FINAL REPORT
DIPA BIOTROP 2018

TROPHIC STRUCTURE OF MACROZOOBENTHOS COMMUNITY ON MANGROVE EKOSISTEM

Ananingtyas Septia Darmarini

MINISTRY OF EDUCATION AND CULTURE
SECRETARIAT GENERAL
SEAMEO SEAMOLEC
SOUTHEAST ASIAN REGIONAL CENTRE FOR TROPICAL BIOLOGY
(SEAMEO BIOTROP)
2018

Approval sheet

1. ResearchTitle : Trophic Structure of Macrozoobenthos Community on Mangrove Ecosystem
2. Research Coordinator
   a. Name : Ananingtyas Septia Darmarini
   b. Sex : Female
   c. Occupation : Lecturer in Teuku Umar University, Meulaboh, Aceh
3. Institution
   a. Name of Institution : Bogor Agricultural University
   b. Address : .Agatis Kampus IPB Darmaga, Bogor
   c. Telephone/Fax. : +622518622932
   d. Email Address : pssdpipb@gmail.com

4. Research Schedule : 9 months
5. Research Budget :

Bogor, 01 Desember 2018

Endorsed by
Deputy Director for Programme
SEAMEO BIOTROP

Research Coordinator

Dr. Jesus C. Fernandez

Ananingtyas Septia Darmarini
NIDT.:05919750915 20740202

Approved by
Director of SEAMEO BIOTROP

Dr. Ir. Irdika Mansur, M.For.Sc
NIP 19660523 199002 1 001

List of content

List of Table

List of Figure

Abstract

Mangrove ecosystems provide a large role in the presence of macrozoobenthos which will have an impact on the availability of food sources for fish. Research carried out in the mangrove ecosystem of Lubuk Damar, Aceh Tamiang, Aceh showed the results of and percentage of the presence of macrozoobenthos in the study site was Sipuncula with values ranging from 65.31% - 95.69%, Annelids (3.32-23.02), Mollusca 0.37-3.18, Arthropods (0.13- 6.26%), Nemertea (0.12-1.87%), Brachiopoda (0.26-0.99%), Echinodermata (0.06-0.72%), Cnidaria (0.02-0.46), 0.07% Platyhelminthes and 0.02% nematodes. Macrozoobenthos abundance in the range of 595 ind/m^2 - 4,335 ind/m^2. The research substrate included with texture percentage are sandy loam and loam classes. The ratio of carbon and nitrogen isotope in food sources in the mangrove ecosystem was the highest -26.96 ‰ ($\delta^{13}C$), 5.14 ‰ ($\delta^{15}N$), the lowest was -29.08 ‰ ($\delta^{13}C$), 0.00 ‰ ($\delta^{15}N$). The average isotope ratio in macrozoobenthos has the highest value of -14.75 ‰ ($\delta^{13}C$), 8.29 ‰ ($\delta^{15}N$) and lowest of -25.00 ‰ ($\delta^{13}C$), 5.59 ‰ ($\delta^{15}N$). The test results of the analysis of carbon and nitrogen isotopes on several phyllum found at the study site showed that such as D. cuprea and Sipunculus sp.8 were directly related to different mangrove leaves as food sources. While the transverse A., Anthozoa D. myctiroides, Gastrana sp., O. woodmasoni, Lingula sp. Pugillina sp., S. serrata does not describe the similarity of the results of assimilation with food sources. In this ecosystem food web, there is a disconnected net at the trophic levels of 2.07 and 2.11, so there is an imbalance in transfers with the rhik level above and below. The trophic level at the research location ranges from 2.03-2.81.

1. Introduction

1.1. Background

Benthic invertebrates have an important function in ecosystems because they help in the process of decomposition of organic matter, nutrient cycling in photosynthesis and transfer of energy to high-level consumers in the food web of an ecosystem (Gaston et al, 1998). Added by Bouillon et al, (2002) macrofauna can also produce trophic relationships in some consumers at sea when they enter the mangrove ecosystem.

Mangroves are said to be an important resource in coastal areas. This ecosystem consists of detritus, litter, from mangroves that build a food web that connects food nets on land and waters (Thilagavathi et al, 2013). Thompson et al, (2012) describe existing food webs to build a framework for species relations and community composition that would be combined with the management of species diversity. This can function on coastal ecosystems. Trophic nets and food interactions in the time and space scale based on Abrates et al (2015), it is important to understand the different coastal environments and benthic food webs can describe interactions that build ecosystems, community structures and population dynamics (Pascauad et al, 2007; Abrantes et al, 2015), and supports management of all life cycles in each species (Sheaves et al, 2015). This is due to the fact that mangroves play a role in supplying food, according to the opinion of Hutchison et al (2014) that mangroves are important formations and are part of the marine food web that supports fisheries.

Manson et al (2005) state that mangroves are the basis of food webs from trophic levels used by different high-level consumers. Explained by Hirons and Park (2012) mangroves provide a source of energy, substrata in supporting the productivity of major producers and consumer systems and are a place for the decomposition process. Fisheries management can be carried out based on identification of tropical relations in the ecosystem (Tyrell et al, 2011).

Indonesia's water resources management policies are based on consideration of trophic structures and food sources that prioritize very little ecosystem sustainability. The selection of stable isotopes as a method is based on need, because most benthic species are relatively small fauna.

1.2. Objectives

This study, was conducted recontruction of trophic structure in mangrove ecosystem of Aceh Tamiang, Indonesia to describe:

1) Acertain of distribution and richnees, of macrozoobenthos,

2) Analyze food sources of macrozoobenthos community

3) Reveal trophic structure based on stable isotope $\delta^{13}C$ dan $\delta^{15}N$ ratio approach.

1.3. Expected Output

The framework of thought presented in Figure 1,

1.3. Keluaran yang diharapkan

The framework of research thinking and the outputs expected from this study are presented in Figure.

Based on the framework of Figure 1 it is expected that the results of this study are:

1. Distribution, abundance of macrozoobenthos species in the Lubuk Damar mangrove ecosystem
2. Finding dominant macrozoobenthos food sources and showing trophic levels (isotopes δ13C and δ15N) of the macrozoobenthos community in the mangrove ecosystem.
3. International journals 1) Distribution and diversity of macrozoobenthos in Lubuk Damar Aceh Tamiang, 2) Trophic structure of macrozoobenthos in the mangrove ecosystem Lubuk Damar (based on the isotope approach δ13C and δ15N).

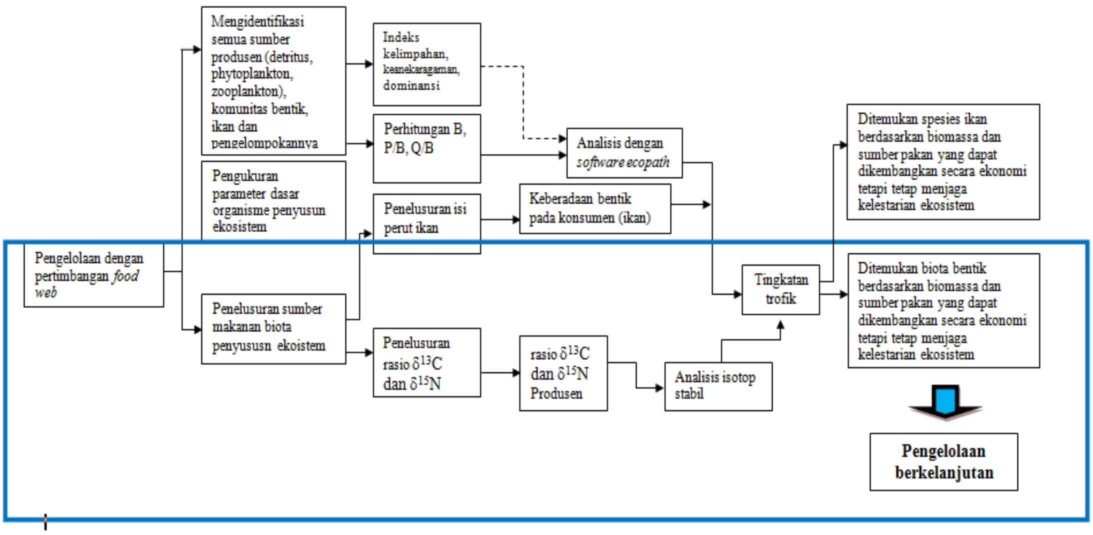

Figure 1. Frame work research

2. Benefits and importance of conducting research

3. Methodology

Research sites

Sampling was conducted on January 2017 - May 2018 in Lubuk Damar Village, Seruway Aceh Tamiang. Sampling was carried out at 98◦15 '24,164 "E - 98◦ 15' 33,019" E and 4◦ 17 '38,725 "N-4◦ 18' 19,646" N (Figure 2). At a distance of 0-200 m from the highest tide. Sample analysis was carried out in the field laboratory at the research site, Micro Laboratory, Aquatic and Environmental Productivity Faculty of Fisheries and Marine Sciences, Bogor Agricultural University (IPB), Microbiology Laboratory, Biology Research Center, LIPI Cibinong and Hydrogeology and Hydrogeochemistry lab Faculty. Mining Engineering Bandung Institute of Technology (ITB).

Sampling Technique

Sampling in the Lubuk Damar mangrove ecosystem. The location is divided into 2 stations, station I and station II. Benthic samples are collected using a 5-inch core and 1 mm filter size. Most of the fauna found in the ecosystem is collected. All samples (collected were then separated into two groups for identification (stage 1) and isotope analysis (stage 2). Collecting samples of mangrove leaves using hands is done on all mangrove species in the ecosystem. The leaves are taken with scissors, selected old leaves and then put on the envelope so that the next treatment.

