BIODIVERSITAS
Volume 18, Number 2, April 2017
Pages: 601-608

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d180222

Diversity and community structure of fish, plankton and benthos in Karangsong Mangrove Conservation Areas, Indramayu, West Java, Indonesia

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Manuscript received: 20 October 2016. Revision accepted: 20 March 2017.

Abstract. *Sihombing VS, Gunawan H, Sawitri R.2017. Diversity and community structure of fish, plankton and benthos in Karangsong Mangrove Conservation Areas, Indramayu, West Java, Indonesia. Biodiversitas 18*: *601-608.* The Karangsong Mangrove Conservation Area in Indramayu District, West Java, Indonesia, extending across 20 hectares of coastal land, has undergone eight years of managed revegetation. It has a variety of productive habitats that support the availability of fish resources. The research described in this paper was conducted in July 2016 with the purpose of assessing the diversity, evenness, and structure of fish, plankton and benthos communities as an indicator of the effectiveness of the rehabilitation of the mangrove ecosystem. The fish, benthos, and plankton were collected and analyzed in the Biotrop Laboratories. Fish sampling was carried out using a gill net with mesh size of 25 mm, and with traps. Juvenile fish were collected using a fish net with mesh size of 15 mm, by combing the water column horizontally for 10-15 minutes in the morning and afternoon. For plankton sampling a net No. 25 was used, while samples of benthos were collected using an Ekman Grab sampler. To calculate the community structure and diversity of fish, the study used ecological indices (abundance, dominance, constancy and ecological significance) and diversity indices (Shannon and Simpson diversity). A total of 413 individuals were obtained from 18 fish species, representing 16 families. Family Lutjanidae and Acanthuridae had the highest representative number of species and Pomacentridae showed the highest relative abundance of individuals. The value for the fish diversity index was 2.44 and for the species evenness index was 0.84. The fish population consisted of 44.44% omnivores, 38.89% carnivores and 16.67% herbivores/ detritivores. The highest density of plankton was accounted for by Bacillariophyceae (78.57%), followed by Chlorophyceae (14.29%) and Zooplankton (7.14%). The diversity index for the plankton (H) ranged between 1.040 and 1.462 across habitats, while the evenness index (E) ranged between 0.144 and 1.22. The benthos consisted of Gastropods (83.58%), Crustacea (3.28%), Palaemonidae (1.64%) and Oligochaeta (11.48%). The diversity index for the benthos ranged from 0. 939 to 1. 199 and the evenness index from 0.158 to 0.207. Hence, it may infer from the domination of the environment by Bacillariophyceae and Gastropods, and the low values for diversity index and evenness index, that the area is not particularly good as a fish nursery and breeding habitat. Nevertheless, there are two species of fish that exhibit potential productivity in every habitat; they are *Chanos chanos* and *Scatophagus argus.*

Keywords: diversity, fish, plankton, benthos, mangrove

INTRODUCTION

Mangroves are salt tolerant plants that occur within inter-tidal zones where a river enters into the sea (Zakaria 2015). They are highly productive, forming tropical coastal ecosystems that encompass estuaries, creeks, lagoons, black waters, mud-flats, salt-pans and islands, and which contain great aquatic and terrestrial biodiversity (Mmom 2010). Mangrove forests are considered to provide important ecological and economic benefits to coastal regions of the tropics.

Estuaries are areas of physical and biological transition between the land, freshwaters, and the sea (Chowdhury et al., 2010). The study of the characteristics, abundance and diversity of fish, plankton, and benthos components of mangrove ecosystems can be used as an indicator of the potential productivity of the fish resources dependent on them. Such a study could be used as an input into determining management policy to be applied at the Karangsong Mangrove Ecosystem, in Indramayu on the northern coast of West Java, which is the subject of this paper.

Patty (2008) suggests that fish behavior around mangrove forest is an interesting subject for research since the movement of fish populations quickly follows food availability, and is influenced tidal currents, the presence of predator sand other diverse factors in the ecosystem. Gunarto (2004) reports that a diversity of fish types, encompassing herbivorous, omnivorous and carnivorous feeding habits are to be found around mangrove. Mangrove ecosystems serve as feeding grounds, spawning grounds, and nursery grounds providing a comprehensive habitat for many fish species. Fish resources in a mangrove ecosystem include both species that stay within the area for their lifetime or that transit through it for spawning and rearing, thus contributing to the biodiversity of mangrove forests such as those found along the Karangsong coast.

The occurrence, density, and diversity of plankton in the Karangsong Mangrove Conservation Area is directly connected to the physical and chemical quality of the water on the mangrove ecosystem. This mangrove ecosystem located on the waterfront has been subject to impacts from residential, recreational, and industrial developments. These anthropogenic impacts influence mangrove areas by such things as the disposal of waste-water either into the rivers or directly into the area (George et al. 2012). The polluting waters impact the growth and sustainability of phytoplankton populations through effects on the seawater, including factors such as light penetration, temperature, clarity, acidity (pH), carbon dioxide (CO_2) concentration, water level fluctuation, and concentrations of nutrients, such as nitrates, orthophosphates, dissolved oxygen (DO) and trace metals (Nontji 2008). So, plankton can be used as a bio-indicator to monitor water condition and fish habitat. According to Nwankwo (2004), Anyema (2007), and Ajuonu et al. (2011), plankton may serve as a bio-indicator to monitor the estuarine environment for pollution, and for modeling fish population dynamics and the condition of fish habitat.

