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Short Communication: Community structure of prawns (Decapoda: Penaeidae and Palaemonidae) in mangrove inlets of Kuala Langsa, Aceh, Indonesia

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Abstract. *Faisal TM, Akbar H, Putriningtias A, Putra SA. 2019. Short Communication: Community structure of prawns (Decapoda: Penaeidae and Palaemonidae) in mangrove inlets of Kuala Langsa, Aceh, Indonesia*. *Biodiversitas 20: 1306-1311.* The aim of this research is to describe the structure of prawn community that found at mangrove inlets of Kuala Langsa (Aceh, Indonesia). The survey was done in August 2018. Sampling sites were defined as arbitrarily. Scope netting (mesh size 1 cm and diameter 100 cm) was used to sample the prawn community. Samples were analyzed and stored at The Primary Laboratory of Universitas Samudra, Kota Langsa, Aceh. Five species of prawns from two families (i.e., Decapoda: Penaeidae and Palaemonidae) were found, i.e., *Penaeus monodon, Penaeus indicus, Metapenaeus monoceros, Penaeus vannamei, Palaemon* sp. The most dominance species found is *M. monoceros*, and the most infrequently species found is *Palaemon* sp. Prawn community between sampling sites are found in a high level of similarity, with medium diversity and evenness index, and no dominance indicated.

Keywords: Biodiversity, community structure, Indonesia, Kuala Langsa, mangrove, prawn

INTRODUCTION

Mangrove forests are a part of natural ecosystems that have an important role in the coastal environment and its surroundings. Mangrove forests can be used as a barrier to abrasion, waves, strong winds, seawater intrusion controllers, and land builders through a sedimentation process (Saenger 2002; Schaduw 2013). In the other hands, mangrove area is also used for various development purposes, e.g. tourism, marine culture, logging, settlements, and transportation (Bennett and Reynolds 1993; Dahdouh-Guebas et al. 2000; Valiela et al. 2001; Schaduw 2013). The interaction between species in mangrove forests has an important role in the equilibrium of populations, communities and another process that occurs at the ecosystem level (Tomlinson 1994).

Benthic organisms are also important for energy flow in mangrove ecosystem, can be seen from their abundance in this ecosystem (Woodroffe 1982; Sukardjo 2004; Hogarth 2007, Sari et al. 2017). One of the benthic organisms that commonly found in the mangrove area is prawn (Crustacea: Decapoda). Staples et al. (1985) showed the larvae and juvenile prawn commonly found in the mangrove area. Prawns and other invertebrates inhabiting the mangrove ecosystem as a decomposer of mangrove litter. They mechanically process the litter (i.e., mangrove leaves and other parts) into smaller particles. This process makes expand the surface for decomposed by other microorganisms, e.g. amphipods, bacteria, fungi (Woodroffe 1982; Alongi 1994; Yulma et al. 2017; Sari et al. 2017).

The coast of Kuala Langsa (Langsa City, Aceh, Indonesia) is an estuary and its surrounding of wetlands, mangrove forests, and inlet/river. It is experiencing semi-diurnal tides with average ranges of 2,5 m (Sugiarti et al. 2014), and the condition of the mangrove ecosystem in this area has a significant impact on the economic growth of the people community surroundings (Wetland International 2009). Vegetation of mangrove forests in Kuala Langsa is around 7.837 hectares and dominated by *Rhizophora* species. The area of mangrove forests protected by the local regulation (local: *qanun*), and used as an ecotourism purpose (BPS 2015; Febri et al. 2017). A positive correlation between near-shore catches of prawn or shrimp and mangrove area has been reported. Mangrove forest act as nursery areas for larval and juvenile prawns and fishes. (Martosubroto and Namiin 1977; Sukardjo 2004). However, information regarding the abundance and diversity of mangrove prawn community in Aceh, especially in the Kuala Langsa are still unknown. Here, we try to present the diversity of prawn community that occupies mangrove vegetation in Kuala Langsa. This information is important for knowing crustacean diversity and as reference consideration for sustainable mangrove management in that area.

MATERIALS AND METHODS

Study area

This research was conducted in mangrove inlets of Kuala Langsa, Langsa City, Aceh, Indonesia. The sampling sites were defined arbitrarily by purposive sampling method (Singarimbun and Effendi 1982). Sampling sites were divided into three mangrove inlets with different environmental characteristics (see Figure 1). Station 1 at 6 Km street, which has vegetation of mangrove forests adjacent to the fiber boat manufacture factory. Station 2 at Alur Badai, which nearly pristine from human activity with calm water. Station 3 at Simpang Lhee, which is not too dense mangrove vegetation (estimated to be one year old), and also heavy shipping traffic from Port of Kuala Langsa (see Supplementary Figure 1 for detail of study location).