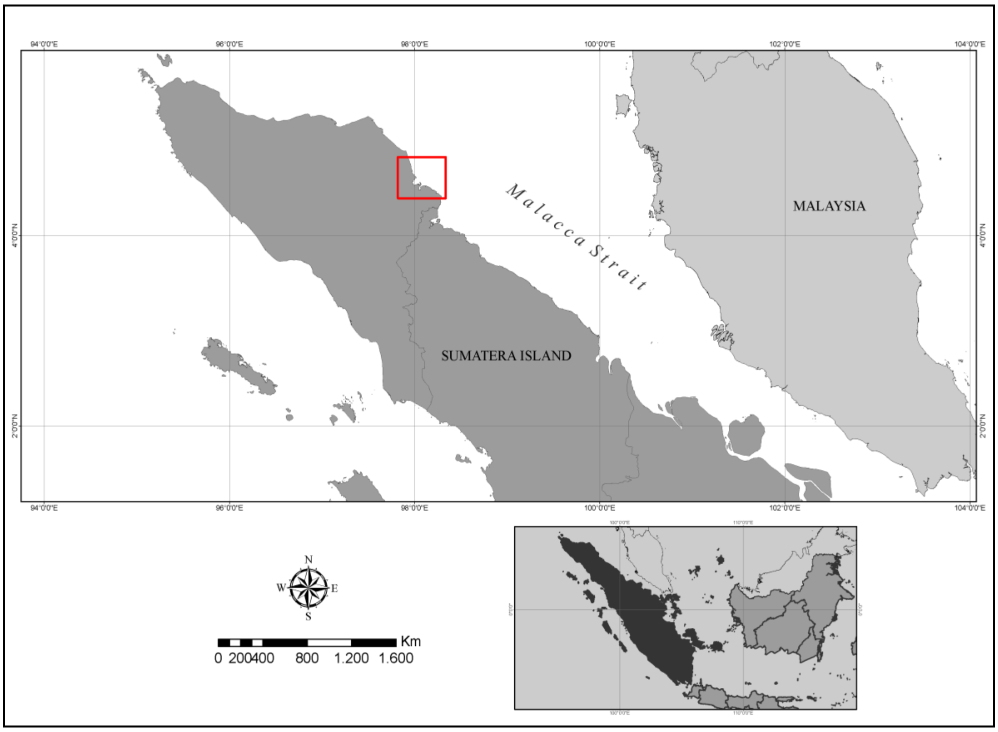

Figure 2. Research location

Taking environmental and sediment parameters

Sediment samples were carried out by random technique at the location of the macrozoobenthos sampling. Cores with a diameter of 2 inches and a length of 20 cm are used to extract sediments (Lopes et al, 2008). Sediment analysis includes analysis of texture, pH, nitrogen and organic C. Water samples were collected from each station with 3 replications. Water temperature, pH, and salinity were analyzed in situ.

Sampling and identification of Macrozoobenthos

At each station, lines are made at the lowest tide from the coastline to up to 200 m of mangrove vegetation. Point A is in the range from the highest to the low tide of 100 m and point B is from 101 m to 200 m. Macrozoobentos was collected using 5-inch cores with 10 replications. The sampling depth is 20 cm (Beatty et al, 2006; Tagliapietra and Sigovini, 2010). The samples were then preserved and filtered using a 1 mm size filter (Baoming et al, 2008; Stokes et al., 2009) and added 10% formalin (Beatty et al, 2006; Tagliapietra and Sigovini, 2010) and thick rose solution (Roberts, 2006 ; Tagliapietra and Sigovini, 2010; Pravinkumar et.al, 2013). Specifically the sample for isotope is stable, all samples are conditioned fresh or frozen (during transportation).

Stable Isotope Preparation

The substrate was taken by using a 2.4 cm PVC core into a 20 cm diameter at low tide. The collected substrate samples are then cleaned of particles other than soil. Mangrove leaves are collected by hand and then labeled with paper envelopes. Further treatment of leaf samples is washed to remove impurities that adhere to Haines and Montague (1979); Thimdee et al (2004); Kristensen et al (2010) and cut into small pieces. Macrozoobenthos sampling uses a PVC core with a size of 12.6 cm and a depth of 20 cm at low tide, then filtering with a 1 mm sieve, sorted and washed with distilled water. All types of substrate samples, phytoplankton, litter, mangrove leaves and macrozoobenthos after washing were then stored in plastic clips in freezing conditions in the coolbox with the addition of ice gel (Ultra Cool Machine size 22 x 9 x 3 cm and sachets 19 x 11.5 x 2 cm) during transportation to the laboratory for further treatment.

Preparation of stable isotope analysis

The substrate samples were dried freeze and stored in frozen conditions until the next treatment was carried out, based on Thimdee et al, (2004) the samples were homogenized and mashed with mortar. The subsequent treatment of the macrozoobenthos sample was dried using a freezed cake and stored in a labeled bottle. In this study frozen dry treatment was carried out for 2-5 hours. Drying using freeze dryer type FDU-1200 in the Microbiology Laboratory, Biology Research Center LIPI Cibinong. C-13 and N-15 isotope tests using Thermo delta V Isotopic-Ratio Mass Spectrometry (IRMS) in the Hydrogeology and Hydrogeochemical Laboratory of Mining Engineering at ITB Bandung. In this analysis, when the treatment is not applied, washing with acidification is done because of the very limited sample and it is feared there will be a decrease of δ13C and an increase of $\delta^{15}N$. It is based on Jaschinski et al, (2008) that the acidification process will reduce its carbon isotope.

After drying, all samples (substrate and macrozoobenthos) are mashed with mortar until smooth (Pinnegar and Polunin, 1999; Jardine et al, 2003) and then homogeneous can be tested for isotopes or otherwise stored in the desiccator until the isotope test is performed (Pinnegar and Polunin, 1999). The samples were then weighed around 400 µg and added to tin tin produced by Thermo scientific Universal. Tin tin is then stored on a coded tray.

Stable isotope analysis

Stable isotope analysis $\delta^{13}C$ and $\delta^{15}N$ Isotopic-Ratio Mass Spectrometry (IRMS) Thermo delta V in the Hydrogeology and Hydrogeochemical Laboratory of Mining Engineering at ITB Bandung. The isotope ratio is calculated based on the previous method Bouillon et al, 2002

δX = (R sample / standard R) -1 * 103 ‰,

where X is $\delta^{13}C$ or $\delta^{15}N$, and R represents the ratio of ^{13}C: ^{12}C or ^{15}N: ^{14}N

Relative Tropic Level (RTL) can be estimated from fauna species using the Hobson and Welch (1992) model with the formula:

RTL = (δ^{15}Ncon- δ^{15}Nbase) /3.4+2

Where is $\delta^{15}N$ from the consumer, while the initial isotope is $\delta^{15}N$ base $\delta^{15}N$. Value 3.4 represents the assumption of abundance of ^{15}N. The standard used in this isotope test is the standard NBS 18 for $\delta^{13}C$ and IAEA N-1 for $\delta^{15}N$. The precision of this isotope test is 0.039 ‰ for $\delta^{13}C$ and 0.134 ‰ for $\delta^{15}N$.

4. Results and Discussion

Distribution and diversity of macrozoobenthos

The diversity of macrozoobenthos in the study site consisted of 10 phylum, 15 classes, 76 families and 167 species (Appendix 1). Station 1 is a mangrove area dominated by Sonneratia alba vegetation and station 2 Aegiceras floridum. The density of macrozoobenthos during the study has a density that varies at each station and distance. The abundance of macrozoobenthos is based on the phylum which composes the benthic community in the mangrove ecosystem of the Damar (Figure 3). The highest abundance at the study site was in the phylum sipuncula at all stations and distances. Station 1 distance A phylum sipuncula abundance of 4,335 ind/m^2, B 11,175 ind/m^2. At station 2 phylum abundance is lower than station 1 which is 595 ind/m^2 distance A and 1,049 ind/m^2 at distance B.

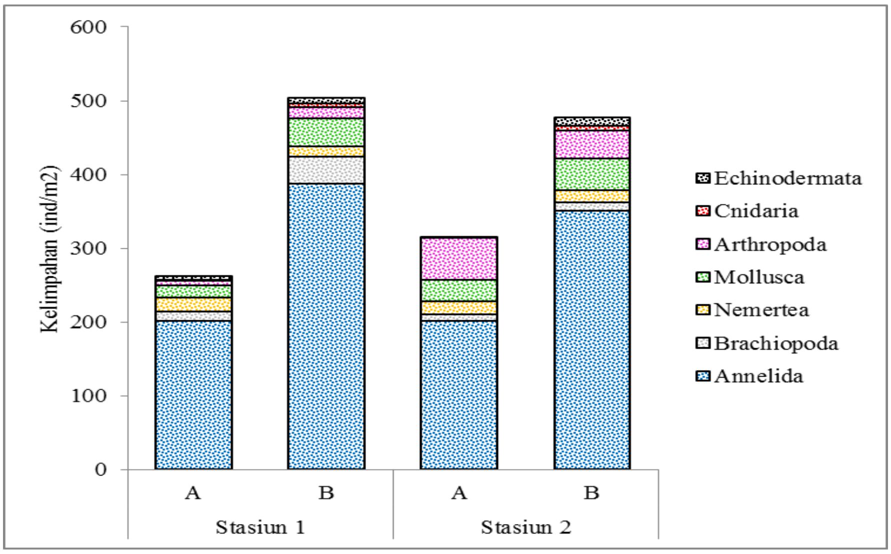

Figure 3 The abundance of macrozoobenthos based on phylum at the study site, A = (0-100 m); B = (101-200)

Overall abundance at stations 1 and 2 has greater abundance at distance B compared to distance A. Highest abundance to lowest distance A phylum sipuncula, annelida arthropoda, mollusca, brachiopoda, echinodermata, cnidaria, nematodes and platyhelminthes. The highest distance B abundance at the distance to the lowest in sequence is sipuncula, annelida, mollusca, arthropod, nemertea, echinodermata, cnidaria, platyhelminthes and nematodes.

The percentage of the presence of macrozoobenthos in the study location was Sipuncula with a range of 65.31% - 95.69%, Annelida (3.32-23.02), Molluscs 0.37-3.18, Arthropods (0.13-6.26%), Nemertea (0.12-1.87%), Brachiopods (0.26-0.99 %), Echinodermata (0.06-0.72%), Cnidaria (0.02-0.46), 0.07% Platyhelminthes and 0.02% nematodes. At station 1 distance A Sipuncula> Annelida> Nemertea> Mollusca> Arthropoda> Brachiopda> Echinodemata> Nematodes and Platyhelminthes not founded. Station 1 distance B phylum sipuncula> Annelida> Mollusca> Brachiopoda> Arthropda> Nemertea> Echinoderms and no nematodes and platyhelminthes found. Station 2 distance A Sipuncula> Annelida> Arthropoda> Mollusca> Brachiopoda> Echinodermata> Cnidaria and no nematodes and Platyhelminthes founded. Presence of macrozoobenthos at station 2 distance B Sipuncula> Annelida> Mollusca> Arthropoda> Nemertea> Echinodermata> Cnidaria> Brachiopods> Platyhelminthes and Nematodes not founded. The difference in the percentage of phylum occurs because of differences in texture conditions at each station. This is in line with the opinion of Chusna et al (2017) that the substrate based on its fraction can affect the abundance of mollusks that commonly live on coarse to fine substrates.