The area of Karangsong village of Indramayu, West Java, Indonesia is 384,45 ha. It is a coastal village directly bordering the Java ocean. It borders with Pabean Udik Village in the north, with Tambak Village in the south, with Paoman Village in the west and the Java Ocean in the east. The village is 0.5 to 1.0 m above sea level with 0.9 km length of the coast. It is average annual rainfall is 2,000 mm and it has an average temperature of 29-31^{o}C (Bappeda Indramayu 2009).

The main type of habitats in the research area is wetland in the form of mangrove vegetation, an estuary with a muddy substrate affected by tidal waves and river water, and land habitat in the form of coastal vegetation with a beach sand substrate. The surrounding area is the Java Ocean on the outer part with fish pond culture. The biophysical condition of the Karangsong mangrove forest is highly influenced by the water and sediment brought by the Cimanuk watershed with its rivers flowing through the environment; especially the Prajagumiwang river through Karangsong village; the Cimanuk river itself flowing through Pabean Udik and Brondong Villages; a small branch of the Cimanuk entering into the sea through Brondong Village; and the Prawirakepolo river let through Singajaya Village. Human activities in the surrounding area are fishing, fish pond culture, and ecotourism.

The purposes of our research in Karangsong were to assess the diversity, evenness, and the structure of fish, plankton, and benthos communities influenced by the revegetation of the mangrove ecosystem over an eight-year period.

MATERIALS AND METHODS

The research was carried out in July 2016 at Karangsong Village, District of Indramayu, West Java, Indonesia. The research plot was in the Karangsong Mangrove Conservation Area located between 6°17'38.52" Sand 6°18'17.52" S and between 108°22'03.60" E and 108°22'17.94" E. Within the plot, from which samples for plankton, benthos, and fish diversity were taken, is depicted in Figure 1.

The materials and equipment used in the research included GPS, digital calipers, substrate/water samplers, plankton net no.25, pull net (25mm), fish net (15mm), an Ekman Grab (30 cm), sample bottles, a cooler box, formalin, Lugol solution, alcohol 80%, and guidelines for fish identification (Fischer, 2013). The details of the methods and materials are outlined in Table 1.

Analysis of the data gathered from sampling for fish, plankton and benthos in the plot area comprised calculation of Shannon-Weaver Index (Shannon and Weaver 1949) for estimation of Diversity, Margalef Index (D) (Margalef 1968) for Species Richness, Pielou's Index (E) for Evenness, and Simpson Index (D) for Dominance.

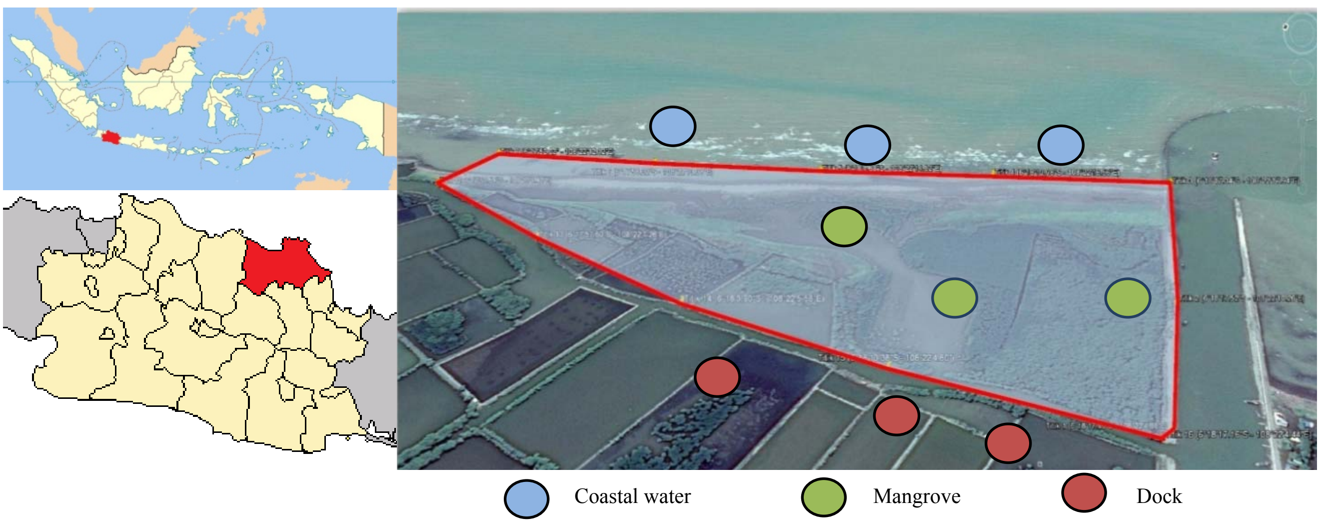

Figure 1. Plot design for biotic sampling in Karangsong Mangrove Conservation Areas, Indramayu, West Java, Indonesia

RESULTS AND DISCUSSION

Fish biodiversity

A total of 413 fish were caught at sampling sites in the mangrove ecosystem (251 individuals), in the ponds (110 individuals) and the coastal waters (52 individuals), Identification of the fish resulted in 18 species from 16 fish families (Table 2). The mangrove ecosystem had the most with a total of 14 different species, followed by the ponds with eight, and the coastal waters with seven species.

