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MACROALGAE ASSOCIATION WITH INVERTEBRATE BIOTA IN MADASARI COAST WEST JAVA, INDONESIA

Bil Ashabi Ruhamak, Herman Hamdani, Iis Rostini, Asep Sahidin

Department of Fisheries, Faculty of Fisheries and Marine Science, Universitas Padjadjaran, Bandung – Sumedang KM. 21 Jatinangor 45363, Indonesia
E-mail Address : bilashabi.me@gmail.com

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Abundance, Association, Canopies, Diversity, Evenness, Invertebrate, Macroalgae

ABSTRACT

This research aims is to determine the diversity, macroalgae canopies, invertebrate abundance, distribution of the types of macroalgae and invertebrate biota and also analyze their linkages in intertidal zone of Madasari Coast. This research was conducted in August 2018 until November 2018. The results showed water quality (DO 3,3-9,8 mg/L, pH 6,62-8,37, temperature 26,34,3 ^{o}C, salinity 29-39 $^{o}/_{oo}$, nitrate concentration 0,0572-1,012 mg/L, phosphate 0,03-0,27 mg/L), substrate, sea current and rainfall affect diversity, canopies, abundance and distribution of types of macroalgae and invertebrate biota. The macroalgae diversity index is classified as high at all stations, 4,271 at station 1, 4,007 at station 2 and 4,508 at station 3. The invertebrate diversity index is classified as high at all stations, 3,82 at station 1, 4,19 at station 2 and 4,23 at station 3. The macroalgae evenness index is classified as very stable at station 1 (0.753) and station 3 (0.795), while at station 2 it is classified as a stable category (0.706). Invertebrate evenness index is classified as stable at all stations, 0,67 at station 1, 0,73 at station 2 and 0,72 at station 3. Canopies of macroalgae *Ulva lactuca, Gracilaria coronopifolia, Valoniopsis pachynema* and *Polysiphonia strictiss* have a mutually beneficial with abundance of invertebrate Anthozoa while canopies of macroalgae *Ulva flexuosa* have a mutually beneficial with abundance of invertebrate Gastropoda and Echinoidea at each observation stasion in the intertidal zone of Madasari Coast.

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INTRODUCTION

Invertebrates are found living together with macroalgae which provide many nutrients and shelter that is very suitable for invertebrate habitat, while most invertebrates also play a role in the survival of macroalgae by eating habits and their function as nutrient remodeling to form mutually beneficial communities in the marine ecosystem (Duggins *et al*. 1990). Macroalgae in large quantities can provide complex physical benefits to the substrate and can enrich the diversity and density of species (Bulleri *et al*. 2002, Gilinsky 1984). Aquatic invertebrate biota in abundant waters will support other biota especially algae that require a nutrient overhaul in the waters (Prather 2012).

Macroalgae is one of the marine biological resources that has economic value and has an ecological role as a producer in the food chain (feeding ground), a place for spawning marine biota (spawning ground) and a place of care for small fish (nursery ground) (Bold and Wayne 1985). Macroalgae releases organic substances and chemicals that are useful for invertebrate biota (Duggins *et al*. 1989). Canopy from macroalgae can protect intertidal ecosystems from currents that can increase the number of living larvae and provide shelter (Eckman 1983), besides that macroalgae canopy can also modify physical factors such as light penetration, temperature and sediment which can increase the survival of recruitment as well as the growth of filter feeders (Young and Chia 1984, Eckman and Duggins 1991).

Invertebrates release large amounts of ammonium in the tidal zone (Jensen and Muller-Parker 1994), nitrogen from the invertebrate excretion indicated can provide sufficient nutrients for macroalgae (Taylor and Rees 1998). The presence of invertebrates around macroalgae has a positive effect by reducing the level of stress caused by nutrients in the waters that are too much used by filter feeders (Bracken 2004, Bracken and Nielsen 2004), while herbivore invertebrates also maintain the balance of the ecosystem by eating macroalgae so that algal blooms do not occur (Duggins *et al*. 1989). Several types of invertebrates that have the habit of eating as deposit feeders can maintain the flow of current by reducing waste in the water so that it can support the role of the canopy of macroalgae (Prather *et al*. 2012).

Research by Bégin *et al*. (2004) showed an important relationship between the macroalgae canopy and a collection of invertebrates, different invertebrate communities can be found in the canopy of different macroalgae species, showing the diversity of invertebrates is influenced by the diversity of macroalgae. Macroalgae can increase the abundance of invertebrates, even one of the macroalgae species, namely *Desmarestia viridis* that does not live throughout the year can increase the abundance of six species of invertebrates, this is possible because macroalgae provide shelter.