Abundance based on each month indicates a variation in the number of each month (Figure 4).

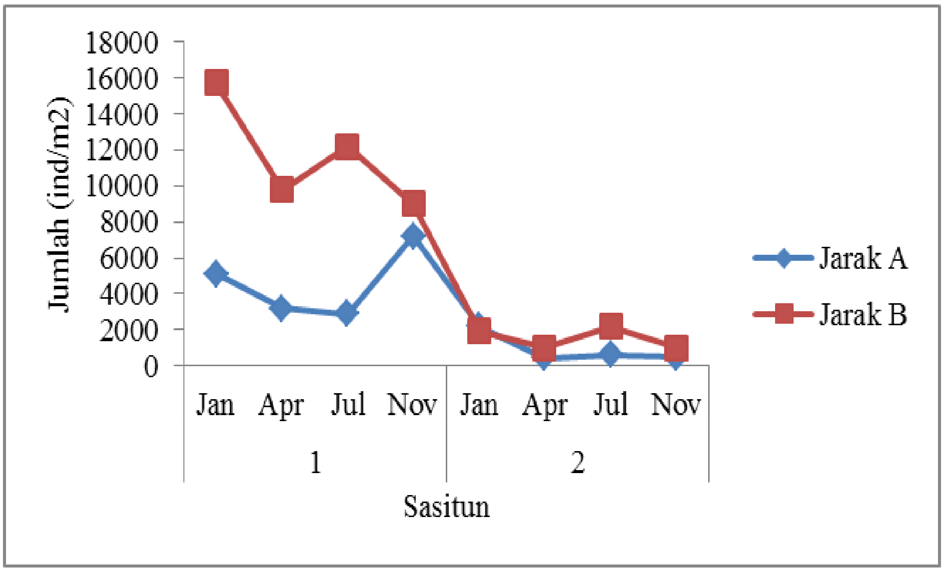

Figure 4. Abundance of macrozoobenthos every month at the study site, (Su=substrat, Ae=*Aegiceras floridum*, Br=*Bruguiera sexangula*, Ex=*Exorcaria agallocha*, Rh=*Rhizophora apiculata*, At= *A. transversa*, Ga= *Gastrana* sp., Pu= *Pugillina* sp., Li= *Lingula* sp., Do= *D. myctiroides*, Or= *Oratosquilla woodmasoni*, Sc= *Scylla serata*, An=Anthozoa, Di= *Diopatra cuprea*, Si= Sipunculus sp.8.)

At stations 1 and 2 the highest abundance of individuals occurred in January, whereas when compared to distance, station 1 distance A in November had the highest abundance with a value almost 8000/m^2. The height of each point, especially at distance B, is usually dominated by the existence of the Sipuncula phylum.

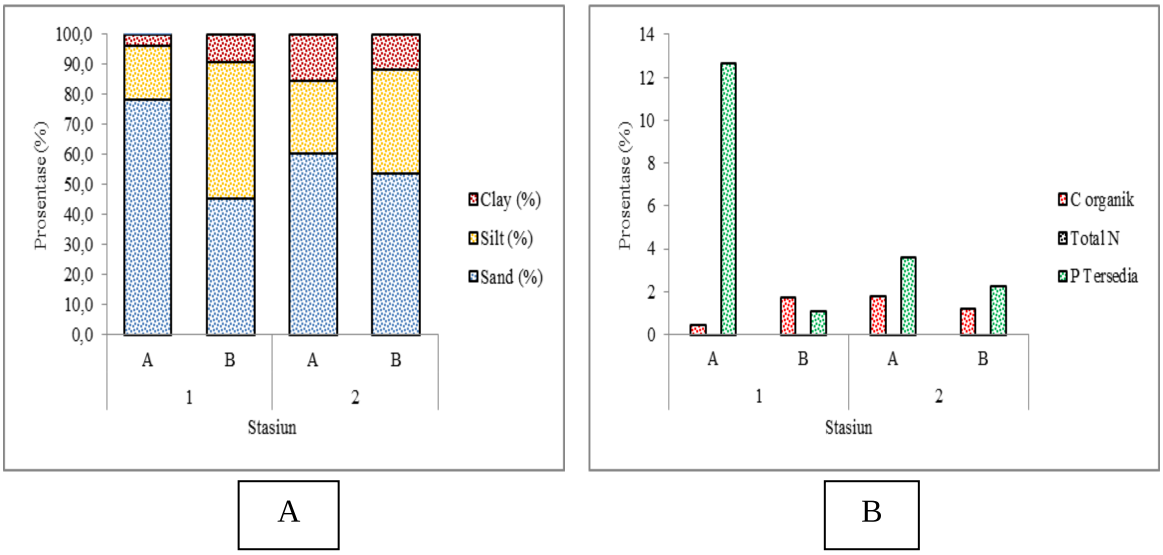

Figure 5 (A) Percentage of substrate texture, (B) Percentage of organic C, Total N and P available at the study site

The results of the substrate analysis showed that there were 2 (Figure 5) types of substrate in the study location, namely sandy clay and clay. The substrate at each station and distance has a different percentage of texture. At station 1 the distance A texture has the type of sandy clay, distance B is the type of clay. Distance A and B at station 2 have a type of sandy clay substrate. The organic C content at the research location is 1 distance A 0.47 and distance B 1.73. The total N of study sites was very low in all locations and distances. The P content available at distance A is greater than the distance B.

Stable isotop ratio on food sources

Benthos food sources in the study sites tested consisted of 5 food sources namely substrate and 4 species of mangrove leaves *Aegiceras floridum, Bruguiera sexangula, Exocaria agallocha*, and *Rhizophora apiculata* (Table 1 and Figure 2). The number of benthos tested was 10 types representing 6 phylum from 10 phylum found at the study site. The types of macrozoobenthos consist of *Anadara transversa, Gastrana* sp., *Pugilina* sp., *Lingula* sp. *D. myctiroides*, *O. woodmasoni*, *S. serata*, Anthozoa, *D. cuprea*, and *Sipunculus* sp.8.

The ratio of carbon and nitrogen isotope in food sources in the mangrove ecosystem was the highest -26.96 ‰ ($\delta^{13}C$), 5.14 ‰ ($\delta^{15}N$), the lowest was -29.08 ‰

($\delta^{13}C$), 0.00 ‰ ($\delta^{15}N$). The average isotope ratio in macrozoobenthos has the highest value of -14.75 ‰ ($\delta^{13}C$), 8.29 ‰ ($\delta^{15}N$) and lowest of -25.00 ‰ ($\delta^{13}C$), 5.59 ‰ ($\delta^{15}N$).

The results of the analysis of carbon and nitrogen isotopes in the leaves of *Aegiceras floridum, Bruguiera sexangula, Excoecaria agalloca* and *Rhizophora apiculata* at the study sites showed almost the same value. The highest isotope value is owned by *E. agallocha* and lowest *B. sexangula*. *Aegiceras floridum* leaves have carbon isotopes lower than 1.8 ‰ compared to *E. agallocha* but still tend to be similar. Previous studies related to carbon and nitrogen isotope values in the range of -29.5 ± 0.5 ‰ and 4.2 ± 0.3 ‰ in A. corniculatum (Herbon and Nordhaus, 2013). Likewise, *R. apiculata* and *B. sexangula* have lower values of 0.9 ‰ and 2.1 ‰ compared to *E. agallocha.* The carbon isotope *E. agalloca* at the study site has a value similar to the results of the research by Bouillon et al, 2003 in Galle, India, which is -28.1 ± 2.0 ‰. *R. apiculata* shows the carbon and nitrogen isotope values similar to the results of Kristensen's study, et al (2010): -28.5 ($\delta^{13}C$) and 3.3 ($\delta^{15}N$), Nordhaus et al (2011): -28.5 ± 0.3 ($\delta^{13}C$) and 3.9 ± 0.6 ($\delta^{15}N$), Herbon and Nordhaus (2013): -27.6 ± 0.3 ‰ ($\delta^{13}C$) and 2.6 ± 20.5 ‰ ($\delta^{15}N$). The carbon isotope ratio *R. apiculata* similar to *R. mucronata* was only 0.3 ‰ lower (Penha-Lopes et al. 2009). The ratio of carbon isotope and nitrogen B. sexangula is similar to lower with *B. gymnorrhiza* 0.5 ‰ ($\delta^{13}C$) and -0.8 ‰ ($\delta^{15}N$) (Thimdee et al, 2004).

The ratio of carbon isotopes on the substrate is smaller when compared with the results of Indian research (-22.8 ‰ to -20.7) ‰); Tue et al (2011) in Vietnam's estuary Ba, Zulkifli et al (2014) in Malaysia (-21.18 ‰ to -25.41 ‰); and Wardiatno et al (2016) in the Manko mangrove ecosystem, Japan (-24.23 ‰). In the isotope ratio of mangrove leaves which had the lowest ratio found in Bruguiera sexangula and the highest in the Exocaria agallocha. Carbon isotope E. agallocha is greater than Bouillon et al (2002) which states that this type has a carbon isotope of -27.9 27.

Table 1 Composition ratio δ^{13}C (‰); δ^{15}N (‰) food sources and consumers at the research site

Phylum	Sample		δ^{13}C (‰)	δ^{15}N (‰)
Food sources				
Substrat	Substrat	Su	-27,063	0,000
Mangrove	*Aegiceras floridum*	*Ae*	-28,799	4,135
	Bruguiera sexangula	*Br*	-29,08	5,139
	Exocaria agallocha	*Ex*	-26,967	4,112
	Rhizophora apiculata	*Rh*	-27,839	4,075
Macrozoobentos				
Annelida	*Diopatra cuprea*	*Di*	-25,004	5,748
Sipuncula	*Sipuncula*	*Si*	-24,804	5,592
Brachiopoda	*Lingula sp.*	*Li*	-20,674	5,881
Mollusca	*Anadara transversa*	*At*	-19,56	6,200
	Gastrana sp.	*Ga*	-17,293	6,256
	Pugillina sp.	*Pu*	-17,859	6,997
Arthropoda	*Dotilla myctiroides*	*Do*	-15,732	6,129
	Oratosquilla woodmasoni	*Or*	-14,755	7,033
	Scylla serrata	*Sc*	-19,935	7,708
Cnidaria	*Anthozoa*	*An*	-18,855	7,726

Stable isotope ratio on macrozoobenthos

The composition of the stable isotope ratio in macrozoobenthos was tested in 10 types of benthos (Figure 6). The range of stable carbon and macrozoobenthos isotope ratios ranges from -25.0 ‰ to -14.8 ‰ (δ^{13}C) and 5.6 ‰ to 7.7 ‰ (δ^{15}N). The types of macrozoobenthos consist of *Anadara transversa*, *Gastrana* sp., *Pugillina* sp., *Lingula* sp. *D. myctiroides*, *O. woodmasoni*, *S. serata*, Anthozoa, *D. cuprea*, and *Sipunculus* sp.8.