Chanos chanos and *Scatophagus argus* were the most prevalent fish species and were found in all three habitat categories (coastal waters, mangrove ecosystem and ponds) (Table 2). This is because these two species of fish have a high level of adaptability to variation in environment factors such as salinity, DO, pH, tidal wave action and to temperature, which is important not only the species ability to obtain food but also for their self-protection against predators. Young Milkfish (*Chanos chanos*) and their fishings stay in the sea water for 2-3 weeks, and then move to mangrove roots in brackish water, and sometimes to saline channels. *Chanos chanos* will return to the sea when they are adult for breeding. The fish species with the narrowest range in the area were *Ambassis marianus* and *Terapon jarbua*. In India, pugnose ponyfish (*Secutor* sp.) is one of the major by-catch composition (Muddula 2015) from the country leiognathids were known 16 species (Abraham et al. 2011).

From Table 2, we can estimate similarity index of the fish communities between the habitat types. The results are presented in Table 3. The similarity index between fish communities of the three habitats types was low. This shows that the community structure differs between each habitats. The fish communities in the mangrove and the ponds showed a relatively higher similarity index value (64%) compared with sea and mangrove (29%) or sea and pond (40%). The higher similarity index between mangrove and pond may be because the two habitats are located adjacent to each other and are directly connected, and/or due to the similarity of habitat types (substrate and water quality, and the existence of mangrove trees around the pond).

Table 1. Required data, source and sampling method

Aspect of study	Data requirement	Source of data	Data sampling method	Tools and materials
Biotic riparian diversity	Plankton diversity	Field (mangrove area; pond and sea/ocean water)	*Purposive sampling* (9 stations)	Plankton net No 25 Materials: alcohol, Lugol solution, sampling bottles (1 liter)
	Benthos diversity	Field (mangrove area; pond and sea/ocean water)	*Purposive sampling* (9 stations)	Ekman Grab (30 cm), filter/strainer, Materials: alcohol, sampling bottles (1 L)
	Fish diversity	Field (mangrove area; pond and sea/ocean water)	*Purposive sampling* (9 stations)	Pull net *mesh size* 25 mm, fishnet mesh size 15 mm, bubu, lambayang (crab snare), meter reading Materials: alcohol, sampling bottles (1 L)

Table 2. Fish biodiversity at in Karangsong, Indramayu, West Java, Indonesia mangrove ecosystem and feeding guilds

Family	Species	Feeding guilds	Pond	Mang-rove	Coastal water
Acanthuridae	*Gobius viridis* F. Hamilton, 1822	O	-	+	-
	Periophthalmus modestus Cantor, 1842	O	+	+	-
Ambassidae	*Ambassis marianus* Gunther 1880	H/D	-	+	-
Bagridae	*Mystus nigriceps* Valenciennes, 1840	O	-	+	-
Chanidae	*Chanos chanos* Forsskal, 1775	H/D	+	+	+
Cichlidae	*Oreochromis mossambicus* W.K.H. Peters, 1852	O	+	+	-
Cynoglossidae	*Cynoglossus arel* Bloch & J.G. Schneider, 1801	O	-	+	+
Drepanidae	*Drepane punctata* L., 1758	O	-	-	+
Haemulidae	*Pomadasys maculatus* Bloch, 1793	K	-	-	+
Lutjanidae	*Lates calcarifer* Bloch, 1790	K	+	-	+
	Lutjanus campechanus Poey, 1860	K	-	-	+
Megalopidae	*Megalops cyprinidae* Lacepède, 1803	K	-	+	-
Mugilidae	*Valamugil speigleri* J. L. B. Smith, 1948	H/D	+	+	-
Plotosidae	*Plotosus canius* Hamilton, 1822	K	+	+	-
Scatophagidae	*Scatophagus argus* Linnaeus, 1766	O	+	+	+
Synbranchidae	*Monopterus albus* Zuiew, 1793	K	+	+	-
Terapontidae	*Terapon jarbua* Forsskal, 1775	O	-	+	-
Trichiuridae	*Trichiurus savala* Cuvier, 1829	K	-	+	-
	Total		8	14	7

Note: H = Herbivore, D = Detritivore, K = Carnivore, O = Omnivore

Table 3. Fish community *similarity index* among habitat types

Habitat	Pond	Mangrove	Coastal water
Pond	-	0.64	0.40
Mangrove		-	0.29
Coastal water			-

The fish species found in the mangrove ecosystem, particularly at the highest trophic levels, are mostly visitor/migrating fish during certain periods or seasons (Wahyudewantoro dan Haryono 2011). Several commercial fish are connected to mangroves, such as Milkfish (*Chanos chanos*) and Mullet (*Valamugil speigleri*).There are four categories of fish found in the Karangsong mangrove ecosystem: (i) the resident/inhabitant fish that spend their whole life cycle in mangrove forest such as Mudskippers (*Periopthalmus* sp.); (ii) the partially-resident fish that are associated with mangrove forest during the hatchling phase, but that tend to school along the coastline near mangrove forest when they reach adult phase-these included Mullet (*Valamugil speigleri*) and Megalopidae; (iii) the tidal-migrating fish that migrate to mangrove forest during high tide for foraging (e.g. *Drepane punctata* and *Mystus nigriceps*); and (iv) the seasonal migrating fish using mangrove forest as a nurturing place or spawning place as well as seasonal protection place from predators-such as the White and Red Snappers (Lutjanidae). Juvenile fish are *neustonic*, that is they are floating and sometimes at the surface of mangrove waterways.