This research aims is to determine the diversity, macroalgae canopies, invertebrate abundance, distribution of the types of macroalgae and invertebrate biota and also analyze their linkages in intertidal zone of Madasari Coastal.

MATERIALS AND METHODS

Research was conducted in August to November 2018 on the coast of Madasari, West Java, Indonesia. There are three observation stations representing the Madasari coast intertidal zone with the coordinates of stations 1, 07°48'37" S and 108°27'40" E, stations 2, 07°48'38" S and 108°27'30.7" E, and stations 3, 07°47'37" S and 108°29'45.3" E (Figure 1).

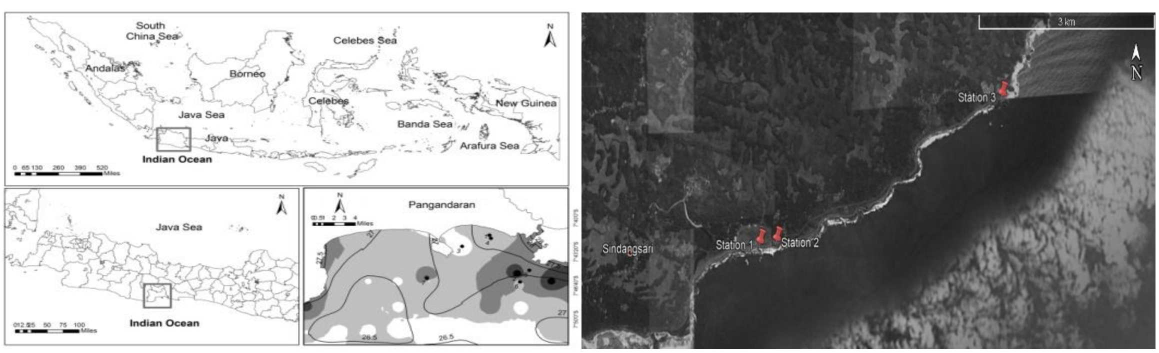

Figure 1. Research Location

Data collection for macroalgae and invertebrates was carried out using the 1 x 1 m quadrant transect method with a 20 x 20 cm grid with intervals between transects within ± 10 m (English 1997). Macroalgae and invertebrates found were counted and recorded and species identification was carried out in the field and in the Aquatic Resources Management laboratory of the Faculty of Fisheries and Marine Sciences, Padjadjaran University. Baseline conditions and substrates at the observation station are recorded.

The observed water quality parameters are temperature, acidity (pH), dissolved oxygen (DO), salinity, nitrate and phosphate levels. The parameters of observing macroalgae community structure are covering macroalgae species cover, species composition, diversity and evenness index. Meanwhile, the parameters of observing invertebrate community structure include abundance, species composition, diversity and evenness index. The diversity and evenness index are classified based on their classes in table 1 refers to Shannon-Werner diversity and evenness classes. Analysis of the relationship of macroalgae linkages with invertebrate biota using the SPSS 23 application using the Multidimensional Scaling (MDS) method with macroalgae cover and invertebrate abundance as observational variables.

Table 1. Shannon-Werner Diversity and Evenness Classes

Index	Range	Classes
Diversity	H’ < 1,0	Low
	1,0 > H’ < 3,0	Medium
	H’ >3,0	High
Evenness	0,00 < E < 0,50	Low
	0,50 < E < 0,75	Stable
	0,75 < E < 1,00	Very Stable

RESULTS

Condition of the Madasari Coastal Area

Madasari Coast is located in Masawah Village, Cimerak District, Pangandaran, West Java, Indonesia which is located at the coordinates 07°48'38 "S 108°27 '30.7" E. Madasari Coast has clear water and coral substrate with large waves. Station 1 and station 2 are located close to a river mouth with a muddy coral substrate. Station 3 is a tourist spot with sandy coral substrate. There is a large towering rock which protects the coast around station 3.

Based on current data from the ECMWF Era-Interim Reanalysis (European Center for Medium-Range Weather Forecasts) from September to November 2018 the average current speed ranges between 1.870-2.039 m/s. Current velocity at the research location is classified as weak current velocity which is in the range of 0-4 m/s. Flow is a primary ecological factor for marine biota that enables aeration, nutrient recirculation and can minimize suspended materials in water and epiphytes (Foley *et al*. 2010, Menge *et al*. 2002). Based on rainfall data from BMKG, the average rainfall in the Pangandaran in September and October 2018 is classified as low category, ranging from 20-50 mm, while in November 2018 is classified as high category, ranging from 300-400 mm.

Water Quality

The existence of macroalgae and invertebrates is influenced by the quality of physical and chemical factors of the waters. The results of measurements of several environmental parameters namely temperature, salinity, pH, DO, nitrate and phosphate are presented in table 2.