Procedures

This research was conducted between June and August 2018. Explorative description method was used to describe systematically characters of a particular population (Suryabrata 1993). Structure of the community will be calculated as diversity, evenness, dominance, and similarity index (Krebs 1989; Odum and Barrett 2004). Specimen collecting was done using scope netting (mesh size 1 cm, diameter 100 cm) in four weeks during low tide in the morning. Specimens then grouped base on morphological forms, collected representatively, and photographed, then preserved (70% alcohol) in the bottles with labeled-containing information about the date and location (Pratiwi 2008). The specimens were identified by external morphological characters (Cardover and Brick 1972). All collections were stored at Primary Laboratory of the Universitas Samudra, Kota Langsa, Aceh, for further study. Furthermore, the environmental parameters (i.e., temperature, salinity, pH, depth) also measured with in-situ devices (i.e., water checker, hand-refractometer, roll-meter/rope) as supporting data.

Data analysis

The abundance of prawns calculated as a total number of individuals per unit area, i.e. 10 m x 10 m (Odum and Barrett 2004) (Equation 1). Biodiversity indexes were calculated from Shannon-Wiener diversity (*H'*) and evenness index (*e*) (Equation 2 and 3) to describe the species diversity and equitability (Odum and Barrett 2004). Where Simpson dominance index (*C*) was calculation form (Equation 4) for indicating the domination between prawn communities (Odum and Barrett 2004). The similarity index (*S*) used (Equation 5) to compare the level of similarity between two communities (Odum and Barrett 2004).

$$A = \frac{xi}{ni} \quad (1)$$

A = Abundance
xi = Individual number of species -i
ni = Unit area of sampling site was used (10 m x 10 m)