Monopterus albus, and *Oreochromis mossambicus* are freshwater fishes with a wide tolerance of salinity. They are diurnal and usually live in a groups in sheltered estuaries between algae. The spotted-scat fish (*Scatophagus argus*) is a predator that can reduce pond harvests. Pond-farmer usually spread saponin during pond-field preparation time and filter the water during pond replenishing to prevent predatory fish from entering into their ponds. *Cynoglossus arel* (family Cynoglossidae) are actually salt-water fish that are limited to the coast. They form small groups in mangrove forests, or around rocks and litter in waters of sheltered beaches, and then disguise themselves in the sand/mud. The fish mainly feed on plankton, Crustacea, and small fish. Their larvae are nocturnal pelagic and hide during daytime, in mangrove vegetation of shallow waters around estuaries.

Intertidal mud flats found outside the mangrove forest directly facing the sea are habitat for the abundant necton community. This is evident that the area is rich with feed resources of primary and secondary production as well as evident of organic material imported from sea and mangrove. Chong (2006) reported that the dominant fish species at intertidal muddy waters are estuarine species, such as *Osteogeneiosus militaris*, *Arius caelatus*, *Plotosus canius*), *Valamugil speigleri*, *Pennahia argentata*, *Protonibea diacanthus*, *Stolephorus macroleptus*), and *Hemiscyllium indicum*. On the floor of mangrove forests can be found Mudskipper fish capable of living outside the water for 7-8 minutes, because of their ability to breath through their skin, mucous layer in the mouth, and the gullet. *Drepane punctata* is usually found in mangrove areas at high tide, while *Ambassis marianus* is usually found at beaches and estuaries and also in sheltered waters with a sandy substrate. A mangrove forest is also a nursery and a feeding place for several species of fish and shrimp. Chong (2006) reported that a mangrove forest is a feeding place in time of high-tide for both economical and non-economical fish.

In the mangrove ecosystem, six species of juvenile fish were found. They were *Chanos chanos, Valamugil speigleri, Plotosus canius, Monopterus albus, Cynoglossus arel,* and *Scatophagus argus.* Fish caught in the mangrove forest were of relatively juvenile size. They slowly swim at the edges of the mangrove and are often found swarming allowing then to be easily caught. According to Odum (1996), a mangrove ecosystem is an ideal place for several species of fish (particularly young fish) and is recognized as a prime nursery and feeding ground. Subiyanto et al. (2008) found that the distribution pattern for fish larvae include mangrove forest, as well as river, estuary, and sea.

Fish species composition

The existence of aquatic vegetation affects fish biodiversity. Aquatic vegetation supplies food sources and shelter for fish. The Karangsong mangrove ecosystem has various coastal plant and mangrove species that support the life of various fish species. Depending on their particular food niches, fish can be classified into 5 classes, although it should be noted that the fish feeding pattern changes according to age, season and food availability. Fish classification based on food types according to Gracia (2011) are: (i) Herbivores: Fish in this class feed on phyto material (eat plants), and include Tawes/Java carp (*Puntius javanicus*), Nila/Parrotfish (*Osteochilus hasselti*), Bandeng/ Milkfish (*Chanos chanos*); (ii) Carnivores: Fish of this class get their main food from animal (meat eaters), and include such species as Belut/eel (*Monopterus albus*), and Kakap/snapper (*Lates calcarifer*); (iii) Omnivores: Fish in this class can eat both vegetation and animals, but adjust their consumption to whatever food source is available. Fish in this class include Mujair/Tilapia (*Oreochromis mossambicus*), Mas/Common carp (*Cyprinus carpio*), Gurami (*Osphronemus gouramy*); (iv) Plankton eaters: Fish in this class consume plankton throughout their life-phase, whether phytoplankton or zooplankton. Fish in this class include Terbang/Flying fish (*Exocoetus volitans*), Cucut (*Rhinodon typicus*); (v) Detritivores: Fish in this class consume remnants of decomposing organic material and litter that decay in water, derived from both from plant and animal origins. Fish in this class include Belanak/Mullet (*Valamugil speigleri*) (Figure 2).

Based on their food sources, fish species at Karangsong could be classified as herbivores, detritivores, carnivores and omnivores (Tables 2-3).The herbivorous fish or detritivores consume detritus and plankton as their main food. Omnivorous fish eat natural feed such as water insects, shrimp, fry, and aquatic plants (Purnomo et al. 1992). Omnivorous fish dominated the fish community in the Karangsong mangrove ecosystem, followed by predators/ carnivores and then herbivorous/detritivores fish species.

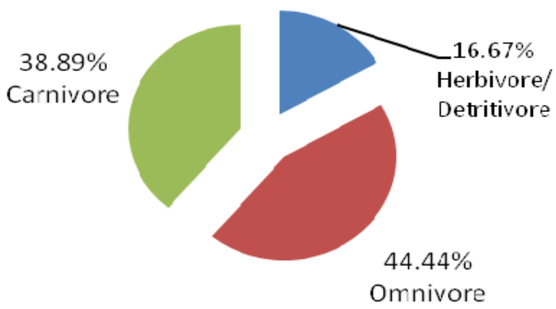

Figure 2. Classification of fish species according to feeding guilds

Based on their feeding pattern, fish at the research location were classified into (i) Predatory fish, which directly consume the prey alive. These were equipped with strong jaws and teeth, such as in *Lates calcarifer* and *Lutjanus campechanus*; (ii) Grazing fish, which consume their food by nibbling at it-examples of fish in this class are Tilapia (*Oreochromis mossambicus*) and *Scatophagus argus,* (iii) Strainer fish, which consume food by sifting it with mouth open, the food usually being plankton-included in this class is the Spotted Sickle Fish (*Drepane punctata*), (iv) Sucker fish, which take their food by sucking the mud or detritus at the seafloor-included in this class is Belanak/Mullet (*Valamugil speigleri*).