Table 2. Results of Measurement of Water Quality Parameters

Parameters	Units	Stations			Standard*
		1	2	3	
Temperature	°C	27.5-32	26.7-29.5	26-29.6	28-32
Salinity	°/₀₀	33-36	29-37	35-38	33-34
pH	-	6.9-8.4	7.5-8.2	6.9-8.3	7-8.5
DO (mg/L)	mg/L	6.9-7.9	5.9-8.8	4.2-8.8	5
Nitrate (mg/L)	mg/L	0.19-0.97	0.11-1	0.17-0.2	0.008
Phosphate (mg/L)	mg/L	0.05-0.21	0.06-0.16	0.08-0.27	0.015

*Ministry of Indonesian Environment and Forestry (2004)

The results of water quality measurement in the sites (Table 2) are still within the supporting range for marine life compared to the water quality standards from the Ministry of Indonesian Environment and Forestry (KMLH 2004) on water quality standards for marine biota.

Macroalgae Types Composition

Macroalgae species found on the Madasari coast consist of three divisions and 51 species are presented in table 3.

Table 3. Composition and Canopies of Macroalgae Types in Madasari Coast

Division	Species	Canopies (%)		
		1	2	3
Chlorophyta	*Caulerpa racemosa*	33.33	16.67	75
	Caulerpa lentillifera	16.67	0	0
	Caulerpa sp.	0	33.33	16.67
	Caulerpa taxifolia	0	0	33.33
	Codium harveyi	0	0	25
	Codium reediae	33.33	0	16.67
	Halimeda discoidea	16.67	16.67	8.33

Division	Species	Canopies (%)		
		1	2	3
	Microdictyon umbilicatum	0	16.67	0
	Chaetomorpha crassa	16.67	25	25
	Chaetomorpha sp.	8.33	0	8.33
	Chaetomorpha antennina	25	83.33	58.33
	Cladophora catenata	8.33	0	0
	Boergesenia forbesii	0	0	8.33
	Dictyosphaeria caversona	8.33	0	25
	Valoniopsis pachynema	58.33	58.33	75
	Ulva flexuosa	100	75	50
	Ulva lactuca	100	100	91.67
Rhodophyta	*Acanthophora spicifera*	33.33	25	16.67
	Chondria macrocarpa	8.33	0	16.67
	Laurencia obtusa	0	8.33	0
	Polysiphonia strictissima	66.67	66.67	50
	Corallina vancouveriensis	33.33	8.33	16.67
	Gelidiella acerosa	33.33	58.33	66.67
	Gelidium latifolium	66.67	41.67	66.67
	Gelidium micropterum	0	0	33.33
	Callophylis laciniata	8.33	16.67	25
	Chondracanthus acicularis	0	0	16.67
	Eucheuma edule	16.67	83.33	58.33
	Eucheuma denticulatum	0	8.33	8.33
	Chondrus crispus	0	0	8.33
	Gigartina clavifera	0	8.33	33.33
	Gigartina insignis	0	16.67	16.67
	Ahnfeltiopsis humilis	0	8.33	0
	Gracilaria coronopifolia	50	75	50
	Gracilaria Corticata	50	41.67	25
	Gracilaria salicornia	0	8.33	0
	Gracilaria sp.	0	0	8.33
	Gracilaria spinulosa	0	0	8.33
	Gracilaria verrucosa	0	0	8.33
	Melanthalia abscissa	8.33	0	8.33
	Halymenia sp.	0	0	8.33
	Pachymenia dichotoma	50	0	50
	Galaxaura sp. 1	0	0	8.33
	Galaxaura sp.2	8.33	0	0
	Galaxaura rugosa	8.33	8.33	8.33
	Rhodymenia palmata	50	33.33	16.67
Ochrophyta	*Padina australis*	16.67	8.33	33.33
	Padina boryana	83.33	0	66.67

Division	Species	Canopies (%)		
		1	2	3
	Sargassum aquifolium	25	0	16.67
	Sargassum muticum	0	16.67	25
	Sargassum sp.	58.33	58.33	41.67

Macroalgae which are included in the Chlorophyta division consist of 17 species, Rhodophyta division consists of 29 species and Ochrophyta division consists of 5 species. Overall individuals analyzed were around 1045 macroalgae individuals consisting of 558 individuals of the Chlorophyta division, 302 individuals of the Rhodophyta division and 185 individuals of the Orthophyta division. Based on all the individuals analyzed, the Chlorophyta division is a division that dominates the composition of macroalgae on the Madasari coast (Figure 2).

