchlet and Java fat-nose goby (*Pseudogobius javanensis*); while Crescent gunter, Greenback mullet and Giant mudskipper (*Periophthalmodon schlosseri*) categorized as predominant species (relative abundance 2-5%). Singapore glass perchlet is the most dominant (24.138%) in the OM area, followed by Greenback mullet, Crescent gunter, Whipfin silver-biddy, Milkfish, Spotted scat and Thumbprint emperor (*Lethrinus harak*). Details of fish composition and abundance are available in Table 1.

Table 1. Composition and number of individuals of fish in mangrove of Labuhan, Sepulu, Bangkalan.

No.	Species	English name	Family	Fishing gear	Number of individuals	Economic importance
Inner mangrove area (IM)						
1	*Oryzias javanicus*	Javanese medaka	Adrianichthyidae	3	72	NEP
2	*Ambassis buruensis*	Buru glass perchlet	Ambassiidae	1,2	4	NEP
3	*Ambassis kopsii*	Singapore glass perchlet	Ambassiidae	1,2,3	51	NEP
4	*Bagrus* sp	Bagrid catfish	Bagridae	1,2,4	3	NEP
5	*Mystus* sp	River catfish	Bagridae	1,2	2	NEP
6	*Butis butis*	Crazy fish	Butidae	1,2	4	NEP
7	*Ophiocara porocephala*	Northern mud gudgeon	Butidae	1,2	14	LEP
8	*Chanos chanos*	Milkfish	Chanidae	4	3	HEP
9	*Oreochromis mossambicus*	Mozambique tilapia	Cichlidae	4	80	LEP
10	*Gerres filamentosus*	Whipfin silver-biddy	Gerreidae	3,4	5	LEP
11	*Acentrogobius caninus*	Tropical sand-goby	Gobiidae	1,2	4	NEP
12	*Glossogobius giuris*	Tank goby	Gobiidae	3	5	NEP
13	*Pseudogobius javanicus*	Java fat-nose goby	Gobiidae	3	25	NEP
14	*Zenarchopterus buffonis*	Buffon's river garfish	Hemiramphidae	3,4	12	NEP
15	*Planiliza subviridis*	Greenback mullet	Mugilidae	3,4	17	HEP
16	*Ellochelon vaigiensis*	Squaretail mullet	Mugilidae	3,4	4	HEP
17	*Boleophthalmus pectinirostris*	Great blue-spotted mudskipper	Oxudercidae	3	7	NEP
18	*Periophthalmodon schlosseri*	Giant mudskipper	Oxudercidae	3	18	NEP
19	*Periophthalmus gracilis*	Slender mudskipper	Oxudercidae	3	8	NEP
20	*Periophthalmus variabilis*	Dusky-gilled Mudskipper	Oxudercidae	3	14	NEP
21	*Scatophagus argus*	Spotted scat	Scatophagidae	3	4	LEP
22	*Sillago sihama*	Silver sillago	Sillaginidae	2,4	4	HEP
23	*Terapon jarbua*	Crescent grunter	Terapontidae	3,4	16	LEP
	Total of individu				**376**	
Outer mangrove area (OM)						
1	*Ambassis buruensis*	Buru glass perchlet	Ambassiidae	3	2	NEP
2	*Ambassis kopsii*	Singapore glass perchlet	Ambassiidae	3	28	NEP
3	*Arius sagor*	Sagor catfish	Ariidae	4	3	HEP
4	*Tylosurus crocodilus*	Houndfish	Belonidae	4	3	HEP
5	*Gnathanodon speciosus*	Golden trevally	Carangidae	4	1	HEP
6	*Chanos chanos*	Milkfish	Chanidae	4	6	HEP
7	*Elops hawaiensis*	Hawaian ladyfish	Elopidae	4	1	HEP
8	*Gerres filamentosus*	Whipfin silver-biddy	Gerreidae	3,4	8	LEP
9	*Gerres oyena*	Common silver-biddy	Gerreidae	3	1	LEP
10	*Pentaprion longimanus*	Longfin mojarra	Gerreidae	4	2	LEP
11	*Lates calcarifer*	Barramundi	Latidae	4	2	HEP
12	*Leiognathus equulus*	Common ponyfish	Leioganthidae	4	2	LEP
13	*Lethrinus harak*	Thumbprint emperor	Lethrinidae	4	5	HEP
14	*Lutjanus russelli*	Moses' snapper	Lutjanidae	4	4	HEP

No.	Species	English name	Family	Fishing gear	Number of individuals	Economic importance
15	*Megalops cyprinoides*	Indo-Pacific tarpon	Megalopidae	4	1	HEP
16	*Planiliza subviridis*	Greenback mullet	Mugilidae	3,4	18	HEP
17	*Ellochelon vaigiensis*	Squaretail mullet	Mugilidae	4	1	HEP
18	*Scatophagus argus*	Spotted scat	Scatophagidae	4	5	LEP
19	*Siganus canaliculatus*	White-spotted rabbitfish	Siganidae	4	3	HEP
20	*Sillago sihama*	Silver sillago	Sillaginidae	4	1	HEP
21	*Sphyraena barracuda*	Great barracuda	Sphyraenidae	4	2	HEP
22	*Terapon jarbua*	Crescent grunter	Terapontidae	3,4	17	LEP
	Total of individuals				**116**	