Fish species diversity

The fish biodiversity index on the mangrove habitat was 2.36, and was higher than the indices for the pond habitat and coastal waters nearby (Table 4). The diversity index for the total of the three habitats was 2.44. According to Michell (1995) a species diversity index between 1.5 and 3.5 is categorized as moderate. A diversity index less than or equal to 1.5 is categorized as low. A diversity index more than 3.5 is categorized as high.

The diversity index of an area describes the richness of the fish in the area in question. Diversity index depends on variation in the number of individuals of each species; the fewer the species and the variation in a number of individuals of a species, the lower is the diversity of the ecosystem and vice versa. The reason that mangrove had a higher diversity index compared to pond and nearby sea water is probably because the mangroves provide a better habitat a greater variety of fish to thrive (Unsworth et al. 2008). Mangrove forest that has formed for eight years creates a habitat for various kind of riparian and mangrove-associated fish species. In summary, fish in the Karangsong Mangrove Ecosystem were relatively abundant, with a diversity of species. The density of the mangrove stand in the system is likely to be a factor influencing the fish abundance because mangrove litter increases water nutrients thereby affecting primary and secondary productivity and thus food availability for fish (Benke 2010).

Plankton community structure

Plankton abundance was determined at four locations representative of different habitat types, for which populations were presented as the number of individuals of a species per liter (Table 5).A total of 11 sub-orders of plankton were recorded; four of which were most dominant in terms of species abundance (i.e. >5%).

Diatoms (order: Bacillariophyceae) were most abundant forming light-brown colored blooms. High species diversity occurred in those habitats with significantly higher relative diatom abundance. Bacillariophyceae have been reported by many authors to be dominant components of phytoplankton in such habitats (Polat et al. 2000). The species of highest relative abundance at the Karangsong site was *Coscinodiscus* sp. (45.24%). *Fragilaria* sp. (14.29%) and *Tabellaria* sp. (11.90%) were the second and third most abundant diatom species respectively (Table 5). Low phytoplankton diversity and the dominance of diatoms is probably a result of pollution and aquaculture activities (Wardana 2006; Biswas 2014).

According to Mason (1991), environmental pollution of waterways is generally classified according to its specific causes such as trace metal pollutants, organic pollutants, and gas pollutants. These pollutants originate from

Table 4. Diversity index of fish species and species evenness

Index	Pond	Mangrove	Sea	Sum
Diversity Index	1.67	2.36	1.82	2.44
Evenness Index	0.80	0.89	0.94	0.84

Table 5. Plankton population and abundance at Karangsong, Indramayu, West Java, Indonesia

Organism	Population (ind./L)				Relative abundance (%)
	Coast	Open mangrove forest	Dense mangrove forest	Pond	
Phytoplankton					
Bacillariophyceae					
Asterionella sp.	-	-	1.250	-	2.38
Coscinodiscus sp.	10.000	2.500	2.500	8.750	45.24
Fragilaria sp.	7.500	-	-	-	14.29
Navicula sp.	1.250	-	-	-	2.38
Surirella sp.	1.250	-	-	-	2.38
Tabellaria sp.	3.750	1.250	-	1.250	11.90
Chlorophyceae					
Ceratium sp.	-	-	3750	-	7.15
Closterium sp.	1.250	-	1.250	-	4.76
Triceratium sp.	-	-	-	1.250	2.38
Zooplankton					
Rotifera					
Brachionus sp.	-	-	1.250	-	2.38
Cyclopid sp.	-	1.250	-	1.250	4.76

industrial, agricultural and domestic waste. Inorganic elements such as trace metals can be absorbed into the tissues of aquatic organisms through the food chain. Dissolved phosphorous is probably the most important factor affecting the water quality, because it is a driver of phytoplankton growth (Hossain 2007).

In the mangrove forest, *Ceratium* sp. (7.15%) was the most dominant of the Chlorophyceae followed by *Closterium* sp. (4.76%), and *Triceratium* sp. (2.38%) (Table 5). The dominance of *Ceratium* sp. is probably caused by various abiotic factors. The decomposition process releases mineral elements such as nitrogen, phosphorus, and other essential nutrients, a condition often indicated by a high measured concentration of phosphate. Mangrove waters are often nutrient rich habitats, with high phosphate concentrations directly promoting chlorophyll growth in primary producers.

Zooplankton has an important role in the food chain. Zooplankton diversity and abundance is much affected by factors in the environment quality of mangrove habitats, such as turbidity level, current velocity, and both physical and chemical conditions of the water. Zooplankton are good indicators of changes in water quality because they are strongly affected by environmental conditions, and having short life cycles, their communities often respond quickly to water quality changes. In our sampling at Karangsong, copepods of the *Cyclopid* sp. were the most abundant forms of zooplankton in all stations of open mangrove and pond. The abundance of *Cyclopid* sp. may be attributed to its dependence on phytoplankton and detritus as food (Bazmi 2011).

Plankton diversity

A total of six zooplankton taxa were found in the coastal sea water of the Karangsong research area (Table 6). This is more than what was found in the other sampled habitats: the sparse quayside mangroves; the ecotourism mangrove forest with thick stand density; and the ponds.

Furthermore, the density of plankton in the coastal water (25.000 ind./L) was greater than in the other the other locations; the quayside mangrove (5,000 ind./L), the ecotourism mangrove forest with thick stands density (6,250 ind./L), and the pond (1,650 ind./L). Their distribution is likely to be affected by abiotic conditions such as current, light, nutrient, and fluctuation of these conditions at different time of the day and at different location (Astuti et al. 2012).