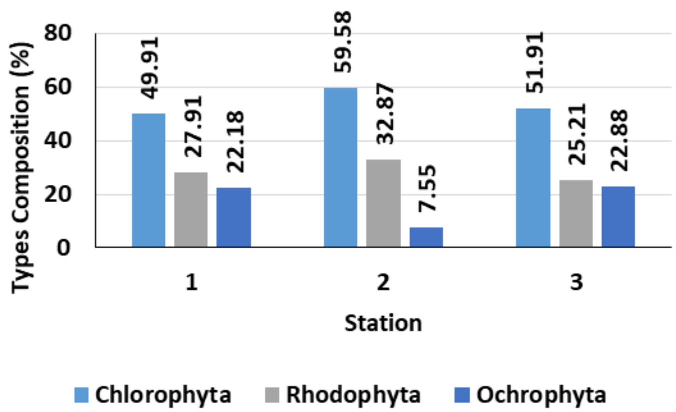

Figure 2. Macroalgae Composition

The high composition of Chlorophyta is because Chlorophyta is generally more likely to grow attached to hard substrates and can withstand strong currents. Intertidal zone usually have the highest abundance of macroalgae. The high abundance of macroalgae on intertidal zone has been shown to be due to the lower intensity of grazing by herbivorous fish in these areas and has high sunlight intensity (Diaz-Pulido and McCook 2008).

Macroalgae Canopies

The type of macroalgae cover on the Madasari coast ranges from 8-100% (table 3). The highest cover value of macroalgae species is *Ulva lactuca* macroalgae species ranging from 92-100%, this indicates that the *Ulva lactuca* macroalgae species spread over most of the intertidal area of the Madasari coast. The high percentage of *Ulva lactuca* is also caused by the leaf type of *Ulva lactuca* which is wide so that it covers almost half of the percentage of macroalgae cover on the Madasari coast. *Ulva lactuca* has a thallus-like sheet of green color resembling a braided broad band that grows to form a thick colony and is attached to a dense substrate and grows abundantly in the upper tidal zone.

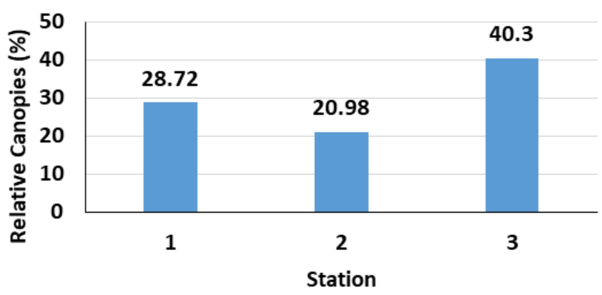

Figure 3. Macroalgae Relative Canopies

The highest relative macroalgae cover on the Madasari coast is at station 3 at 40.3% (Figure 3). Station 3 has the characteristics of sandy coral substrate and there are towering rocks so that the current that is coming is blocked by rocks. Rocks that block currents produce weak currents but currents are still able to reach up to the shoreline so that nutrient exchange can continue so that station 3 has the most optimal conditions for macroalgae growth. The high macroalgae cover is caused by high nutrient and the location of macroalgae which is getting closer to the main land will cause high macroalgae cover because the main habitat of macroalgae is the tidal zone (Litler *et al*. 2006).

Shannon-Werner Macroalgae Diversity and Evenness Index

Diversity indices throughout the Madasari coast station are in the high category at 4.271 at station 1, 4.007 at station 2 and 4.508 at station 3 (Figure 4). The high value of the macroalgae diversity index at the research location shows that the macroalgae in these waters are evenly distributed on the entire surface of the waters. The high value of the macroalgae diversity index is due to the homogeneity of the substrate at the research location, namely coral, sand and mud. Places that have rocky substrates, dead coral fragments and sand which tend to be more stable have higher macroalgae diversity compared to places that have only sand and mud substrate. The rocky area is the area that has the greatest diversity of algal species because the algal rocky substrate can grow attached (Diaz-Pulido and McCook 2008).

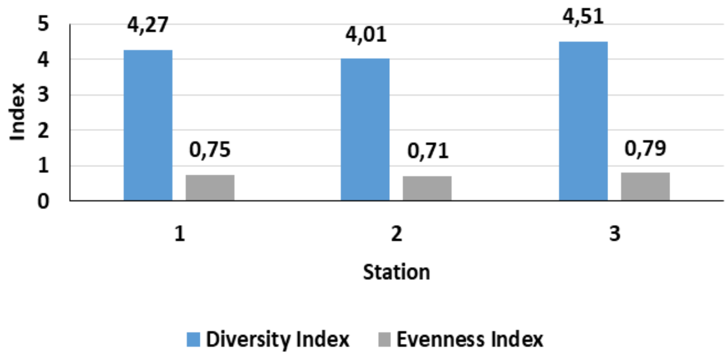

Figure 4. Macroalgae Diversity and Evenness Index

The evenness index at stations 1 and 3 is classified as very stable in the category of 0.753 at station 1 and 0.795 at station 3, while station 2 is classified as stable with a value of 0.706 (Figure 4). This indicates that macroalgae are distributed evenly and that no macroalgae species dominate and the environment is balanced.