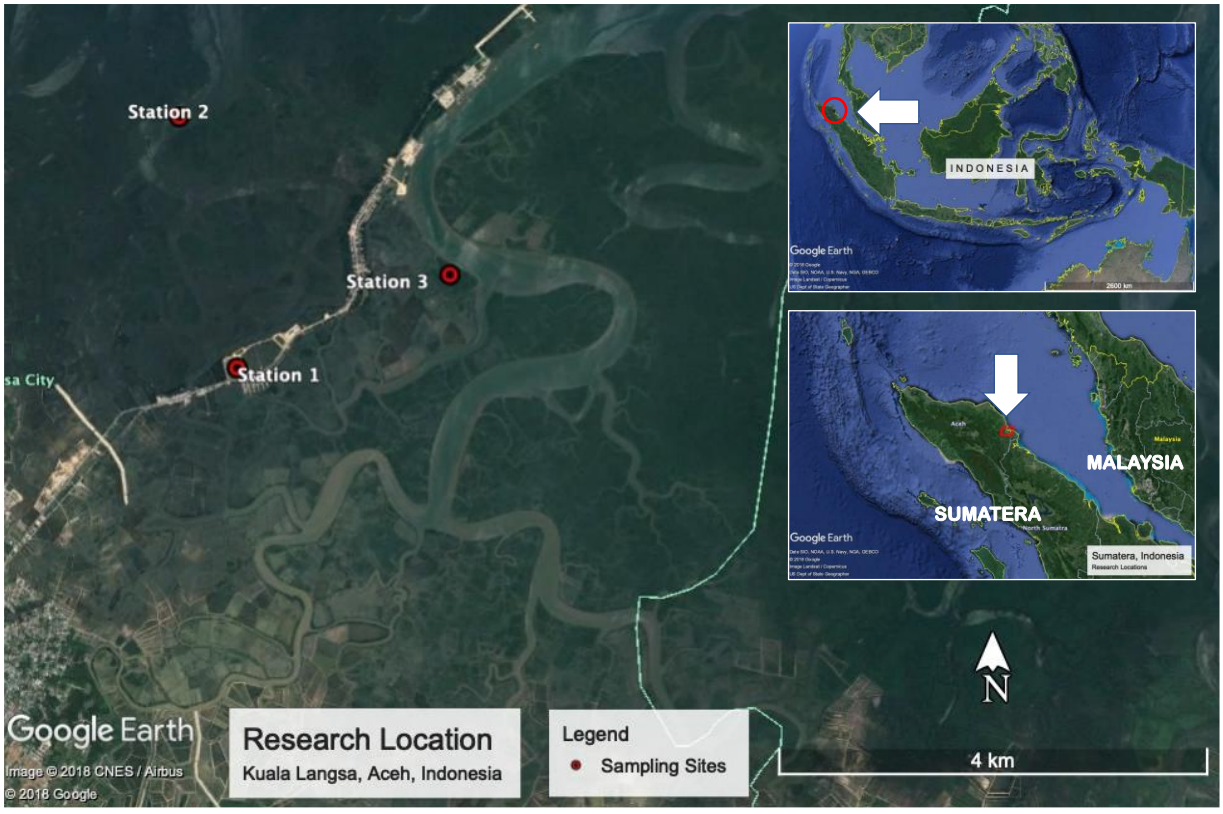

Figure 1. Research area in mangrove inlets of Kuala Langsa. Red dots indicating the sampling sites: Station 1 (4°29'56.13"N, 98° 0'2.04"E), Station 2 (4°31'15.36"N, 97°59'41.88"E), and Station 3 (4°30'25.10"N, 98° 1'7.64"E). Source: Google Earth 2018

$$H' = -\sum_{1}^{\infty} \frac{ni}{N} \log_2 \frac{ni}{N} \quad (2)$$

H' : Shannon-Wienner Diversity Index
∞ : Species number
ni : Individual number of species -i
N : Total individual numbers of all species

Diversity Index criteria based on Odum and Barrett (2004):
$H' < 1$: low diversity
$1 \leq H' \leq 3$: medium diversity
$H' > 3$: high diversity

$$e = \frac{H'}{LogS} \quad (3)$$

e : Evenness Index
H' : Shannon-Wienner Diversity Index
S : Number of species

Evenness value ranges between 0 -1 (Krebs 1989):
$e > 0.6$: high evenness
$0.4 \leq e \leq 0.6$: medium evenness
$e < 0.4$: low evenness

$$C = \sum \left(\frac{ni}{N}\right)^2 \quad (4)$$

C : Simpson Dominance Index
ni : Individual number of species -i
N : Total individual number of all species

Simpson Dominance Index criteria based on Odum and Barrett (2004):
$0 < C < 0.5$: No species dominance indicated
$0.5 > C > 1$: Species dominance indicated

$$S = \frac{2C}{A+B} x100\% \quad (5)$$

S : Similarity Index
C : Number of species from two sites
A : Number of species in 1st sampling site
B : Number of species in 2nd sampling site

Similarity Index criteria based on Odum and Barrett (2004):
1-30% : low
31-60% : medium
61-91% : high
> 91% : very high

RESULTS AND DISCUSSION

Prawn community

A total of 128 specimens were encountered during observation. Five species of mangrove prawns from two families were identified, i.e. *Penaeus monodon* Fabricius 1798, *Penaeus indicus* H. Milne Edwards 1837, *Metapenaeus monoceros* (Fabricius 1798), and *Penaeus vannamei* Boone 1931 (Family: Panaeidae); *Palaemon* sp. Weber 1795 (Family: Palaemonidae). Generally, the most abundant and commonly found species (n = 32) is *M. monoceros*, this species often found in the muddy-sand substrate, while the least common is *Palaemon* sp. (see Figure 2).

Prawn diversity

Diversity index of prawn community in mangrove inlets of Kuala Langsa is about 0.55 to 1.00. Where the highest value found at Station 2 and the lower value found at Station 3. Evenness index showed that the lowest value found at Station 3 and the highest found at Station 1, (0.28 and 0.43, respectively), and Simpson dominance index showed no indication of species dominance (0.09 -0.30) in mangrove inlets of Kuala Langsa (see Table 1). Prawn community between sampling sites also found in the high level of similarity (88.89 -100.00%).

Environmental quality

Environmental parameters in research location showed in good condition (see Table 2). *pH* concentration in an average of 8.2±0.1 and dissolved oxygen known about 6.9±1.3. Water temperature during the surveyed is about 22 to 24 °C, where the salinity measurement showed about 20±1.2 psu.