A transversa has a value of δ^{13}C -19.6 ‰ and δ^{15}N of 6.2 ‰. The ratio of *A. transversa* carbon isotopes at the study site is similar to the ratio of carbon isotope A. granosa -18.5 ‰ and smaller 3 ‰ to A. natalensis. The isotope ratio of nitrogen *A. transvera* is smaller than that of *A. granosa* and *A. natalensis* (data processed from Bouillon et al. 2002). *Gastrana* sp. has a stable isotope ratio similar to other species in one family (Tellinidae), namely Tellina spp. ($\delta^{13}C$) -17.5 ‰; ($\delta^{15}N$) 8.3 ‰ (Bouillon et al, 2002) and greater than *M. calcarea* ($\delta^{13}C$) -21.2 ‰; ($\delta^{15}N$) 6.6 ‰ (Sokolowski et al, 2014).

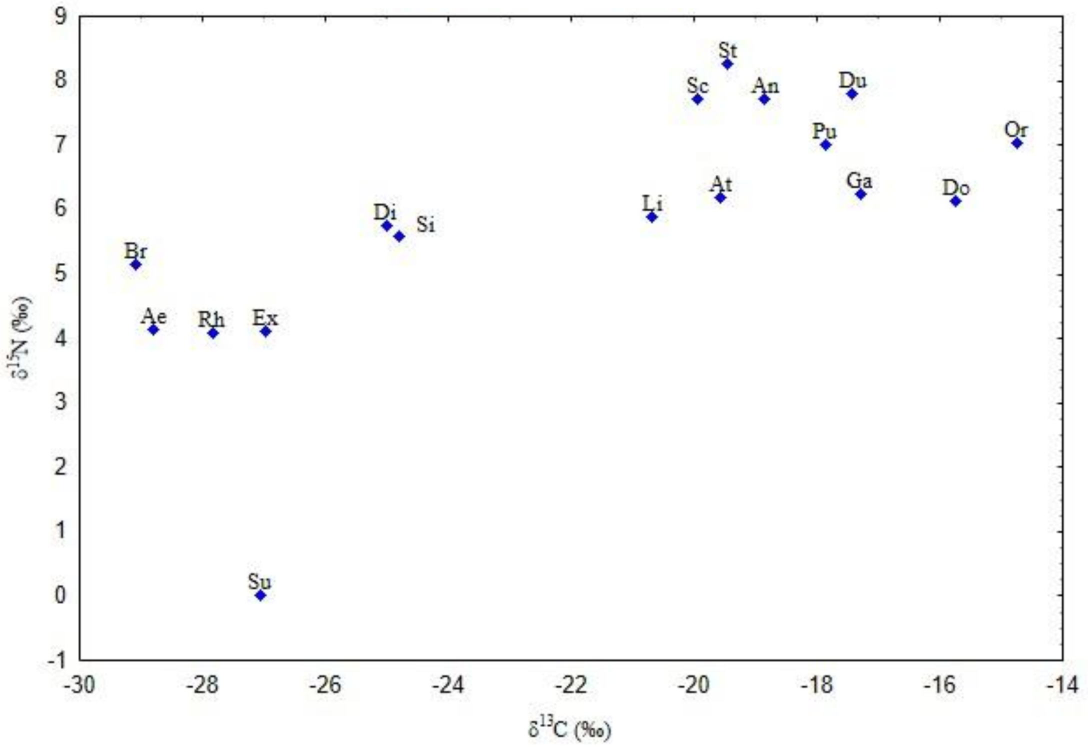

Figure 6. Composition of stable isotope ratios of food sources and macrozoobenthos at the study site, (Su=substrat, Ae=*Aegiceras floridum*, Br=*Bruguiera sexangula*, Ex=*Exorcaria agallocha*, Rh=*Rhizophora apiculata*, At= *A. transversa*, Ga= *Gastrana* sp., Pu= *Pugillina* sp., Li= *Lingula* sp., Do= *D. myctiroides*, Or= *Oratosquilla woodmasoni*, Sc= *Scylla serata*, An=Anthozoa, Di= *Diopatra cuprea*, Si= Sipunculus sp.8., Du=*Dussumeira elopsoides*, St=*Stolepharus indicus*)

Carbon stable and nitrogen isopic values of Dotilla myctiroides are higher than S. serata. The isotope ratio of D. myctiroides is similar to the species in one family, Scopimera, with a ratio of $\delta^{13}C$-14.5 ± 0.3 ‰ (Doi et al, 2005), but a smaller carbon ratio than Scopimera globusa found at Ago Bay ($\delta^{13}C$) - 10.7 ± 0.4 ‰ and ($\delta^{15}N$) 7.9 ± 0.7 ‰ (Ishishi and Yokoyama, 2009). O. woodmasoni has a carbon and nitrogen isotope ratio (Table 1) which is 3.3 ‰ higher than Oratosquilla sp. (Bouillon et al, 2002) and lower than other types of mantis shrimp (N. Bredini) in ecosystem seagrass ($\delta^{13}C$) -10.0 ± 0.7 ‰ and ($\delta^{15}N$) 7.3 ± 0.4 ‰; 8.0 ± 0.5 ‰ (deVries et al, 2016). Ning et al. (2016) mentioned the range of *O. Oratoria* carbon and nitrogen ratios -18.1 ‰ to -16.3 ‰ and 10.9 ‰ to -13.5 ‰. The ratio of carbon isotope carbon when compared to the two studies is the value of the O. Woodmasoni carbon isotope ratio is higher, this shows the difference in food sources consumed by different species and locations. This illustrates the adaptation of macrozoobenthos to available food sources.

The ratio of *S. serata* carbon and nitrogen is evenly similar to that of Abrates and Sheaves (2009), namely (yaitu13C) -19.6 ‰, ($\delta^{15}N$) 8.0 ‰ and Demopoulus et al, (2008) analysis of isotope carried out on meat ($\delta^{13}C$) −21.8 ± 0.6 ‰, ($\delta^{15}N$) 7.8 ± 0.3 ‰. However, it is lower than the results of research by Rodelli et al (1984), namely -17.2 ‰ and Thimdee et al (2004), which are ($\delta^{13}C$) -17.7 ± 0.4 ‰, ($\delta^{15}N$) (12.2 ± 0.1 ‰).

In general, crabs in Lubuk Damar *D. myctiroides* ($\delta^{13}C$) -15.7 ‰ and ($\delta^{15}N$) 6.1 ‰, Scylla serata ($\delta^{13}C$) -19.9 ‰ and ($\delta^{15}N$) 7.7 ‰ have lower stable isotope values compared to crabs in Jakarta Bay ($\delta^{13}C$) -13.9 ± 0.13 and ($\delta^{15}N$) 12.6 ± 0.36 (Sudaryanto et al 2012). This shows that *D. mytiroides* and *Scylla serata* in the Lubuk Damar region, food sources are dominated by food sources that have low carbon isotope content.

Ratio of carbon and nitrogen isotopes of *Pugillina* sp. have similarities with species that are in one family (Melongenidae), *Volema cochlidium* -18.0 ‰ for carbon isotopes and 9.6 ‰ for nitrogen isotopes (Bouillon et al, 2002). Lingula sp. which is a brachiopoda that is found and always exists throughout the year in Lubuk Damar, its existence has been reported by Darmarini et al (2017). *Lingula* sp. has a stable carbon isotope ratio of -20.0 ‰ and nitrogen isotope 5.9 ‰, similar to the results of Bouillon et al (2002) which is equal to -20.1 ‰ (δ13C) while for nitorgen values (δ15N) higher 3.4 ‰ ie 9.3 ‰. However, this ratio is greater than the species of one phylum, *Liothyrella uva* which has a carbon ratio of -22.6 ± 3.0 ‰ and nitrogen 6.4 ± 0.1 ‰ (Dunton 2001).

Anthozoa is one of the fauna found abundantly in March 2018 having a carbon and nitrogen isotope ratio of -18.9 ‰ for $\delta^{13}C$ and 7.7 ‰ for $\delta^{15}N$. Dunton (2001) reports that anthozoa found at Anvers island have carbon and nitrogen isotope ratios ($\delta^{13}C$) -24.5 ± 0.3 ‰ and ($\delta^{15}N$) 6.0 ± 0.1 ‰. This value is lower than the anthozoa in Lubuk Damar. However, when compared with the results of the Nyssen et al. (2002) anthozoa *Thouarella* sp. (-16.1 ‰) has a higher carbon isotope ratio than Lubuk Damar.

Polychaeta in general according to Moncreiff and Sulivan, (2001) has carbon and nitrogen isotope ratios -17.7 ‰ and 11.6 ‰. D. cuprea in Lubuk Damar has a smaller carbon and nitrogen isotope ratio compared to the average *D. neapolitana* 2.9 ‰ and 4.3 ‰ (though data from Bouillon et al, 2002). The difference in the carbon isotope ratio can describe different food sources of the same species.

Sipunculus sp.8 is a fauna that dominates at the study site. This type has stable isotope values ($\delta^{13}C$) -24.8 ‰ and ($\delta^{15}N$) 5.6 kecil smaller than fauna in 1 class of sipunculidae (*Golfingia vulgaris*). The ratio of carbon and nitrogen isotopes in the body of Sipunculus sp.8 is lower 5.2 "and 2.7" than the results of research by Sokolowski et al, (2014).

Food sources and macrozoobenthos

A. ransversa, Gastrana sp., *D. myctiroides O. Woodmasoni*, *Lingula* sp., *Pugilina* sp, *Scylla serata* and Anthozoa showed no closeness or enrichment in the assimilation values of carbon isotope ratios to potential food sources (Appendix 2). *D. cuprea* when seen from the assimilation value of the ratio of carbon isotopes with potential food sources shows closeness to substrate 2.06 ‰, and leaves of *E. agallocha* 1.96 ‰. This illustrates that the food source of this type of polychaeta consumes the above two food sources. Sipunculus sp.8 has an assimilation value of carbon isotopes close to two food sources namely substrate (1.26 ‰) and *E. agallocha* (2.16 ‰). Based on the above analysis it can be made an illustration of the relationship of eating eaten in the macrozoobenthos community in the Lubuk Damar mangrove ecosystem (Figure 7).