Fishing gear (1. centipede net, 2. hexagonal-shaped fish trap, 3. scoop net, 4. gill net); economic importance (NEP. non-economically important species; LEP. low economically important species, HEP. high economically important species)

Mozambique tilapia, along with Nile tilapia (*O. niloticus* – not found in this study) and their natural hybrids are usually known as freshwater species. However, several studies stated that those species are euryhaline and able to grow and breed in saline water to 40 ppt [23]. Their excellent adaptability to various salinity regimes makes them to be considered as a good candidate for brackish aquaculture commodities [23, 24]. In this study, Mozambique tilapia usually caught only in IM by gill net and fish trap around the waterways with the salinity range to 25 ppt. Other speciesthatare highly saline-tolerant species and grow well in hyperosmotic environments which are caught only in IM is Javanese medaka. This species is naturally common in coastal water of Greater Sunda [25]. Java fat-nose goby is relatively common in Southeast Asia [26] and usually became dominant in waterways and abandoned ponds near to mangroves [27]. Another common gobiid, the Giant mudskipper, is also common in mangrove habitat where the preferential food sources (Javanese medaka and *Uca* spp) are abundant [28, 29].

The Singapore glass perchlet are dominant both in IM and OM. This species is generalist in various habitats such as seagrass beds and mangroves as well as in muddy or sandy shores [30] and can be abundant in mangroves [31]. Greenback mullet is also dominant in IM and OM and has wide global distribution in estuarine and coastal of temperate and tropical waters [33, 34]. Other dominant species in this research are also cosmopolitan species commonly found in estuaries and coastal waters [1, 8, 27, 34].

3.3 Important species for local fishery

Of all the species, 17 of them (or 47.22% of the total number of species) have economic value and are the main catch fishery commodities in the. Fish species with high economic value include Greenback mullet, Squaretail mullet, Great barracuda (*Sphyraena barracuda*), Hawaiian ladyfish (*Elops hawaiiensis*), Golden trevally (*Gnathodon speciosus*), Milkfish, Barramundi (*Lates calcarifer*), Thumbprint emperor, Moses' snapper (*Lutjanus russelli*), Indo-Pacific tarpon (*Megalops cyprinoides*), White-spotted rabbitfish (*Siganus canaliculatus*), Silver sillago, and Houndfish (*Tylosurus crocodilus*) (Figure 4). Except for Greenback mullet, all these species were caught in the OM area with low abundance (from 1 to 6 individuals).

Almost all those species were also found in juvenile and/or immature stages, with exception to Milkfish, Thumbprint emperor, Houndfish, Moses' snapper and Silver sillago that caught as juvenile and adult stages. As the most abundant commercially important species found in the area, Green mullet were mostly found in stage of juvenile. Similar result showed by [32] in Kedungmalang, Jepara, Central Java; which stated that during early life stage, Mullet are highly associated with mangrove and the adults will move to coastal area adjacent to mangrove.

Fig. 4. Photographs of fresh specimens of several economic importance species caught in the study area; high economic value: a. *Ellochelon vaigiensis*, b. *Planiliza subviridis*, c. *Chanos chanos*, d. *Sphyraena barracuda*, e. *Lates calcarifer*; low economic value: f. *Gerres filamentosus*, g. *Terapon jarbua*, h. *Ophiocara porocephala*, i. *Oreochromis mossambicus*

Apart of those species, other commonly caught fish such as Crescent gunter, Spotted scat, Silver biddy, Longfin mojarra, Common pony and Mozambique tilapia locally known for low economic values. These fish are generally for household consumption and rarely traded in the market, or sometimes further processed as dry-salted fish. In addition, the Giant mudskipper and Northern mud gudgeon which abundant and frequently caught are treated as very low economic commodities; although those species are commonly consumed in many regions due to high protein content [35, 36, 37].

4 Conclusion

At each sampling period, inner mangrove area always has higher species richness, abundance and value of diversity index compared to outer mangrove (or coastal water in front of mangrove). In spite of occupying only a relatively small area, diversity and abundance of fish in the study area can be considered high, showing the importance of mangroves in supporting fish biodiversity including economically important species. Therefore, extension of mangrove by conservation and rehabilitation program is clearly needed; not only to maintain faunal biodiversity and other ecological roles of the mangrove but also to ensure the economic security of the local fishermen household.

The researchers thank PT Pertamina Hulu Energi – West Madura Offshore, the local government of Labuhan Village and Pokdarwis Payung Kuning of Labuhan, Sepulu Bangkalan for supporting the research.

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