Table 1. Number of species found and biodiversity index of prawn community in mangrove inlets of Kuala Langsa, Aceh, Indonesia

Family	Species	Station		
		1	2	3
Penaeidae	*Penaeus monodon*	8	10	7
	Penaeus indicus	9	12	7
	Penaeus vannamei	12	10	-
	Metapenaeus monoceros	10	15	7
Palaemonidae	*Palaemon* sp.	7	8	6
Number of species		5	5	4
Abundance (N = 128)		46	55	27
Diversity Index		0.97	1.00	0.55
Evenness Index		0.42	0.43	0.28
Dominance Index		0.21	0.30	0.09

Table 2. Environmental parameters measurement in mangrove inlets of Kuala Langsa, Aceh, Indonesia

Water Quality	Unit	Station			Mean*	SD**
		1	2	3		
pH	-	8.1	8.2	8.4	8.2	0.1
Dissolved Oxygen	-	8	7.6	5	6.9	1.3
Temperature	°C	23	22	24	23	0.8
Salinity	psu	19	20	22	20	1.2
Depth	cm	6	9	3	6	2.4

Note: *average, **standard deviation

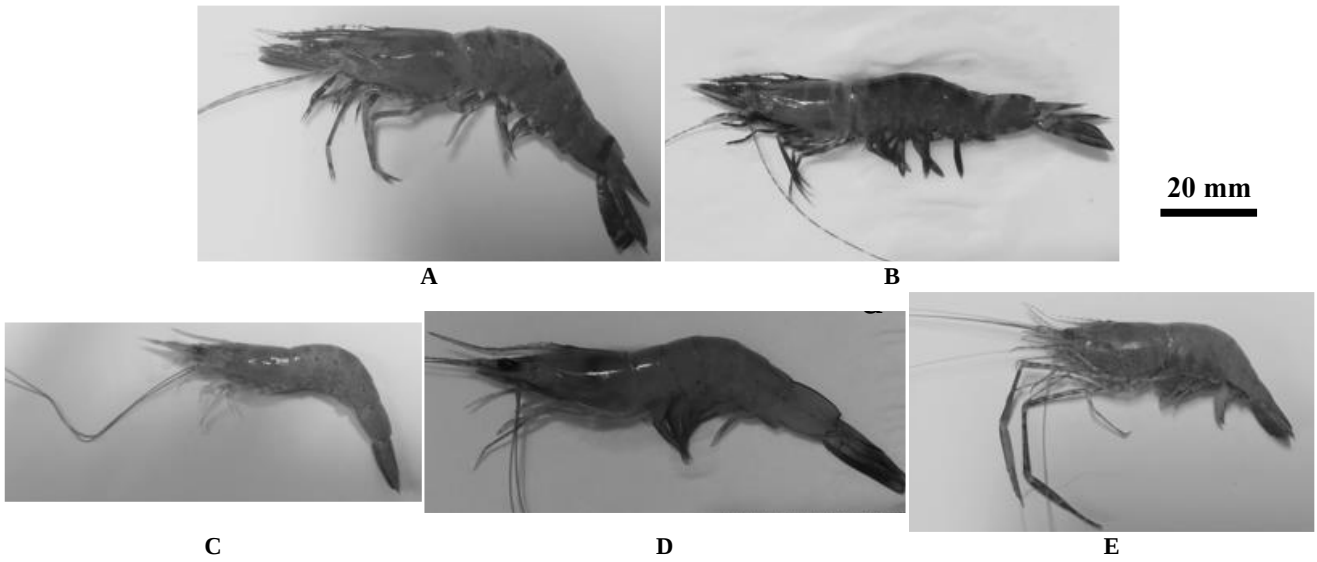

Figure 2. Prawn community found in mangrove inlets of Kuala Langsa, Aceh, Indonesia. A. *Penaeus monodon* Fabricius 1798; B. *Penaeus indicus* H. Milne Edwards 1837; C. *Metapenaeus monocerus* (Fabricius 1798); D. *Penaeus vannamei* Boone 1931; E. *Palaemon* sp. Weber 1795. Scale bar: 20 mm

Discussion

The most abundant species found is *M. monoceros* in the sampling site with good condition vegetation of mangrove forest (i.e. Station 2). *M. monoceros* was originally found in the Indo-West Pacific and is a demersal species. This prawn is one of the most important commercial species in another region like in African coast, Mediterranean Sea, Red Sea, Madagascar, India, and Bay of Bengal (Holthuis 1980; Kumlu et al. 2001). They live in shallow waters down to 60 meters, mostly between 10 and 30 meters. This euryhaline species prefers sandy and sandy-mud bottoms in brackish to marine salinities as low as 5 and up to 30 ‰. Juveniles are found in estuaries, lagoons or coastal areas, the adults further offshore (Holthuis 1980; FAO-MedSudMed 2018). According to our observation, this prawn is living in a group during the day and the night, rarely found immerses itself in the mud and almost always active especially in the night.