In figure 7, there is a food webs area that was cut off at the trophy level 2.07 to 2.11. *D. cuprea* is a fauna that is not related to the trophic level above and so is sipuncula. This causes the energy transfer link in this case the ^{13}C stable isotope ratio is interrupted, this causes an ecosystem imbalance. This is evidenced by the number of sipuncula which is dominant in the study site, this can be due to other macrozoobenthos which act as sipuncula predators do not exist. While the sipuncula food source is fulfilled (substrate, leaves of *Exorcaria agallocha* and *D.cuprea*). This imbalance will result in an increasing number of sipuncula without predators. The phenomenon of 8 types of benthos which are mutually consuming only revolves around these types can also result in competition in meeting food sources that will decrease.

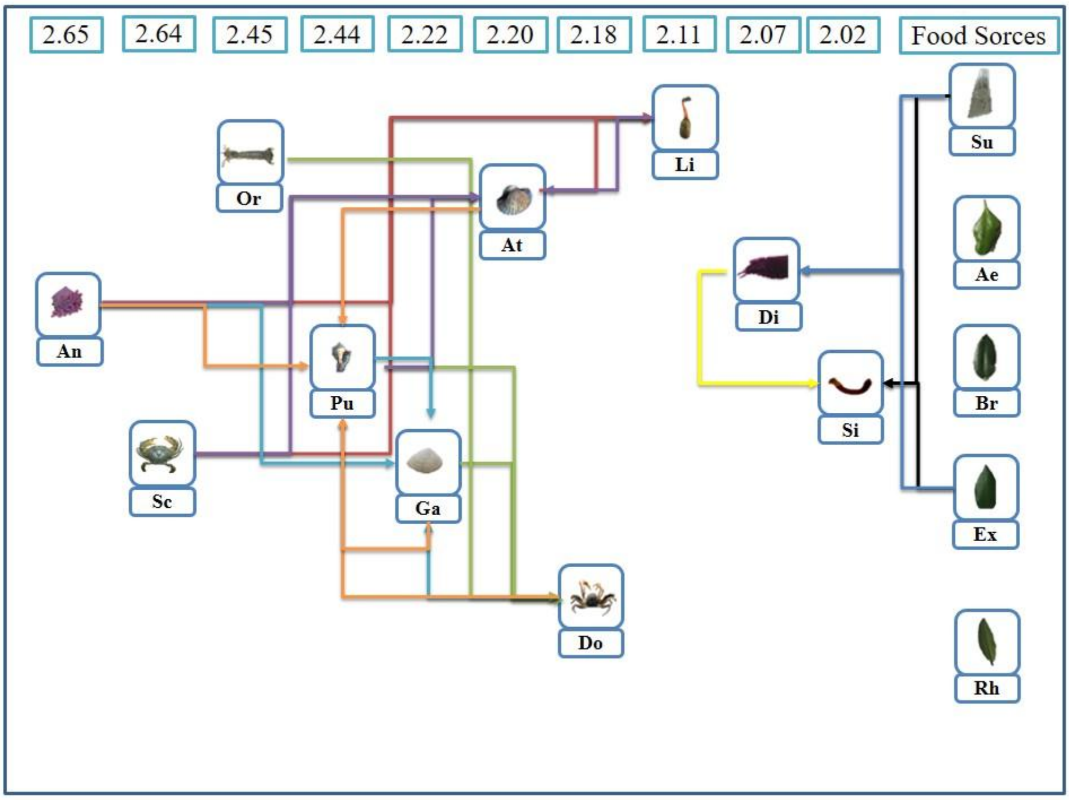

Figure 7. Macrozoobenthos food webs based on food sources on the Lubuk Damar mangrove ecosystem, (Su=substrat, Ae=*Aegiceras floridum*, Br=*Bruguiera sexangula*, Ex=*Exorcaria agallocha*, Rh=*Rhizophora apiculata*, At= *A. transversa*, Ga= *Gastrana* sp., Pu= *Pugillina* sp., Li= *Lingula* sp., Do= *D. myctiroides*, Or= *Oratosquilla woodmasoni*, Sc= *Scylla serata*, An=Anthozoa, Di= *Diopatra cuprea*, Si= Sipunculus sp.8)

The food webs formed will illustrate that from the potential sources of food tested only provide food sources for polycheta and sipuncula. This does not mean that other types of macrozoobenthos do not get food sources, but other macrozoobenthos have food sources from fellow macrozoobenthos (Figure 7).

Simulations on food nets with two types of feeding fish show the importance of macrzoobenthos in fisheries development. Dussumeira. elopsoides with carbon and nitrogen isotope ratios (δ13C) -17.42 ‰ and (δ15N) 7.80 ‰. and Stolephorus indicus (δ13C) -19.44 ‰ and (δ15N) 8.27 ‰ indicate their food source requirements originating from macrozoobenthos. *D. elopsoides* from assimilation results showed consuming *A. transversa*, Anthozoa, *D. myctiroides, Gastrana* sp. and *Pugilina* sp. *S. indicus* based on assimilation results showed consuming *A. transversa*, Anthozoa, *D. myctiroides*, *Lingula* sp., *Gastrana* sp. and *Pugilina* sp. Trophic determination of benthos level is done using a ratio of 15N values to consumers and 15N food sources. The stable isotope ratio of macroozoobenthos nitrogen in the study location was in the range of 4.1 ‰ to 7.7 ‰. The ratio of nitrogen isotope to substrate is not measurable. This condition is also supported on the results of the total N test (in this study), the substrate has a low value (0.07-0.15%).

The low nitrogen isotope can be caused by the assimilation of 15N in organisms from limited N sources, because based on Robinson et al (2012) the results of nitrogen assimilation in organisms to produce biomass originating from source N are converted to organic N stored in sediments and different sources of nitrogen will give impact on nitrogen isotope content in an organism due to different fractionation processes (McClelland and Montoya, 2002). Level of Relative Trophic or Relative Trophic Level (RTL) macrozoobenthos in Lubuk Damar mangrove ecosytem in the range between 2.02 to 2.81 (Figure 8) The lowest trophic level in the macrozoobenthos community in the Lubuk Damar ecosystem mangrove was occupied by Sipunculus sp.8, 2.03. The 2.07 trophic position is filled by *D. cuprea*. The trophic position similarity between the two is due to the same types of food sources, namely *E.agallocha* substrate and leaves.

Pugilina sp. and O.woodmasoni occupies trophic positions 2.44 and 2.45. Different potential food sources are found in mantis shrimp. The assimilation produced in this study is that mantis shrimp has no resemblance to the potential of any kind of food source. The *O.woodmasoni* RTL is different from the results of Ning et al (2016) that the trophic O. oratorial position is at 3.01 ± 0.22. both have a different interval of 0.87 trophic levels. Trophic level differences in the same genus can occur due to food availability at different locations .

RTL 2.07 is occupied by *D. cuprea*. This class of polychaeta has proximity to its food source, E. agallocha leaves. Another potential source of food that has proximity to this type of polychaeta is the substrate. Transverse A. in the location of the Lubuk Damar

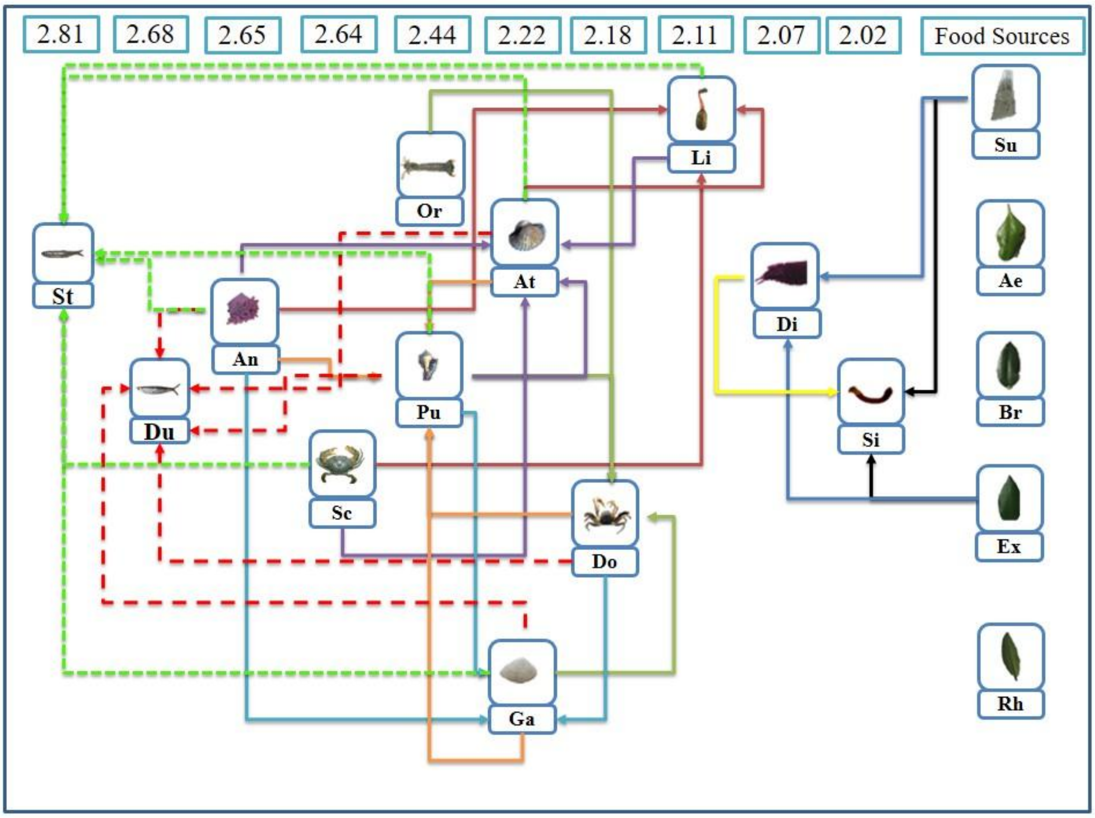

Figure 8 Foodwebs of mangrove ecosystem Lubuk Damar (Su=substrat, Ae=*Aegiceras floridum*, Br=*Bruguiera sexangula*, Ex=*Exorcaria agallocha*, Rh=*Rhizophora apiculata*, At= *A. transversa*, Ga= *Gastrana* sp., Pu= *Pugillina* sp., Li= *Lingula* sp., Do= *D. myctiroides*, Or= *Oratosquilla woodmasoni*, Sc= *Scylla serata*, An=Anthozoa, Di= *Diopatra cuprea*, Si= Sipunculus sp.8., Du=*Dussumeira elopsoides*, St=*Stolepharus indicus*)

mangrove ecosystem occupies on trophic level 2.20. Anthozoa in this ecosystem occupies the highest trophic level with a position at 2.65 Trophic levels of anthozoa is the highest trophic level in the macozoobenthos community at the study site. In trophic positions 2.65 and 2.81 which are the highest trophic positions in this study.