Such abiotic conditions and the plankton that respond to them affect the productivity of fish aquaculture in ponds around mangrove forests. These face problems related to the fertility of the environment, since in habitats where there is a scarcity of mangrove vegetation, cultured Bandeng/milkfish (*Chanos chanos*) take a longer time (about 10-12 months) to obtain a size of 2-3 fishes/kg compared with another pond that only requires5-6 months for the fish to obtain 0.6 kg size (Mangampa, 2014). Polyculture of Bandeng/milkfish and seaweed (*Gracilaria* sp.) in this region, reveal positive impacts on fish growth because in addition to natural food such as plankton and milkfish will also utilize epiphytes organism at thallus *Gracilaria* sp. (Reksono et al. 2012).

The values for the diversity index (H’) of plankton obtained in the Karangsong Mangrove Forest Area, ranging between 1.040 and1.462, can be considered as quite low . According to Probosunu (2008) values for the diversity index in the range $0.81<H'<1.60$ are classified as low. Based on the diversity index (H’) values we obtained, the degree of pollution can be considered moderate ($1.0<H'<1.5$) (Probosunu 2008).

The evenness index (E) of near zero (0.122-0.152) showed domination by a certain type of plankton. This indicated that a mangrove condition in this area is unstable, especially at quayside where passing boats disturb the floor sediments mud leading to increased turbidity, and reduced phytoplankton photosynthesis due to decrease in oxygen and increase in Zn and Pb toxicity (Wahyuni et al. 2013).

Benthos community structure

The existence of macrobenthos is another indicator of water quality in the aquatic environment (Afif et al. 2014). Benthos abundance is affected by the substrate and environment of the microhabitats (pH, temperature, salinity), by food nutrients, predation, and by human activity (Riniatsih and Kushartono 2009).The base substrate that affects the benthos is the sand or mud forming a habitat strata for intertidal scavenger organisms such as mud snails Nassariidae contained in the sand and muddy substrate (Morton and Chan 2004). Predation is a factor affecting benthos density. Gastropod defense against the predators uses shell morphology and their ability to aggregate (Zaleha 2009). Human activity affecting benthos is the consumption of clams as food.

In Karangsong, we found eight kinds of micro-invertebrate or benthos that belonged to one class and three families, three of which showed relatively high abundance (>5%); *Terebra* sp. (63.93%), *Venus* sp. (13.11%) and *Lumbricus* sp. (11.48%) (Table 7). The abundance of this Gastropod class is a result of high adaptability and tolerance of variation in the hardness/softness of the substrate, in comparison with other classes (Turra and Denadai 2006; Rachmawaty 2011).

Some species of *Terebra*, such as *Terebra palustris* and *Terebra liasuleata* prefer muddy waters or spacious inundated areas (Kurniawan 2007). Such conditions are found at Unak waters, in Kota Langsa, Aceh, where gastropods were observed during high tide (82%) and low tide (67%). According to Rangan (1996) substrate condition influences the development of biotic communities of the benthos, in which mud with a little clay is a desirable substrate for Gastropods. Gastropods, particularly *Terebra* sp., compete for their existence with cultured Bandeng/milkfish. Both the gastropods and milkfish depend on plankton for food; therefore, there is a need to control the proliferation of the gastropods.

Other species of the benthos, include *Venus* sp., which is also relatively abundant because it has adapted to life in the harsh environment of the intertidal zone. *Venus* sp. are able to close their clam/shell and utilize water inside during dry and hot conditions. *Fenneropenaeus* sp. and *Scylla* sp. are species of the Crustacea family, and utilize the mangroves as nursery grounds. *Lumbricus* sp. (class

Oligochaeta), is an earthworm that can also be found in the mangrove area.

Benthos diversity

Expansion of the mangrove restoration area will increase the biodiversity of the benthos as well as fish biodiversity and abundance (zu Erngassen et al. 2015).

Table 6. Plankton Diversity and Evenness at Karangsong mangrove forest, Indramayu, West Java, Indonesia

Parameter	Location			
	Sea	Quayside mangrove	Ecotourism mangrove	Pond
Number of taxa	6	3	4	5
Individual/litre	25000	5000	6250	1650
Diversity Index (H')	1.462	1.040	1.332	1.260
Evenness Index (E)	0.144	0.122	0.152	0.130
Dominance (D)	0.280	0.335	0.280	0.361

Table 7. Population and abundance of benthos at Karangsong Mangrove Conservation Area, Indramayu, West Java, Indonesia

Organism	Population (individual/m^2)			Species relative abundance (%)
	Quayside mangrove forest	Dense mangrove forest	Pond	
Gastropoda				
Terebra sp.	210	120	255	63.93
Venus sp.	30	30	60	13.11
Nassarius sp.	15	-	-	1.64
Cassis sp.	-	-	45	4.9
Crustacea				
Fenneropenaeus sp.	15	-	-	1.64
Scylla sp.	-	-	15	1.64
Palaemonidae				
Synbranchus sp.	15	-	-	1.64
Oligochaeta				
Lumbricus sp.	45	60	-	11.48

Table 8. Benthos diversity and evenness at Karangsong mangrove conservation, Indramayu, West Java, Indonesia

Parameter	Location		
	Open mangrove forest	Thick/dense mangrove forest	Pond
Number of taxa	6	3	4
Number of ind. /m^2	330	210	375
Diversity Index (H')	1.199	0.956	0.939
Evenness Index (E)	0.207	0.179	0.158
Dominance (D)	0.438	0.429	0.504

A total of eight taxa of benthos were found in the study are. In the open area of the quayside mangrove forest there were six species; the ponds had four species, and at the high-density mangrove area there were three species. The highest number of individuals (375 individuals/m^2) was found in the pond area. This is probably due to the slow movement of the benthos in this habitat.