Three major biotic factors are considered as the abundance controls of estuarine macrofaunal: food supply, the supply of colonizing larvae, and interspecies competition (Wildish 1977). The abundant availability of food derived from organic matter in Station 2 will also affect the abundance of other mangrove fauna, such as zooplankton. The high abundance of zooplankton will also affect the supply of food (Harjo 2009). That is why Station 2 found more abundance of prawn community than other stations. Furthermore, the environmental conditions in the research location (see Table 2) are still suitable for habitat preference of prawn community (Hawkes 1978).

Mangrove inlets between sampling sites are not far from each other and still in one coastline of Kuala Langsa (see Figure 1). The environmental condition between sampling sites is not much different. Salinity, *pH*, and temperature in all sampling sites did not show any significant differences (indicated by low SD value, see Table 2). Communities with the same abundance may differ in diversity based on the individual's distribution among the species (McIntosh 1967). It makes the prawn community here in high to very high similarity between sampling sites (> 61%), also makes diversity in research location is in low to medium category (H'<1). Maximum diversity results if individuals are distributed equally among species and no dominance indicated (McIntosh 1967). The evenness index value is in the low to moderate category (0.28 -0.43), and was no dominance indicated (0.09 -0.30). The low evenness index means the distribution between species are not same and tends to be dominated by certain species, while the high evenness index means the distribution between species are same, and there will be no dominance indicated (Odum and Barrett 2004).

Waters with high nutrients contain around mangrove inlets are caused by the inclusion of organic material derived from mangrove litter (Nonjti 1987). Nutrient recycling in the mangrove ecosystem is highly promoted by litter-consuming mangrove communities such as crabs, prawns, mollusks (Stoner and Zimmerman 1988; Nordhaus and Wolff 2007). The falling mangrove leaves were broken down by fungi, bacteria, and protozoa into smaller organic components (i.e., detritus) which became a food source for primary or secondary consumers (Naamin 1990; Sasekumar et al. 1992; Alongi 1994). In the other hands, crustaceans like prawn or other secondary consumers are omnivorous (i.e., feed both plants and animals), make it easy to get food (Wardhana 2008).

The distribution of prawn community (i.e., diversity, evenness, similarity) is also determined by genetics and habitat preference (Krebs 1989; Sukardjo 2004; Annawaty et al. 2016). The number of prawn species found in

mangrove inlets of Kuala Langsa as large as prawn community in mangrove inlets at Selangor, Malaysia, which is nine species found (Sasekumar et al. 1992). The species richness will decrease when mangrove area experiencing disturbance, such as Segara Anakan Lagoon (Cilacap, Central Java), only three species were found (Zurochman 2003), this is suspected due to the environmental condition in Kuala Langsa and Selangor are relatively better than the Segara Anakan Lagoon, which has experienced a decrease in environmental quality caused by sedimentation and pollution. Highly disturbance and water quality decrease in a particular area can make some benthic fauna challenging to find (Akbar et al. 2018). A large number of prawn species found at the study location is also very dependent on the survival of their juveniles. Mangrove ecosystem is a place to take refuge for small nekton (e.g., fishes, decapods) from various predators (Martosubroto and Namiin 1977; Laegdsgaard and Jhonson 1995; Nagelkerken et al. 2000; Laegdsgaard and Jhonson 2001; Sheridan and Hays 2003). This prawn community will be also difficult to find in a lower intertidal and upper subtidal coastal zone, i.e. seagrass bed ecosystem (Hamid and Wardiatno 2018).

Prawn community found in mangrove inlets of Kuala Langsa is in a high level of similarity, with low to medium diversity and evenness, there was also no indication of dominant species. Five species of prawns were described, where the most abundance community and species found in the mangrove forests with nearly pristine from human activity with calm water. The environmental condition in mangrove inlets of Kuala Langsa relatively suitable for habitat preference of prawn community. This research shows us that prawn community will be commonly found rich in the area with dense vegetation of mangrove forests and good environmental condition.

