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Diversity, distribution and decreasing factor of intertidal invertebrate communities in the Pangandaran Turism, Indonesia

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Abstract
The intertidal of Pangandaran is one of the tourist destinations on the southern coast of Java Island. The purpose of this study was to describe the diversity, distribution of invertebrate in Pangandaran Tourism, West Java Province, Indonesia. The sample were taken from eight site sampling locations from July 2017 to November 2018. Sample taken with line transect method and their diversity and distribution was analyzed by Morisita Index and Similarity Index. The research found 139 species spread to 12 classes and 7 phyla of invertebrate. A phylum of mollusca dominated with 71.2%, followed by Cnidaria with 7.9%. *Faunus ater*, *Terebia* sp, *Clithon oualaniensis* found dominant in muddy shore substrate, *Cerithium breviculum*, *Thais jubilaea*, *Anthopleura elegentissima* found dominant in rocky shore substrate and *Hastula bacillus* just found in sand shore substrate. *Clibanarius vittatus* is a cosmopolitan crustacea species found in every substrate characteristic with abundance (69 ± 15) ind.m^{-2}. High diversity shows in rocky shore substrate with a range H' (3.99–5.08) and low diversity shows on steep crag substrate with range H' (0.50–0.65). The distribution of group categories by Morisita is dominant, while the cluster analysis of Bray-Curtis showed four clusters based on the difference of substrate. Diversity and abundance decrease of invertebrate communities influenced by pressure from anthropogenic activities, tourism activities, illegal trade fossil and invertebrate as live, capture and water pollution.

Keywords: Morisita index, cluster, mollusk, substrate, tourism impact

Introduction
The coastal zone is a unique ecosystem with complex interaction of both physical, chemical, biological, socio-economic, and cultural factors. One spot in coastal areas that have rich biodiversity is the intertidal zone [38, 17, 36]. The intertidal zone is the smallest spot of world oceans, which are only a few meters between high and low tides. Although the area is very limited, it has the largest variety of environmental factors compared to other oceans [38] it is habitats of various marine aquatic organisms like for feeding, nursery, and spawning ground [36, 46]. Organisms that are directly associated with the intertidal zone are macroinvertebrates such as mollusks, crustacea, Polychaeta, oligochaete and echinoderms.
Macroinvertebrates are one an important organism of the coastal and marine ecosystem because it plays a direct role in the nutrient cycle [16, 15], pollutant metabolism [52, 47, 27] and secondary productivity aquatic's bottom ecosystem [5]. The existence of macro-invertebrate widely distributed depending on the characteristics of aquatic such as aquatic depth, temperature, salinity, substrate type [13, 43]. Variations of distribution and abundance are an important passage in the ecological and environmental management [19] because it has a role in the preservation of biological diversity, ecosystem stability and economic profitability [24]. Nowadays macroinvertebrate diversity decreases with the large anthropogenic activity in the intertidal zone.
Decreased of macroinvertebrate because they are a slowly or sessile organism in the bottom aquatic ecosystem, so that the macroinvertebrate existence can be affected directly to physic-chemical water quality such as wave, tidal, current, temperature and topography [44], pollutant and sedimentation from anthropogenic activity [55, 49, 47], and economic utilization for food

resource nutritious, jewelry, ornament, specimen and drugs [25, 51]. Macroinvertebrate that is traded, especially mollusks, has occurred in various countries such as Papua New Guinea [29], Switzerland [4], and Mexico [12]. While in Indonesia trade of macroinvertebrate biota found in coastal tourism such as in Bali [31, 30], Pangandaran [32], Sulawesi [11], and Jakarta [7]. Marine food chains leading to seafood species are among the many goods and services generated by marine ecosystems [9]. Their utilization has been a characteristic of human societies since the earliest times.

Pangandaran is a small peninsula on the southern coast of Java Island, Indonesia. Pangandaran has a craggy beach type with narrow ravines, sloping northern slopes with Pananjung bay in the east and Parigi in the sandy west. This area belongs to an intertidal, the coastal zone that experiences shallow tides of seawater and gets sufficient light penetration. Several spots in Pangandaran coastal overgrown of algae like in Karapyak, Pasir Putih and Madasari coastal [18, 37] and seagrass [34]. Thus, there is high diversity and abundance of organisms that are associated with coral algae, seagrass, mangroves, sand and coral reefs.

Seem from the other side, Pangandaran coastal is coastal tourism which is visited by local, and foreign tourists which can disrupt the life of the biota there. In addition, Pangandaran has problems due to a lack of data. Karapyak, Karang Nini, Pasir Putih, Pantai Barat, Batu Hiu, Muara Cijulang, Nusa Wiru and Madasari coastal are one intertidal area in Pangandaran district which has a rocky, coral, sand and muddy substrate. Various species invertebrate found in Karapyak intertidal shore, one of them gastropods [46]. Based on these reasons, it is necessary to research spatial and temporal variations of marine invertebrate biota as an effort to conserve biodiversity in Pangandaran intertidal tourism, Indonesia.