The macrozoobenthos trophic level in this area is mostly between 2.0 and 2.65. The highest trophic level (Figure 8) if the fish is included in the food net, it will occupy the highest trophic position at the position of 2.67 (*D. elopsoides*) and 2.81 (*S. indicus*). Simulation of food webs by including fish as consumers pada posisi trofik 2.65 dan

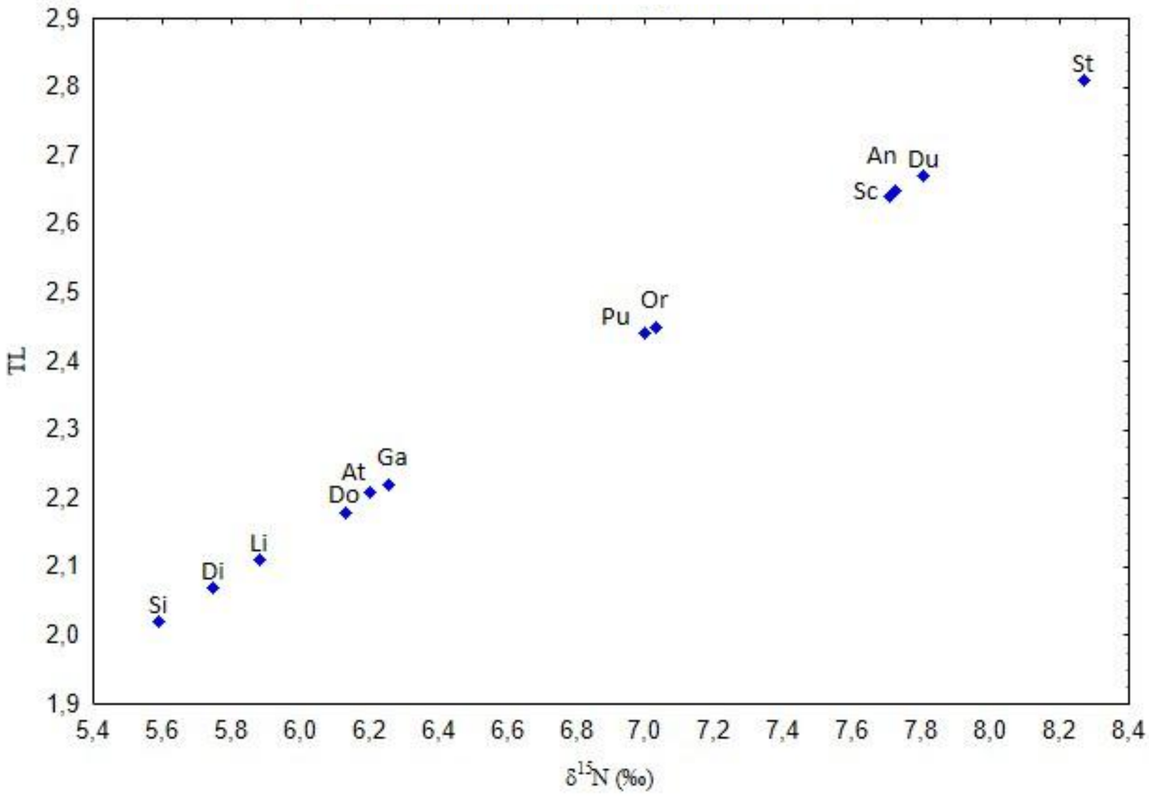

Figure 9 Trophic position konsumen in mangrove ecosystem Lubuk Damar on trophic level (Su=substrat, Ae=*Aegiceras floridum*, Br=*Bruguiera sexangula*, Ex=*Exorcaria agallocha*, Rh=*Rhizophora apiculata*, At= *A. transversa*, Ga= *Gastrana* sp., Pu= *Pugillina* sp., Li= *Lingula* sp., Do= *D. myctiroides*, Or= *Oratosquilla woodmasoni*, Sc= *Scylla serata*, An=Anthozoa, Di= *Diopatra cuprea*, Si= Sipunculus sp.8., Du=*Dussumeira elopsoides*, St=*Stolepharus indicus*)

2.81. Some trophic positions were found to be occupied by two or three individuals such as *Pugilina* sp. and *O. Woomasoni*. Likewise with *Scylla serrata*, Anthozoa and *Dussumeira elopsoides* fish. This illustrates that these individuals have the same interest in consuming the type of pre-recorded prey above or below it.

4. Conclusion

The application of the analysis of δ13C and δ15N at the study site illustrates the importance of the Lubuk Damar mangrove ecosystem, as a provider of macrozoobenthos food sources. The results showed several species of macrozoobenthos such as D. cuprea, and Sipunculus sp.8 directly related to mangrove leaves as a food source. Whereas Lingula sp. Pugillina sp., S. serrata, transverse A., Anthozoa D. myctiroides, Gastrana sp., O. woodmasoni, do not describe the similarity of the results of assimilation with food sources. It is suspected that the food source of these 8 organisms is some type of macrozoobenthos which occupies the trophic position below or above it. This study illustrates the importance of diversity of mangrove vegetation in an ecosystem for food source providers of macrozoobenthos, because macrozoobenthos can occupy several trophic positions in food webs.

The Lubuk Damar mangrove ecosystem shows a food net that was cut off at the trophic level 2.07 and no fauna was found to be a means of transferring energy from the trophic level below and above it, this is thought to have caused the sipuncula dominance in the research application. The RTL in the research location ranged from 2.03-2.65, indicating that the macrozoobenthos community had almost the same trophic position, and had the role of being the first consumer. Simulations given to two types of fish, namely D. elopsoides and Stolephorus indicus illustrate the importance of the macrozoobenthos community in supporting fisheries.

4. Researcher

Name	: Ananingtyas Septia Darmarini
Gender	: Perempuan
Work	: Dosen FPIK Universitas Teuku Umar, Meulaboh, Aceh
Name of Institution	: Institut Pertanian Bogor
Addres	: Jl. Agatis Kampus IPB Darmaga, Bogor
Tlp/Fax.	: +2518622932
Email	: pssdpipb@gmail.com

5. References

Abrantes K.G, Barnett, Baker R., Sheaves M. 2015. Habitat specific food webs and trophic interactions supporting coastal dependent fishery species: an Austrralian case study. Rev Fish Biol Fisheries 25: 337-363. Doi 10.1007/s11160-015-9385-y.

Abrantes KG, Sheaves M. 2009. Food web structure in a near pristine mangrove area of the Australian wet Trophics. Estuarine, Coastal and Shelf Science . 82: 597-607. Doi:10.1016/j.ecss.2009.02.021.

Baoming G., Yixin B., Hongyi C., Huanhuan L., Zhiyuan H. 2008. Trophic functional groups and trophic levels of the macrobenthic community at the eastern tidal flat of Lingkun Island, China. Acta Ecologica Sinica. Vol. 28:1796-4804.

Beatty J.M., McDonald. L.E., Westcott F.M., Perrin. C.J. 2006.Guidline for sampling benthic invertebrates in British Columbia Streams.British Columbia and Ministry of Environment. Columbia. p.28

Bouillon S, Dahdouh-Guebas F, Rao AVVS, Koedam N, Dehairs. 2003. Sources of organic carbon in mangrove sediments: variability and possible ecological implications. Hydrobiologia 495: 33-39.

Bouillon. S, Koedam., Raman.A.V., Dehairs.F. 2002. Primary producers sustaining macro-invertebrate communities in intertidal mangrove forest. Oecologia. 130: 441-448.

Chusna RRR, Rudiyanti S dan Suryanti. Hubungan substrat dominan dengan kelimpahan gastropoda pada hutan mangrove Kulonprogo, Yogyakarta. Indonesian Journal of Fisheries Science and Technology (IJFST) Vol.13 No.1 : 19-23,

Darmarini AS, Wardiatno Y, Prartono T, Soewardi K. 2017. Short Communication: New record of primitive brachiopod, *Lingula* sp. in mangrove ecosystem of Lubuk Damar, Aceh Tamiang, Indonesia. Biodiversitas 18: 1438-1444. doi: 10.13057/biodiv/d180420.

Demopoulus AWJ, Ewel KC, Fry B. 2008. Use of multiple chemical tracers to define habitat use of Indo-Pacific mangrove crab *Scylla serrata* (Decapoda: Portunidae). Estuaries and Coasts 31:371-381. Doi 10.1007/s12237-007-9008-5.

deVreis MS, Stock BC, Christy JH, Goldsmith GR, Dawson TE. 2016. Specialized morphology corresponds to a generalist diet: linking from and function in smashing mantis shrimp crustaceans. Oecologia 182: 429-442. DOI 10.1007/s00442-016-3667-5

Dunton KH. 2001. $\delta^{15}N$ and $\delta^{13}C$ measurements of Antartactic Peninsula Fauna: Trophic relationships and assimilation of benthic seaweeds. America Zoology 41:99-112.

Gaston KJ. 1998. Biodiversity the road to an atlas. Progress in Physical Geography 22, 269–81.

Haines E, Montague CL. 1979. Food sources of estuarine invertebrates analyzed using 13C/12C tatios. Ecology 60(1): 48-56.

Herbon CM, Nordhaus I. 2013. Experimental determination of stable carbon and nitrogen isotope fractionation between mangrove leaves and crabs. Marine Ecology Progress Series vol 490: 91-105. doi: 10.3354/meps10421.

Hirons A and Park K. Trophic dynamic in mangrove ecosystem in Port Everglades. *Marine & Environmental Sciences Faculty Proceedings, Presentations, Speeches, Lectures*. 316. https://nsuworks.nova.edu/occ_facpresentations/316

Hobson KA. Welch. 1999. Determination of trophic relationships within a high Arctic marine food web using δ13C and δ15N analysis Marine Ecology Progress Series 84(1):9-18. DOI: 10.3354/meps084009

Hutchison, J., Spalding, M., zu Ermgassen,P. 2014. The role of mangrove in Fisheries Enhancement. The nature Conservancy and wetland international. 54 p.