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REFERENCES

Akbar H, Suyatna I, Jailani, Putra SA, Azmi F. 2018. Effects of anthropogenic activity on stream water quality in Langsa, Aceh. Jurnal Biologi Tropis 18 (2): 200-207. DOI: 10.29303/jbt.v18i2.826.

Alongi DM. 1994. The role of bacteria in nutrient recycling in tropical mangrove and other coastal benthic ecosystem. Hydrobiologia. 285 (1-3): 19-23.

Annawaty A, Wowor D, Farajallah A, Setiadi D, Suryobroto B. 2016. Habitat Preferences and Distribution of the Freshwater Shrimps of the Genus Caridina (Crustacea: Decapoda: Atyidae) in Lake Lindu, Sulawesi, Indonesia. Hayati J Biosci 23 (2): 45-50. DOI: 10.1016/j.hjb.2016.04.001

Bennett EL, Reynolds CJ. 1993. The value of a mangrove area in Serawak. Biodiv Conserv 2: 359-375.

BPS. 2015. Statistik Daerah Kota Langsa 2015. Badan Pusat Statistik Kota Langsa, Aceh. [Indonesian]

Cardover RD, Brick RW. 1972. Guide to the Identification of Commercially Important Shrimp of Southeast Asean Inshore Waters. Prepared for the Mekong Committee Giant Prawn Culture Training Program, Summer 1972. University of Hawaii, Honolulu, USA.

Dahdouh-Guebas F, Mathenge C, Kairo JG, Koedam N. 2000. Utilization of mangrove wood products around Mida Creek (Kenya) amongst subsistence and commercial users. Econ Bot 54 (4): 513-527. DOI: 10.1007/BF02866549

Febri SP, Putriningtias A, Faisal TM. 2017. Kondisi Vegetasi Hutan Mangrove Kuala Langsa, Kota Langsa, Aceh. Jurnal Ilmiah Samudera Akuatika 1 (1): 12-19. [Indonesian]

FAO-MedSudMed. 2018. *Metapenaeus monoceros* (Fabricius, 1798). FAO UN, Rome, Italy.

Hamid A, Wardiatno Y. 2018. Diversity of decapod crustaceans in Lasongko Bay, South-east Sulawesi, Indonesia. Biodiv J 9 (3): 303-311. DOI: 10.31396/Biodiv.Jour.2018.9.3.303.311

Hawkes HA. 1978. River Zonation and Classification. In: Whitten BA (ed). River Ecology. Blackwell Scientific Publication, Oxford.

Hogarth PJ. 2007. The Biology of Mangroves. Oxford University Press Inc., New York.

Holthuis LB. 1980. FAO Species Catalogue Vol. 1: Shrimps and Prawns of the World. FAO, Rome.

Krebs CJ. 1989. Ecology: The Experimental Analysis of Distribution and Abundance. Harper and Row Publisher, New York.

Kumlu M, Eroldogan OT, Saglamtimur B. 2001. The effects of salinity and added substrates on growth and survival of *Metapenaeus monoceros* (Decapoda: Penaeidae) post-larvae. Aquaculture 196 (1-2): 177-188. DOI: 10.1016/S00 44-8486 (00)00580-9.

Laegdsgaard P, Jhonson CR. 1995. Mangrove habitats as nurseries: unique assemblages of juvenile fish in subtropical mangroves in eastern Australia. Mar. Ecol. Prog. Ser. 126: 67-81. DOI: 10.3354/meps126067

Laegdsgaard P, Jhonson C. 2001. Why do juvenile fish utilize mangrove habitats? J Exp Mar Biol Ecol 257 (2): 229-253. DOI: 10.1016/S0022-0981 (00)00331-2

Martosubroto P, Naamin N. 1977. Relationship between tidal forests (mangroves) and commercial shrimp production in Indonesia. Mar Res Indon 18: 81-86.

McIntosh RP. 1967. An index of diversity and the relation of certain concepts to diversity. Ecology 48 (3): 392-404.

Nagelkerken I, van der Velde G, Gorissen MW, Meijera GJ, van't Hof T, den Hartog C. 2000. Importance of mangroves, seagrass beds and the shallow coral reef as a nursery for important coral reef fishes, using a visual census technique. Estuar Coast Shelf Sci 51: 31-44. DOI: 10.1006/ecss.2000.0617.

Nordhaus I, Wolff M. 2007. Feeding Ecology of The Mangrove Crab *Ucides cordatus* (Ocypodidae): Food choice, food quality and assimilation efficiency. Mar Biol. DOI: 10.1007/s00227-006-0597-5.