Materials and Methods

Study Site and Time Sampling

The research was conducted on the Pangandaran Tourism, Indonesia. The samples were taken on the periods from July 2017 to March 2018 from eight site sampling (Figure 1 and Table 1). Sample of macroinvertebrate was taken with quadratic transect methods is in the sized of a 1x1 m^2 rectangles of five transect of each site location which are then divided into small squares with a size of 20x20 cm and sweep method, macroinvertebrate samples were taken from five small sections of transects randomly selected.

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Table 1: Site and time sampling.

Sampling Site	Coordinate		Substrate and vegetation	Sampling time	
	latitude	longitude		2017	2018
Karapyak Coastal (KR)	-7^{0}42`31.6``	108^{0}45`11.9``	rock, coral, stone, sandy-mud, seagrass, macroalgae	√	√
Karang Nini (KN)	-7^{0}41`31.0``	108^{0}43`45.0``	big rock, not vegetation	√	√
Pasir Putih Coastal (PP)	-7^{0}42`47.0``	108^{0}39`05.0``	big and small rock, sand, macroalgae, seagrass	-	√
Pantai Barat (PB)	-7^{0}42`06.0``	108^{0}39`41.0``	fine sand, not vegetation	-	√
Batu Hiu (BH)	-7^{0}45`23.1``	108^{0}35`29.0``	big rock, not vegetation	-	√
Muara Cijulang (MC)	-7^{0}43`10.1``	108^{0}30`04.0``	muddy-sand, mangrove	√	√
Nusawiru (NW)	-7^{0}43`23.0``	108^{0}29`32.7``	muddy, mangrove	√	√
Madasari coastal (MD)	-7^{0}46`35.0``	108^{0}30`02.0``	big and small rock, stone, macroalgae, seagrass	√	√

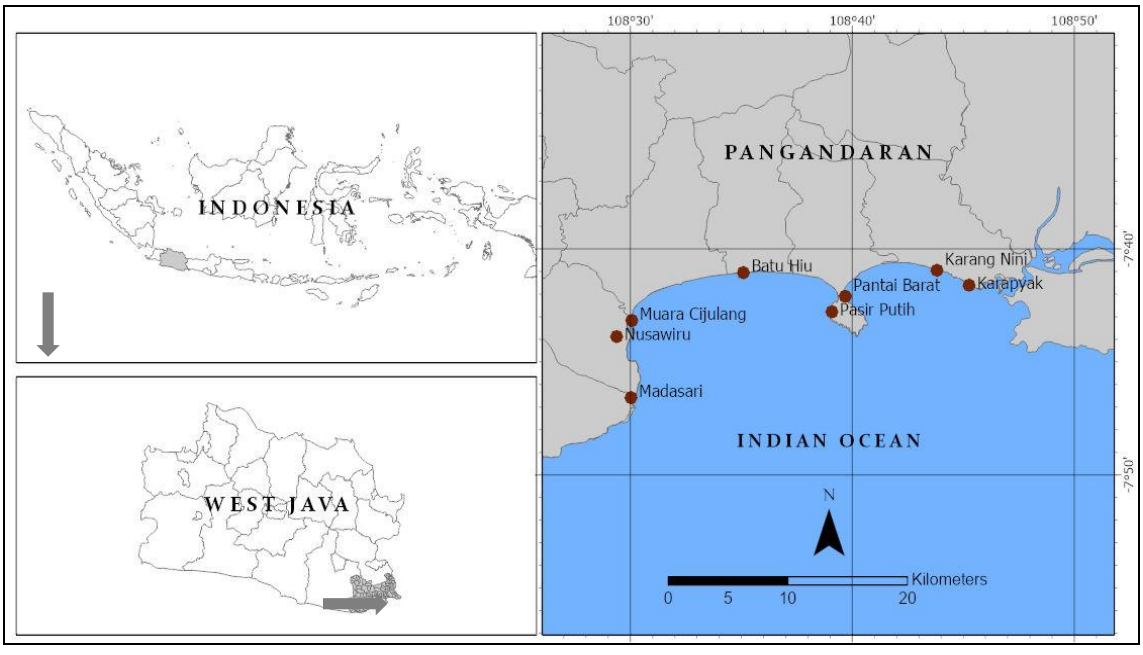


Fig 1: GIS location of sampling site in Pangandaran Tourism, West Java Province, Indonesia

Analysis Data

Sample of invertebrate identified based on comparation between real morphology manual and book identification of aquatic invertebrates such as Echinodermata [(Lee and Shin 1996), Molluscs [10], Polychaeta [45], Crustacea [8] and nomenclature written by *World Register of Marine Species* (WoRMS: http://www.marinespecies.org/index.php) and http://species-identification.org. Macroinvertebrate diversity analyzed with followed by Shannon-Wiener index (H'), Evenness index (J'). Spatial distribution analysis of macroinvertebrate with by Morisita distribution index analysis and similarity index to use MINITAB.v15.1.2-EQUiNOX software.