Invertebrate Composition

Invertebrate species found on the Madasari coast consist of seven phylum and 91 species are presented in table 4. Invertebrates included in the Mollusca phylum consist of 65 species, Echinodermum phylum consists of 5 species, Porifera phylum consists of 1 species, Cnidaria phylum consists of 10 species species, the Annelida phylum consists of 4 species, the Nemertea phylum consists of 2 species and the Arthropod phylum consists of 4 species (Table 4). The total number of individuals analyzed included about 1137 invertebrate individuals consisting of 309 induviduals of Mollusca, 95 individuals of Echinodermata, 8 individuals of Porifera, 682 individuals of Cnidaria, 14 individuals of Annelida, 1 individual of Nemertea and 28 individuals of Arthropod.

Table 4. Composition and Abundance of Invertebrate in Madasari Coast

Phylum	Species	Abundance (ind/m^2)		
		1	2	3
Mollusca	*Conus chaldaeus*	0	0	2
	Conus ebraeus	1	0	0
	Conus coronatus	0	0	2
	Cypraea tigris	2	0	0
	Cypraea lynx	0	1	0
	Cypraea annulus	2	0	1
	Cypraea talpa	0	1	0
	Cypraea minoridens	1	0	0
	Cypraea gracilis	0	0	1
	Strombus mutabilis	1	0	0
	Lambis chiragra	0	1	0
	Pardalinops testudinaria	0	0	1
	Euplica scripta	0	1	0
	Anazola lutaria	2	0	0
	Olive athenia	0	0	1
	Volvarina sp.	1	0	0
	Turritella terbra	2	0	0
	Faunus ater	3	0	1

Phylum	Species	Abundance (ind/m^2)		
		1	2	3
	Epitonium aculeatum	1	0	0
	Thais jubilaea	2	0	0
	Morula granulata	3	9	3
	Morula marginalba	0	2	2
	Semiricinula muricoides	0	1	0
	Orania dharmai	1	0	0
	Cantharus undosus	0	1	1
	Drupella cornus	0	1	1
	Cerithium sp.	3	5	8
	Cerithium breviculum	2	21	1
	Cerithium coralium	0	0	1
	Clypeomorus sp.	1	0	8
	Rhinoclavis sinensis	1	4	1
	Trochus radiatus	21	4	5
	Cellana radiate enneagona	1	4	1
	Nerita plicata	3	0	0
	Nerita albicilla	8	1	3
	Turbo bruneus	2	6	0
	Euchelus asper	10	7	2
	Euchelus sp.	0	1	0
	Pseudostomatella papyracea	1	3	0
	Natica catena	3	1	0
	Natica sp.	3	0	0
	Mitra fulvescens	0	1	0
	Mitra litterata	0	2	0
	Mitra paupercula	0	2	1
	Mitra pica	0	1	0
	Mitra ambigua	0	1	0
	Mitra scutulata	0	0	1
	Pyrene fasciata	0	0	1
	Engina zonalis	1	0	0
	Engina mendicaria	0	0	1
	Latirus craticulatus	0	0	1
	Cymatium rubeculum	0	0	1
	Anachis terpsichore	0	0	15
	Plakobranchus ocellatus	16	5	2
	Onspisious chiton	1	3	0
	Donax sp.	3	5	4
	Anadara antiquata	0	1	2
	Mytilus pictus	1	3	2
	Ostrea odulis	3	19	3
	Tridacna gigas	0	1	0
	Barbatia sp.	6	4	2
	Ardeadoris sp.	0	0	4
	Antigona reticulata	0	3	1
	Octopus sp.	1	0	0
Echinodermata	*Ophiocoma* sp. 1	0	0	9
	Colobocentrotus atratus	0	0	41
	Echinometra oblonga	0	13	31
	Holothuria atra	0	0	1
	Diadema setosum	0	0	2
Porifera	*Haliclona* sp.	0	3	5