The diversity index (H') for the benthos of the across was 0.939 for the pond habitat, 0.956 for the dense mangrove habitat 1.199 for the low-density quayside mangrove habitat (Table 8), which places benthos diversity across the research area in the low to moderate category.

Benthos diversity is an indicator of disturbance in the ecological balance, especially of the substrate in an estuarine habitat. This can happen for example as a result of pollutant accumulation, such as of oils, that contribute to a decrease in the environmental quality (Badrun 2008). Estuarine waters polluted by human activity will exhibit a low diversity of marine organisms (Taqwa 2010).

Fachrul (2007) classifies benthos communities with an evenness index (E) between 0.158-0.207 as of low or negligible inter-species evenness, which means that the abundance of individuals differs greatly between species across an environment. In the opposite case, a high inter-species evenness E-value close to 1 means that the number of individuals of each species is relatively the same across the environment, indicating university of benthos composition habitats in the environment.

The presence of benthos with Dominance value (D) of 0,504 at the pond showed species domination (D>0,5). This is affected by The abundant presence of *Terebra* sp. is considered as a pest because they compete with milkfish for food. The Dominance (D) for the benthos of the pond area was quite high, at 0.504, reflecting the relatively high relative abundance of the *Terebra* sp.

In conclusion, the Karangsong Mangrove Conservation Area of Indramayu, West Java, was found to have a total of 18 fish species from 16 families, out of which 44.44% were omnivores, while 38.89% and 16.67% were carnivores and herbivores respectively. The mangroves harbored plankton such as Bacillariophyceae (78.57%), followed by Chlorophyceae (14.29%) and Rotifera (7.14%). Macrobenthos creatures such as Gastropods, Crustacea, Palaemonidae, and Oligochaeta were also recorded; however, they had low to moderate diversity index (H'). Finally, the overall diversity of plankton resources at Karangsong mangrove forest is categorized as poor or low, because its diversity index (H') ranged between only 1.040 and 1.462.

ACKNOWLEDGEMENTS

We gratefully acknowledge our Forest Research and Development Institution for its support of this research; the Biotrop Laboratory for assistance in analyzing samples; and Pertamina for a supporting donation that enabled the collection of data and information regarding the progress of mangrove rehabilitation at Karangsong, Indramayu, West

Java, Indonesia. For his much-valued assistance, we would like to thank Dr. Graham Eagleton.

REFERENCES

Abraham KJ, Joshi KK, Murty VSR. 2011. Taxonomy of the fishes of the family Leiognathidae (Pisces, Teleostei) from the West coast of India. Zootaxa 2886: 1-18.

Afif JS, Ngabekti TA, Pribadi. 2014. Diversity of macrozoobenthos as an indicator of water quality in the mangrove ecosystem Tapak Region, Village Tugurejo, Semarang. Unnes J Life Sci 3: 47-52.

Ajuonu N, Ukaonu SU, Oluwajoba EO, Mbawuike BE, Williams AB, Myade EF. 2011. The abundance and distribution of plankton species in the bonny estuary. Agric Biol J North Amer 6: 1032-1037.

Astuti RP, Imanto PT, Sumiarsi GS. 2012. Some types of microalgae diatom abundance in the waters of Gumilamo-Magaliho, North Halmahera. Jurnal Ilmu dan Teknologi Kelautan Tropis 4 (1): 97-106. [Indonesian]

Badrun Y. 2008. Quality analysis and the activities of the petroleum industry Kota Dumai. Jurnal Ilmu Lingkungan 2: 58-79. [Indonesian]

Bappeda Indramayu [Regional Development Planning Board Indramayu District]. 2011.Spatial Plan 2011-2031. Indramayu District, Indramayu. [Indonesian]

Bazmi SHM, Shahabuddin MAM, Sayeed Akhtar SM. 2011. Seasonal fluctuation of zooplankton community in relation to certain physicochemical parameters of river Bagmati of Darbhanga, Bihar. Environ. Ecol 29: 922-925.

Benke AC. 2010. Secondary production. Nature Edu Knowl 8: 1-5.

Biswas SN, Rakshit D, Sarkar SK, Sarangi RK, Satpathy KK. 2014. Impact of multispecies diatom bloom on plankton community structure in Sundarban mangrove wetland India. Mar Pollut Bull 85: 306-311.

Chong VC, Sesakumar A, Leh MUC, Cruz RD. 2006. The fish and prawn communities of a Malaysian coastal mangrove system, with comparisons to adjacent mud flats and inshore waters. Estuar Coast Shelf S.31: 703-722.

Chowdhury MS, Hossain NG. 2010. Barua environmental variables and fisheries diversity of the Naaf river estuary. Coast Conserv 15: 163-180.

Fachrul MF. 2007. Sampling Methods in Bioecology. Bumi Aksara, Jakarta. [Indonesian]

Fischer J (ed.). 2013. Fish identification tools for biodiversity and fisheries assessments: review and guidance for decision-makers. FAO Fisheries and Aquaculture Technical. FAO, Rome.

Gracia SM, Resenberg AA. 2011. Food security and marine capture fisheries: Characteristics, trends, driver and future perspective. Phil Trans R Soc London Biol Sci 365: 2869-2880.