Odum EP, Barrett GW. 2004. Fundamentals of Ecology. 5th ed. Brooks Cole, Belmont, CA.

Pratiwi R. 2008. Modul Sosialisasi Pelatihan Sumberdaya Manusia Kelautan Indonesia (PSM-TKI). Jakarta: P2O LIPI.

Saenger P. 2002. Mangrove Ecology, Silviculture and Conservation. Springer Science & Business Media. The Netherlands. DOI: 10.1007/978-94-015-9962-7

Sari KW, Yunasfi, Suryanti A. 2017. Decomposition of mangrove leaf litter *Rhizophora apiculatain* Bagan Asahan Village, Tanjungbalai District, Asahan Regency, North Sumatera Province. Acta Aquatica 4 (2): 88-94.

Schaduw JNW. 2013. Small island mitigation based on mangrove ecosystem management in Bunaken National Park. Aquat Sci Managq 1 (2): 133-142.

Sasekumar A, Chong VC, Leh MU, D'Cruz R. 1992. Mangroves as a habitat for fish and prawns. Hydrobiologia 247 (1-3): 195-201. DOI: 10.1007/bf00008219

Sheridan P, Hays C. 2003. Are mangroves nursery habitat for transient fishes and decapods? Wetlands 23 (2): 449-458. DOI: 10.1672/19-20

Singarimbun M, Effendi S. 1982. Metode Penelitian Survei. LP3ES, Jakarta. [Indonesian]

Staples D, Vance D, Heales D. 1985. Habitat requirements of juvenile penaeid prawns and their relationship to offshore fisheries. In: Rothlisberg PC, Hill BJ, Staples DJ (eds). Proceeding of Second Australian National Prawn Seminar, Kooralbyn, Qld (AU): CSIRO, Cleveland, October 1984.

Stoner AW, Zimmerman RJ. 1988. Food pathways associated with penaeid shrimps in a mangrove-fringed estuary. Fisher Bull 86 (3): 543-551.

Sugiarti AS, Marwan, Setiawan I. 2014. Tidal analysis at kuala langsa and pusong island using admiralty method. In: Muchlisin ZA, Supardan MD (eds). Proceeding of the 4th AIC Syiah Kuala University, Banda Aceh, Indonesia, 22-24 October 2014.

Suryabrata S. 1993. Metodologi Penelitian. Rajawali Press, Jakarta. [Indonesian]

Sukardjo, S. 2004. Fisheries associated with mangrove ecosystems in Indonesia: A view from a mangrove ecologist. Biotropia 23: 13-39. DOI: 10.11598/btb.2004.0.23.201.

Tomlinson PB. 1994. The Botany of Mangrove. Cambridge University Press, Cambridge.

Valiela I, Bowen JL, York JK. 2001. Mangrove forests: One of the world's threatened major tropical environments. BioScience 51 (10): 807-815.

Wardhana AW. 2008. Struktur Komunitas, Komposisi dan Kondisi Biologi Krustasea di Vegetasi Mangrove Teluk Awur, Jepara [Thesis]. Universitas Diponegoro, Semarang. [Indonesian]

Wetlands International. 2009. Hutan Mangrove Kuala Langsa Aceh. Wetlands International, Bogor, Indonesia. [Indonesian]

Wildish DJ. 1977. Factors controlling marine and estuarine sublittoral macrofaunal. Helgoländer wissenschaftliche Meeresuntersuchungen 30 (1-4): 445-454. DOI: 10.1007/BF0220 7853.

Woodroffe CD. 1982. Litter production and decomposition in the New Zealand mangrove, *Avicennia marina* var. *resinifera*. N Z J Mar Freshw Res 16 (2): 179-188. DOI: 10.1080/00288330.1982.9515961

Yulma, Ihsam B, Sunarti, Malasari E, Wahyuni N, Mursyban. 2017. Identifikasi bakteri pada serasah daun mangrove yang terdekomposisi di Kawasan Konservasi Mangrove dan Bekantan (KKMB) Kota Tarakan. J Trop Biodiv Biotech 2: 28-33. DOI: 10.22146/jtbb.27173.

Zurochman. 2003. Laju Tangkap Udang dan Masalah Jaring Apong di Pelawangan Timur sebagai Landasan Manajemen Perikanan Laguna Segara Anakan [Thesis]. PPS Universitas Diponegoro, Semarang. [Indonesian]