Phylum	Species	Abundance (ind/m^2)		
		1	2	3
Cnidaria	*Heteractis aurora*	0	16	4
	Hereractis magnifica	0	0	38
	Aiptasia sp.	109	48	74
	Aiptasia pulchella	10	0	7
	Aiptasia mutabilis	14	12	10
	Actinia sp.	6	27	41
	Anthopleura sp.	3	6	0
	Meandrina sp.	0	9	3
	Zoanthus sp.	57	102	63
	Aurelia aurita	0	0	1
	Physalia physalis	0	0	23
Nemertea	*Baseodiscus* sp.	0	0	1
	Baseodiscus hemprichii	0	0	1
Arthropoda	*Thalamita coeruleipes*	2	1	0
	Eriphia sebana	2	2	2
	Grapsus sp.	3	9	7
	Charybdis riversandersoni	0	0	1
Annelida	*Nereis* sp.	3	0	0
	Sabellastarte australiensis	4	2	1
	Sabellastarte magnifica	0	2	0
	Sabellastarte spectabilis	1	1	0

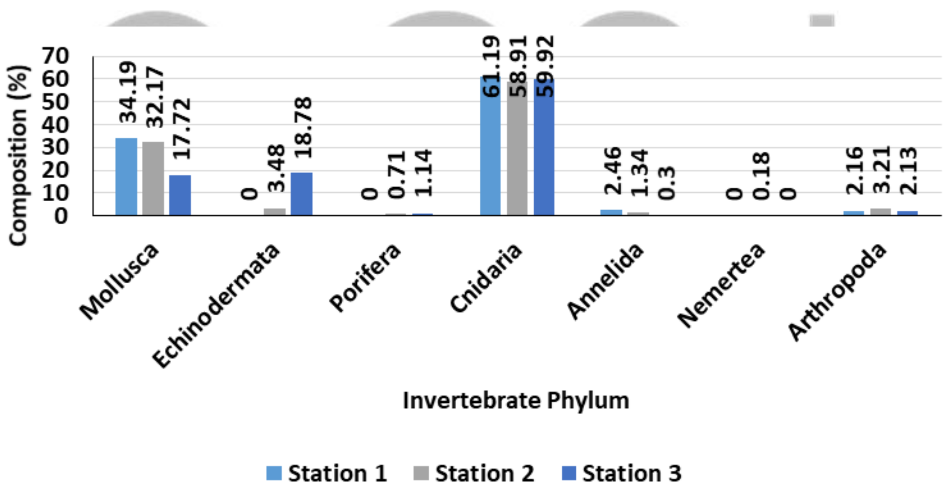

Figure 5. Invertebrate Composition

Based on all the individuals analyzed, the Cnidaria phylum is a phylum that dominates the composition of invertebrates on the Madasari coast (Figure 5). The high composition of Cnidaria is because Cnidaria can produce colonies (Cartwright *et al*. 2006) and Cnidaria which belongs to the sedentary type (sessile) are found to live in shallow habitats (Shostak 2006).

Invertebrate Abundance

The highest abundance of invertebrate species on the Madasari coast is at station 3 with 439 ind / m^2 (Figure 6). Station 3 has the characteristics of a sandy coral substrate and there are coral reefs that protect the coast from currents. The rocks that block the currents produce weak currents but the currents are still able to reach the invertebrates to the shoreline which causes nutrient exchange to continue so that station 3 has the most optimal conditions for invertebrate growth, while stations 1 and 2 are close to the river mouth causing a run off so that the waters become less optimal for growth and productivity of invertebrates. Run off carrying sediments, dissolved particles, organic and inorganic materials causes high levels of turbidity of the water, otherwise it can reduce the value of salinity and temperature.

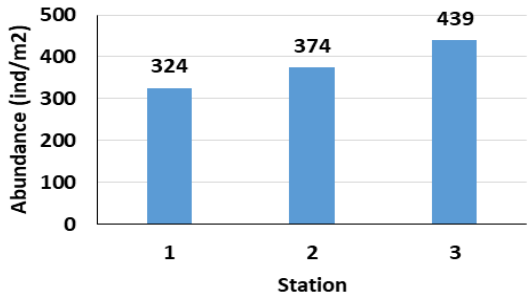

Figure 6. Invertebrate Abundance

The highest abundance of invertebrates is at station 3 which is the station with the highest density and macroalgae cover. This condition explains that there is an association between macroalgae and invertebrates. Macroalgae provides a canopy for the surrounding biota that can modify the physical (Eckman 1983) and biological environment of the surrounding area (Bégin *et al*. 2004). The structural complexity of algae leaves can increase the abundance and diversity of small invertebrates that live around it, besides the long-lived macroalgae colonies have a greater impact on species composition and invertebrate diversity than short-lived macroalgae (Dean and Connell 1987, Hacker and Steneck 1990, Taylor and Cole 1994). In the western part of the North Atlantic, feeding habits (Grazing) of sea urchin species *Strongylocentrotus droebachiensis* are important factors in suppressing macroalgae populations so that no blooming occurs, eliminating sea urchins both experimentally and naturally causing a dramatic increase in macroalgae abundance (Himmelman 1984, Dayton 1985, Witman 1987, Scheibling *et al*. 1999, Bégin *et al*. 2004).