Gunarto. 2004. Conservation mangrove as supporting resources conservation coastal fisheries. Indon Agric Sci 23: 33-38. [Indonesian]

Hossain MY, Jasmine S, Ibrahim AHM, Ahmed ZF, Ohtomi J, Fulanda B, Begum M, Mamun A, El-Kady MAH, Wahab MA. 2007. A preliminary observation on water quality and plankton of an earthen fish pond in Bangladesh. Biol Sci 10: 868-873.

Kurniawan. 2007. The Function and Role in the Ecosystem of Mangrove Gastropods. [Thesis]. Universitas Indonesia, Jakarta. [Indonesian]

Mangampa M, Burhanuddin. 2014. Field experiment of polyculture technology of tiger shrimp (*P. monodon* Farb.), milkfish (*Chanos chanos* Forskal), and seaweed (*Gracilaria verrucosa*) in brackhiswater water pond of Borimasunggu village, Maros District. Jurnal Saintek Perikanan 10 (1): 30-36. [Indonesian]

Mason CF. 1991. Biology of Freshwater Pollution. John Wiley & Sons. Inc., New York.

Mmom CP, Arokoyu SB. 2010. Mangrove forest depletion, biodiversity loss and traditional resources management practices in the Niger Delta. J Appl Sci Eng Technol 2: 28-34.

Morton B, Chan K. 2004. The population dynamics of *Nassarius festivus* (Gastropods, Nassariidae) on three environmentally different beaches in Hongkong. J Mol Stud 70: 329-339.

Muddula KN, Govinda RV, Joseph U, Ranjan T, Siva KV, Ramesh BK. 2015. Length-weight relationship of pugnose ponyfish *Secutor insidiator* (Bloch, 1787) (Family: Leiognathidae) from the Visakhapatnam Coastal Waters, North East Coast of India. Res J Anim Vet Fish Sci 3 (5): 1-4

Nontji A. 2008. Marine Plankton. LIPI Press, Jakarta. [Indonesian]

Odum EP.1996. Fundamental of Ecology. 3rd ed. W.B. Saunders Co. London

Patty W. 2008. Vertical distribution of fish in coastal waters mangrove North Minahasa District in North Sulawesi. Indon J Mar Sci 13 (3): 153-158. [Indonesian]

Polat S, Sarihan E, Koray T. 2000, Seasonal changes in the phytoplankton of the northeastern Mediterranean (Bay of Iskenderun). Turkey J Bot 24: 887-906.

Probosunu N. 2008. Practical Hints Aquatic Ecosystems. Laboratorium Ekologi Perairan Jurusan Perikanan. Fakultas Perikanan, Universitas Gajah Mada, Yogyakarta. [Indonesia]

Rahmawaty. 2011. Diversity index of macrobenthos as a bio-indicator of pollution levels in the estuary Jereberang. Bionature 12 (2): 103-109. [Indonesia]

Rangan JK. 1996. Community structure and typology Gastropods at zone mangrove forest Kulu, Minahasa, North Sulawesi. [Thesis]. Institut Pertanian Bogor, Bogor. [Indonesia]

Reksono B, Hamdana, Yuniarti MS. 2012. Density effect of Gracilaria sp. life growth and survival of milkfish (*Chanos chanos*) at farming polyculture system. J Perikanan dan Kelautan 3 (3): 41-49. [Indonesian]

Riniatsih I, Kushartono EW. 2009. The base of substrate and oceanographic parameters as determining the presence of gastropods and bivalves in Turkish Sluhe, Rembang. Indon J Mar Sci 14 (1): 50-59.

Subiyanto, Ruswahyuni, Cahyono DG. 2008. Composition and distribution of fish pelagic larvae In East Pelawangan Estuaria, Segara Anakan, Cilacap. Indon J Fish Sci Technol 4 (1): 62-68. [Indonesian]

Turra A, Denadai MR. 2006. Microhabitat use by two rocky shore gastropods in an intertidal sandy substrate with rocky fragments. Brazil J Biol 66 (1B): 351-355.

Unsworth RKF, Wylie E, Bell JJ, Smith DJ. 2007. Diel trophic structuring of seagrass bed fish assemblages in the Wakatobi Marine National Park, Indonesia. Estuar Coast Shelf S.72: 81-88

Wahyudewantoro, Haryono. 2011. Mangrove fish in some rivers around Ujung Kulon National Park, Pandeglang: Rainy Season Preview. Bionature 13 (3): 12-19

Wahyuni H, Sasongko SB, Sasongko DP. 2013. The content of heavy metals in water, sediment and plankton communities in mining areas Batu Belubang Village, Central Bangka. Proceedings Seminar on Management of Natural Resources and Environment: Diponegoro University, Semarang, 10 September 2013. [Indonesian]

Wardana W. 2006. Methods of forecasting and managing the impact on aquatic biotic components. Training Model Compiler Environment Impact Assessment. Pusat Penelitian Sumber Daya manusia dan Lingkungan. Universitas Indonesia, Jakarta. Indonesian

Zaleha K, Farah DMF, Amira SR, Amirudin A. 2009. Benthic community of the Sungai Pulai Seagrass Bed, Malaysia. Malay J Sci 28 (2): 143-159.

Zakaria M, Rajpar N. 2015. Assessing the fauna diversity of Marudu Bay Mangrove Forest, Sabah, Malaysia, for future conservation. Diversity 7: 137-148

zu Erngassen DSE, Grabowski JHG, Gain JR, Powers SP. 2015. Quantifying fish and mobile invertebrate production from a threatened nursery habitat. J Appl Ecol53 (2): 596-606.