Ishishi Y., Yokoyama H. 2009. Stable isotope analyses of the trophic structure of macrobenthos on an artificial tidal flat developed using sediments dredged from pearl oyster farms in Ago Bay. Aquaculture System Division. National Research Institute of Aquaculture: 59-67.

Jardine T.D., Mc Geachy, S.A, Paton C.M, Savoie. M., Cunjak. R.A. 2003. Stable isotope in aquatic systems: sample preparation, analysis, and interprestation. Canadian Manuscript Report of Fisheries and Aquatic Science. Canada. p. 39.

Jaschinski S, Hansen T, Sommer. 2008. Effect of acidification in multiple stable isotope analyses. Limnology and Oceanography: Method. 6:12-15.

Kristensesn D.K., Kristensen E., Mangion P., 2010. Food partitioning of leaf-eating mangrove crabs (Sesarminae): Experimental and stable isotope (^{13}C and ^{15}N) evidence. Estuarine, Coastal and Shelf Science. 87: 583-590.

Lopes.G.P, Bouillon. S, Mangion.P, Macia A., Paula J. 2009. Population structure, density and food sources of terebraliapalustris (potamidae:gastropoda) in a low intertidal Avicennia marina mangrove stand (inhaca Island, Mozambique). Estuarine, Coastal, dan Shelf Schience 84: 318-325.

Manson, F.J., Loneragan, N.R., Harch, B.D., Skilleter, G.A., Williams, L., 2005a. A broad-scale analysis of links between coastal fisheries production and mangrove extent: a case-study for northeastern Australia. Fish. Res. 74, 69–85.

McClelland JW and Montoya JP. 2002. Trophic relationships and the nitrogen isotopic composition of amino acids in plankton. Ecology. 83 (8): 2173-2180.

Ning J, Du F, Wang X, Gu Y, Wang L, Li Y. 2016. Feeding habits of mantis shrimp based on stable isotope analysis. DOI: 10.11964/jfc.20151110177

Nordhaus I, Salewski T, Jennerjahn TC. 2011. Food preferences of mangrove crabs related to leaf nitrogen compounds in the Segara Anakan Lagoon, Java, Indonesia. Journal of Sea Reseearch 65: 414-426. doi:10.1016/j.seares.2011.03.006

Nyssen F, Brey T, Lepoint G, Bouquegneau J, Broyer C D, Dauby P. 2002. A stable isotope approach to the eastern Weddell Sea trophic web: focus on benthic amphipods. Polar Biol 25: 280-287.

Pasquaud S, Lobry J and Elie P. (2007). Facing the necessity of describing estuarine ecosystems: A review of food web ecology study techniques. *Hydrobiologia* 588(1): 159–172.

Pinnegar JK dan Polunin NVC. 1999. Differential fractionation of δ13C and δ15N among fish tissues: implications for the study of trophic interactions. Functional Ecology 13:225-231.

Pravinkumar M., Murugesan P., Prakash R.K., Elumalai V., Viswanathan c., Raffi S.M. 2013. Benthic biodiversity in the Pichavaram mangroves, Southeast Coast India. Journal of Oceanolography and Marine Science Vol. 4 (1) pp. 1-11. Doi: 10.5897/JOMS 12.004.

Roberts D.E. 2006. Spatial patterns in the macrobenthic mangrove forests in the Brisbane Water Estuary. Marine, Estuarine & Freshwater Ecology. Bioanalysis PTY LTD. 34p.

Robinson RS, Kienast M, Albuqueque AL, Altabet A, Contreras S, Holz RDP, Dubois N, Francois R, Galbraith E, Hsu T, Ivanochko T, Jaccard S, Kao S, Kiefer T, Kienast S, Lehmann M, Martinez P, McCarthy M, Mobius J, Pedersen T, Quan TM, Ryabenko E, Schittner A, Schneider R, Schneide-Mor A, Shigemitsu M, Sinclair D, Somes C, Studer A, Thunell R, Yang J. 2012. A review of nitrogen isotopic alteration in marine sediments. Paleoceanography. 27(PA4203):1-13. doi:10.1029/2012PA002321.

Rodelli MR, Gearing JN, Gearing PJ, Marshall N dan Sasekumar A. Stable isotope ratio as a tracer of mangrove carbon in Malaysian ecosystem. Oecologia 61(3): 326-333.

Sheaves M., Baker R., Nagelkerken I., Connolly R.M. 2014. True value Estuarine and coastal nurseries for fish: incorporating complexity and dynamic. Estuaries and Coast. Doi 10.1007/s12237-014-9846-x.

Sokolowski A., Szczepanska. A., Richard. P., Kedra.M., Wolowicz., Weslawski J.M. 2014. Trophic structure of macrobenthic community of Hornsund, spitsbergen, based on the determination of stable carbon and nitrogen isotopic signature. Polar Biol 37: 1247-1260.

Stokes D., Healy T., Mason.N. 2009. The benthic ecology of expanding mangrove habitat, Tauranga Harbour, New Zealand. ePublication@SCU. Southern Cross University.10 p.

Sudaryanto A, Riyadi AS, Setiawan IE, Ilyas M, Isobe T, Chang K, Takashi S, Tajima Y. 2012. Bioaccumulation of brominated flame retardants (BFRs) in Different Trophic Level Organisms from Jakarta Bay Indonesia. 4p.

Tagliapietra D and Sigovini M. 2010. Benthic fauna: collection and identification of macrobenthic invertebrate. Terre et Environment. ISBN 2-940153-87-6. Vol 88. P 253-261.

Thilagavanthi B., D Varadharajan ., Manoharan B.A. S Vijayalaksmi., Balasubramanian. Distribution and diversity of macrobenthos in different mangrove ecosystem of Tamil Nadu Coast, India. Aquaculture Research and Devolepment. Vol 4(6) 12p. Doi: http//dx,doi.org/10.4172/2155-9546.

Thimdee W., Deein G., Sangrungruang C., Matsunaga K. 2002. Analysis of primary food sources and trophic relationships of aquatic animals in a mangrove-fringed estuary, Khung Krabaen Bay (Thailand) using dual stable isotope techniques. Wetlands Ecology and Management. Vol 12 (2): 135-144. doi:10.1023/B:WETL.0000021674.76171.69.

Thompson RM, Brose U, Dunne JA, Hall Jr RO, Hladyz S, Kitcing RL, Marinez ND, Rantala H, Romanu TN, Stouffer DB, Tylianakis JM. 2012. Food webs: reconciling the structure and fucntion of biodiversity. Trends in Ecology & Evolution. 27(12): 689-697. https://doi.org/10.1016/j.tree.2012.08.005.

Tue NT, Ngoc NT, Quy TD, Hamaoka H, Nhuan MT, Omori K. A cross-system analysis of sedimentary organic carbon in the mangrove ecosystems of Xuan Thuy National Park, Vietnam. Journal of Sea Research vol 67(1): 69-76.

Tyrrell MC, Link JS, Moustahfid H. 2011. The importance of including predation in fish population models: Implications for biological reference points. Fisheries Research 108: 1–8. doi:10.1016/j.fishres.2010.12.025

Wardiatno Y, Mardiansya, Prartono T, Tsuchiya M. 2016. Possible Food Sources of Macrozoobenthos in the Manko Mangrove Ecosystem, Okinawa (Japan): A Stable Isotope Analysis Approach. Tropical Life Sciences Research 26(1):53-65.

Zulkifli SZ, Mohamat-Yusufi F, Mukhtar A, Ismail A, Miyazaki N. 2014. Determination of food web in intertidal Mudflat of tropical mangrove ecosystem using stable isotope markers: A priliminary study. Life Science Journal 11(3): 427-431.

Appendix 1. Diversity of macrozoobenthos

Phylum	Class	Family	Name of species	Station 1		Station 2	
				A	B	A	B
		Nephtydae	*Nephtys* sp	√	√	-	√
		Phyllodocidae	*Phyllodoce* sp.1	-	√	-	-
			Phyllodoce sp.3	√	√	√	-
			Eteone sp.	-	√	-	√
		Glyceridae	*Glycera sp.1*	-	-	√	-
			Glycera sp.2	√	√	√	√
			Glycera sp.4	-	-	√	√
		Goniadidae	*Goniada* sp.1	√	√	√	√
		Nereididae	*Nereis diversicolor*	√	√	√	√
			Nereis fragilis	√	-	-	-
			Nereis pelagica	√	√	√	√
			Nereis grayii	-	√	-	-
			Platynereis dumerelii	√	√	-	√
			Perinereis cultrifera	-	-	-	√
			Lycastopsis pontica	-	-	-	√
		Pilargidae	*Ancistrosyllis* sp.	-	-	√	√
			Sigambra sp.	√	√	√	√
		Paralacydoniidae	*Paralacydonia* sp.	√	√	√	√
		Ampharetidae	*Ampharete acutiforns*	√	√	-	-
			Hypaniola grayii	√	-	-	-
			Schistocomus sp.	-	√	√	-
		Terebellidae	*Amphitrite cirrata*	√	-	-	-
			Amphicteis sp.	-	-	-	√
			Loimia sp.	-	-	-	-
			Pista sp.1	-	√	√	√
			Pista sp.2	-	√	-	√
			Pista sp.3	√	√	-	√
			Pistella lornensis	√	√	√	√
			Streblosoma sp.	√	√	-	-
Annelida	Polychaeta	Sternaspidae	*Sternaspis* sp.1	√	√	√	√
			Sternaspis sp.2	√	√	√	√
		Trichobranchidae	*Terebellides stroemii*	-	√	-	√
			Trichobrancus sp.2	-	-	-	√
		Eunicidae	*Eunice* sp.	-	-	-	√
			Marphysa sp.1	√	-	-	-
			Marphysa Sp.2	√	-	-	-
		Lumbrineridae	*Lumbrinereis* sp.1	√	√	√	√
			Lumbrinereis sp.2	-	√	-	-
			Lumbrinereis sp.3	-	√	-	-
			lumbrinereis sp.4	-	-	-	√
		Onuphidae	*Onuphis eremita*	√	√	√	√
			Onuphis ophelia	-	-	√	√
			Diopatra cuprea	√	-	√	√
		Oweniidae	*Owenia fusiformis*	√	√	-	-
		Maldanidae	*Axiothella* sp.	√	√	√	√
			Maldane sp.1	√	√	√	√
			Maldane sp.2	√	√	√	√
			Maldanopsis elongata	-	-	√	√
			/N. Lumbricalis	-	√	-	-
			(Praxillella affinis)	√	√	√	√
			Euclymene sp.2	√	√	-	√
		Capitellidae	*Heteromastus* sp.	√	√	-	-
			Notomastus sp.	√	√	√	√
		Cirratulidae	*Cirratulus grandis*	-	√	√	√
			Cirratulus cirratus	-	√	√	√
			Chaetozone setoza	-	-	-	√
			Cirriformia filigera	√	√	√	√
		Paraonidae	*Aricidea* sp.	√	-	√	√
			Paraonis fulgen	√	√	√	√
			Paraonis gracilis	-	-	√	√