Shannon-Werner Invertebrate Diversity and Evenness Index

The diversity index of invertebrates on the Madasari coast is classified as a high diversity category at all stations, which is 3.82 at stations 1, 4.19 at station 2 and 4.23 at station 3 (Figure 7). The high value of the diversity index at the research location shows that invertebrates in these waters are evenly distributed on all water surfaces. The high value of invertebrate diversity is due to the homogeneity of the substrates that exist in the research location, namely coral, sand and mud. Places that have rocky substrate, dead coral fragments and sand which tend to be more stable have higher macroalgae diversity, high macroalgae diversity can increase diversity, biomass and invertebrate productivity with the association between the two (Bracken and Nielsen 2004).

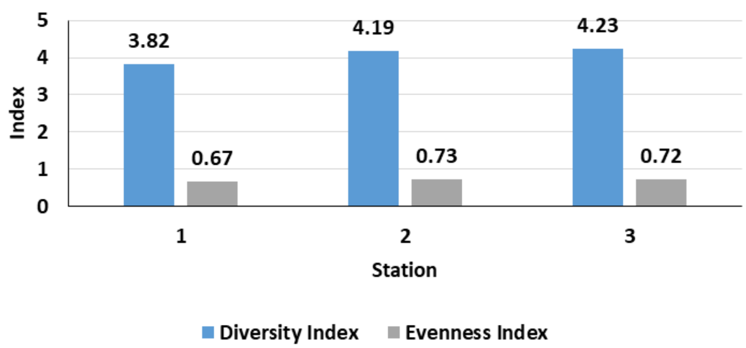

Figure 7. Invertebrate Diversity and Evenness Index

The evenness index at Madasari coast is 0.67 at station 1, 0.73 at station 2 and 0.72 at station 3 (Figure 7) which means that the evenness index at all Madasari coast stations is in the stable category. This indicates that invertebrates are spread evenly and that no invertebrate species dominate and the environment is balanced. Stable aquatic environment will show a balanced number of individuals of all species, conversely also a changing aquatic environment will cause low species distribution and tend to have individuals dominant (Connel 1974).

Macroalgae Association with Invertebrate

Correlation analysis results of the relationship between the canopies of some macroalgae species that have a canopies over >50% with an abundance of invertebrate biota showed that the class of Anthozoa correlated with macroalgae *Ulva lactuca*, *Gracilaria coronopifolia*, *Valoniopsis pachynema* and *Polysiphonia strictiss*, while invertebrate class Gastropod and Echinoidea correlated with *Ulva flexuosa*. Correlations that occur can be interpreted that there is a relationship between the abundance of invertebrates with macroalgae canopies. The presence of *Ulva flexuosa* canopies has a beneficial influence on the abundance of Gastropoda and Echinoidea, while the presence of *Ulva flexuosa* canopies is also influenced by Gastropoda and Echinoidea. The existence of the canopies of *Ulva lactuca*, *Gracilaria coronopifolia*, *Valoniopsis pachynema* and *Polysyphonia strictiss* have a beneficial effect on the abundance of Anthozoa meanwhile, the presence of *Ulva lactuca*, *Gracilaria coronopifolia*, *Valoniopsis pachynema* and *Polysyphonia* *strictiss* was also influenced by Anthozoa.

Invertebrate meso and meiofauna are commonly associated with marine foundation spesies (Taylor and Rees 1998, Duffy *et al*. 2003, Grabowski *et al*. 2005, Stachowicz and Whitlach 2005, Bracken *et al*. 2007). Gastropoda in particular are known to be important macroalgae grazers in many worldwide communities (Williams 1993). In Western Atlantic Peninsula Gastropoda assemblages associated with eight common macroalgae from the hard-bottom subtidal communities (Amsler *et al*. 2015), while in the Mediteranean, Gastropoda abundance and diversity on six macroalgae spesies varied significantly correlating with algae metrics including the degree of branching (Chemello and Milazzo 2002).

Grazing by the green urchin *Strongylocentrotus droebachiensis* is an important factor in the suppression of macroalgae and maintenance of patchiness (Himmelman 1984, Dayton 1985, Witman 1987, Scheibling *et al*. 1999). Removal of sea urchins experimentally (Himmelman *et al*. 1983) or naturally (Scheibling 1986) cause rapid increase in macroalgal abundance. In Mingan Island in the Northern Gulf of St. Lawrence, eastern Canada, the green urchin barrens is extremely abundant and form extensive urchin barrens largely devoid of erect macroalgae. Large kelps, *Alaria esculenta* and *Laminaria digitata* are abundant in shallow water but are excluded from deeper areas by urchin grazing (Gagnon *et al*. 2004).