		Cossuridae	*Cossura longocirrata*	-	-	√	√
		Sabellidae	*Potamilla neglecta*	-	-	√	-
		Magelonidae	*Magelona* sp.	√	√	-	√
		Orbiniidae	*Scolopos* sp.	-	-	√	√
		Opheliidae	*Ophelina* sp.	√	√	√	√
		Amphinomidae	*Paramphinome* sp.	-	√	-	√
			Pseudoeurythoe sp.1	√	√	√	√
			Pseudoeurythoe sp.2	√	-	-	-
			Pareurythoe borealis	-	-	-	√
		Spionidae	*Polydora* sp.	-	√	-	√
			Prionospio sp.	√	√	√	√
			Spiophanes sp.	-	-	√	√
		Trochochaetidae	*Disoma* sp.	√	-	√	√
Platyhelminthes	Platyhelminthes		*Polycladida* sp.3 (unidentified)	-	-	-	√
Nematoda	Nematoda	Nematoda	Nematoda sp.1	√	-	-	-
Sipuncula	Phascolosomatidea	Phascolosomatidae	*Apionsoma* sp.	√	√	√	√
			Antillesoma antilarium	-	√	-	√
	Sipunculidea	Phascolionidae	*Onchnesoma steenstrupi*	-	√	√	√
		Golfingiidae	*Thysanocardia* sp.	√	√	√	√
		Sipunculidae	*Sipunculus nudus*	-	√	-	√
			Sipunculus sp.1	√	√	-	-
			Sipunculus sp.2	√	√	-	-
			Sipunculus sp.3	√	√	-	√
			Sipunculus sp.4	√	√	-	-
			Sipunculus sp.5	√	√	-	√
			Sipunculus sp.5A	√	√	√	√
			Sipunculus sp.5C	√	√	√	-
			Sipunculus sp.6	√	√	√	-
			Sipunculus sp.8	√	√	√	√
			Sipunculus sp.9	√	-	-	-
			Sipunculus sp.10	√	-	-	-
			Sipunculus sp.11	√	√	-	-
			Sipunculus sp.12	√	-	-	-
			Sipunculus sp.13	√	√	-	-
			Sipunculus sp.14	√	-	-	-
		Themistidae	*Themiste* sp.	-	-	-	√
Brachiopoda	Lingulata	Lingulidae	*Lingula* sp.	√	√	√	√
Nemertea	Palaeonemertea	Carinomidae	*Carinoma* sp.	√	√	√	√
			Carinomella lactea	√	-	-	-
		Tubulanidae	*Tubulanus* sp.	√	√	√	√
	Anopla	Lineidae	*Cerebratulus* sp.	√	√	√	√
			Micrura sp.	-	-	√	√
	Enopla	Malacobdellidae	*Malacobdella* sp.	-	-	-	√
Mollusca	gastropoda	Nassariidae	*Nassarius* sp.2	√	-	√	-
			Nassarius sp.3	√	-	-	-
			Nassarius sp.4	-	-	√	-
		Melongnidae	*Volema myristica*	-	-	-	√
		Naticidae	*Natica* sp.1	-	-	√	-
			Natica sp.4	-	-	-	√
			Natica sp.6	-	-	-	√
			Polinices aurantius	-	-	-	√
			Polinices eumidus	-	-	-	√
		Potamididae	*Cerithidea cingulata*	-	-	√	-
		Rissoiddae	*Rissoina* sp.	√	-	-	√
		Pyramideliidae	*Pyramidella* sp.	-	-	-	-
		Limacinidae	*Spiratella helicina*	-	-	-	√
	Bivalva	Solenidae	*Solen grandis*	-	-	-	√
		Pharidae	*Siliqua japonica*	√	√	-	√
		Mactridae	*Mactra* sp.	√	√	√	-
		Tellinidae	*Sanguinolaria diphos*	-	-	√	-
			Macoma calcarea	-	√	-	-
			Gastrana fragilis	√	√	-	-
			Tellina sp.2	-	-	√	-

			Tellina sp.3	-	-	√	√
			Tellina sp.4	-	√	√	√
			Tellina sp.6	-	-	-	√
			Tellina sp.8	-	-	√	√
			Tellina sp.9	-	√	√	√
		Donacidae	*Donax* sp.	-	-	-	√
Arthropoda	Malacostraca	Alpheidae	*Alpheus* sp.2	-	-	-	√
			Alpheus sp.3	√	√	√	√
			Alpheus sp.4	√	-	-	-
		Penaidae	*Metapenaeus* sp.	-	-	-	√
			Peneaus duorarum	-	-	√	-
			Peneaus setiferus	-	-	√	√
			Parapanaeus sp.	-	-	√	-
		Pasiphaeidae	*Paraphasiphae sulcatifronis*	-	-	√	-
		Callianassidae	*Callianasa* sp.	-	√	-	-
		Dotillidae	*Dotilla myctiroides*	-	-	√	-
		Macrophthalmidae	*Australoplax tridentata*	-	√	-	-
			Macrophthalmus sp.1	-	-	√	-
			Macropthalmus sp.2	√	-	-	-
		Paguridae	*Pagurus arcantus*	√	-	-	√
		Diogenidae	*Dardanus insignis*	-	-	√	√
			Clibanarius vittatus	-	-	√	√
		Ocypodidae	*Uca pugnax*	-	-	-	√
			Uca minax	-	-	√	√
			Uca pugilator	-	-	√	√
		Ocypodidae unidentified	Ocypodidae (Unidentified)	-	√	√	-
		Malacostraca unidentified	Malacostraca (unidentified)	-	-	√	-
		Galatheidae unidentfies	Galatheidae (unidentified)	-	-	-	√
		Anthuridae	*Cyathura* sp	√	√	√	√
			Ptilanthura sp	-	√	-	√
		Cumacea	*Diastylis* sp.	-	√	-	-
		Squillidae	*Oratosquilla woodmasoni*	-	-	√	-
		Euphausiacea order	Euphausiacea (Unidentified)	-	-	-	√
		Ameiridae	*Parameira* Sp.	-	-	-	-
		Squillidae	*Heterotanais* sp.	-	√	-	√
Cnidaria	Anthozoa	Hormatidae	*Anthozoa* sp.2	√	-	-	-
		Halcampidae	*Halcampa* sp.	-	√	-	-
		Actiniidae	*Tealia* sp.	-	√	-	-
		Haloclavidae	*Peachia parasitica*	-	-	-	√
	Octocorallia	Virgulariidae	*Virgularia* sp.	-	-	-	√
	Hydrozoa	Sertulariidae	*Thuiaria* sp.	-	-	-	√
Echinodermata	Ophiuroidea	Amphiuridae	*Amphiura pulchella*	√	√	-	√
			Amphiura filiformis	√	√	√	√
			Amphiodia urtica	-	√	-	√

Appendix 2. Assimilating food sources with macrozoobenthos at the study site

Macrozoobenthos	Food soruces	Δδanimal-diets δ13C (‰)	Δδanimal-diets δ15N (‰)	TL
Anadara transversa	Su	7,50	6,20	2,20
	Ae	9,24	2,07	
	Br	9,52	1,06	
	Ex	7,41	2,09	
	Rh	8,28	2,13	
Anthozoa	Su	8,21	7,73	2,65
	Ae	9,94	3,59	
	Br	10,23	2,59	
	Ex	8,11	3,61	
	Rh	8,98	3,65	
Diopatra cuprea	Su	2,06*	5,75	2,07
	Ae	3,80	1,61	
	Br	4,08	0,61	
	Ex	1,96*	1,64	
	Rh	2,84	1,67	
Dotilla myctiroides	Su	11,33	6,13	2,18
	Ae	13,07	1,99	
	Br	13,35	0,99	
	Ex	11,24	2,02	
	Rh	12,11	2,05	
Gastrana sp.	Su	9,77	6,26	2,22
	Ae	11,51	2,12	
	Br	11,79	1,12	
	Ex	9,67	2,14	
	Rh	10,55	2,18	
Lingula sp.	Su	6,39	5,88	2,11
	Ae	8,13	1,75	
	Br	8,41	0,74	
	Ex	6,29	1,77	
	Rh	7,17	1,81	
Oratosquilla woodmasoni	Su	12,31	7,03	2,45
	Ae	14,04	2,90	
	Br	14,33	1,89	
	Ex	12,21	2,92	
	Rh	13,08	2,96	
Pugillina sp.	Su	9,20	7,00	2,44
	Ae	10,94	2,86	
	Br	11,22	1,86	
	Ex	9,11	2,88	
	Rh	9,98	2,92	
Scylla serrata	Su	7,13	7,71	2,64

	Ae	8,86	3,57	
	Br	9,15	2,57	
	Ex	7,03	3,60	
	Rh	7,90	3,63	
Sipuncula	Su	2,26	5,59	2,02
	Ae	4,00	1,46	
	Br	4,28	0,45	
	Ex	2,16*	1,48	
	Rh	3,04	1,52	
Dussumeira elopsoides	Su	9,64	7,80	2,67
	Ae	11,38	3,67	
	Br	11,66	2,67	
	Ex	9,55	3,69	
	Rh	10,42	3,73	
	At	2,14*	1,60	
	An	1,44*	0,08	
	Di	7,59	2,06	
	Do	-1,69*	1,68	
	Ga	-0,13*	1,55	
	Li	3,26	1,92	
	Or	-2,66	0,77	
	Pu	0,44*	0,81	
	Sc	2,52	0,10	
	Si	7,39	2,21	
Stolephorus indicus	Su	7,62	8,27	2,81
	Ae	9,36	4,13	
	Br	9,64	3,13	
	Ex	7,52	4,16	
	Rh	8,40	4,19	
	At	0,12*	2,07	
	An	-0,59*	0,54	
	Di	5,56	2,52	
	Do	-3,71	2,14	
	Ga	-2,15*	2,01	
	Li	1,23*	2,39	
	Or	-4,69	1,24	
	Pu	-1,58*	1,27	
	Sc	0,49*	0,56	
	Si	5,36	2,68	