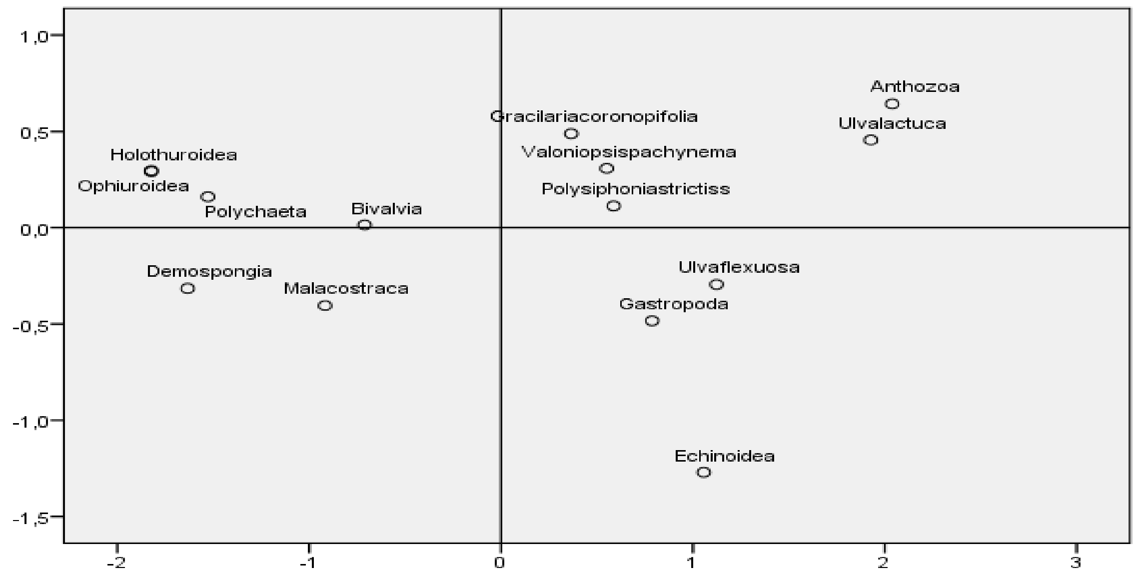

Figure 8. *Multidimensional Scaling* Macroalgae Association with Invertebrate

Anthozoa is associated with macroalgae by providing organic material for photosynthesis. Macroalgae can get 70% of inorganic nitrogen supply from the rest of the Anthozoa metabolism, while Anthozoa get oxygen from photosynthesis, macroalgae accelerates the process of calcification with photosynthesis results in an increase in pH and provides more carbonate ions by taking phosphate ions for photosynthesis. Macroalgae that is often found in association with Anthozoa and sticking is Zooxanthellae. (Tomascik *et al*. 1997). Sesille Anthozoa provide nitrogen for macroalgae in tide zone so that macroalgae nutrient are maintained (Bracken and Nielsen 2004).

Macroalgae *Halimeda kanaloana* associated with invertebrate by provides a suitable habitat for a variety of epibenthic and epifaunal in west Maui, Hawaii. *Halimeda kanaloana* meadows increase invertebrate abundance and species richness (Fukunaga 2008). Macroalgae in large numbers can add physical complexity to the substrate needed by invertebrates and can increase species richness and diversity through a number of interrelated mechanisms (Bulleri *et al*. 2002, Gilinsky 1984). High macroalgae diversity increases nutrient availability which has an impact on productivity, biomass, and invertebrate diversity (Bracken and Nielsen 2004). Macroalgae provide the canopy as a safe habitat for small invertebrates from currents and reduce the density and efficiency of predators (Eckman and Duggins 1991). The benefits provided by a macroalgae canopy may vary depending on the morphology and age of the algae. The structural complexity of algal leaves can increase the abundance and diversity of small invertebrates that live nearby Taylor and Cole (1994).

Conclusion

The macroalgae diversity index on the Madasari coast is classified as high, while the macroalgae evenness index is classified as stable to very stable. The invertebrate diversity index on the Madasari coast is classified as high, while the invertebrate evenness index is classified as stable. Canopies of macroalgae *Ulva lactuca, Gracilaria coronopifolia, Valoniopsis pachynema* and *Polysiphonia strictiss* have a mutually beneficial with abundance of invertebrate Anthozoa while canopies of macroalgae *Ulva flexuosa* have a mutually beneficial with abundance of invertebrate Gastropoda and Echinoidea at each observation stasion in the intertidal zone of Madasari Coast.

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