Results

Biodiversity

139 species of marine invertebrates were identified in Pangandaran Coastal belong to 12 classes and 7 phyla. Number taxa of Mollusca phyla is dominating with 71.2% (n = 99 species) followed to Cnidaria (7.9%, 11 species), Arthropoda (7.2%, 10 species), Echinoderm (6.5%, 9 species), Annelid (3.6%, 5 species), Porifera (1.4%, 2 species) and Nemertea (1.4%, 2 species). The highest number of taxa found on Karapyak followed on Pasir Putih and Madasari (Tab. 2).

Table 2: Numbers indicate the proportion (%) of the numbers of species of each phylum out of the total number of invertebrate species identified at each station.

Phylum	Number of Species	Sampling Site (no. of species / %)							
		KR	KN	PP	PB	BH	MC	NW	MD
Mollusca	100 (72.0)	71 (76.3)	1 (50.0)	64 (73.6)	2(66.7)	1(33.3)	9 (90)	6 (88.9)	51(70.8
Echinodermata	9 (6.5)	5 (5.3)		7 (8.0)					4 (5.6)
Porifera	2 (1.4)	1 (1.1)		2 (2.3)					1 (1.4)
Cnidaria	11 (7.9)	7 (7.5)		7(8.0)					8 (11.1)
Annelida	5 (3.6)	2 (2.2)		1 (1.1)					3 (4.1)
Nemertea	2 (1.4)	1 (1.1)		2 (2.4)					1 (1.4)
Arthropoda	10 (7.2)	6 (6.5)	1 (50.0)	4 (4.6)	1 (33,3)	2 (66.9)	1 (10,0)	1 (11,1)	4 (5.6)
Total species	139 (100)	93 (100)	2 (100)	87 (100)	3 (100)	3 (100)	10 (100)	9 (100)	72 (100)
Abundance (ind/m)		1281	58	349	24	44	677	513	568
Diversity Index (H')		5.08	0.50	3.99	0.80	0.65	2,16	2,03	4,52
Evenness index (J`)		0.59	0.87	0.75	0.75	0.65	0.60	0.61	0.69

Muara Cijulang are found the highest abundance with 342 ind.m^{-2}, followed Nusawiru 230 ind.m^{-2}, Karapyak 191 ind.m^{-2}, Madasari 126 ind.m^{-2} and lowest abundance founded in Pantai Barat 24 ind.m^{-2} (Table 2; Figure 3b). Gastropod found dominate, especially in the species *Cerithium punctatum*, *Clypeomorus bifasciata*, *Clypeomorus petrosa*, *Engina mendicaria*, *Mitra paupercula*, *Morula granulata*, *Plakobranchus ocellatus* and *Thais tuberosa*. They are cosmopolitan species from the mollusca phyla. Another cosmopolitan species, namely *Clibanarius vitarus* and *Grapsus tenuicrustatus* from Arthropoda phyla, and *Ophiocoma scolopendrina* in Echinodermata Phyla.

Shannon-Wiener diversity index (Table 2) of the Karapyak found the highest with H '= 5.08, followed by the Madasari and Pasir Putih with H values' respectively 4.52 and 3.99, and lowest diversity index founded in Karang Nini and Batu Hiu sampling with a value of H'= 0.50 and 0.65, respectively. According to Shannon-Wiener (1971) the index value <1 is included in the low species diversity category, 1-3 is included in the medium category, and the index value > 3 is included in the high category. Based on the Shannon-Wiener index, Karapyak, Pasir Putih and Madasari included the high diversity category, Muara Cijulang and Nusawiru included in the Medium diversity categories, while Karang Nini, Batu Hiu and Pantai Barat included to the low diversity categories.

Distribution

Distribution of invertebrate showed not have correlation between number of taxa and abundance (Figure 2a; 2b). Number of taxa found Gastropod class in Karapyak and Madasari showed highest with 65 and 43 species, while abundance found highest of Anthozoa class 497 ind.m^{-2} and 329 ind.m^{-2}, respectively.

Also, number of Gastropod taxa found low in Nusawiru and Muara Cijulang s, but high found of abundance with 303 ind.m^{-2} and 521 ind.m^{-2}. *Anthopleura elegentssima* found dominant in Karapyak dan Madasari, while *Faunus ater* from Gastropod found dominant in Nusawiru and Muara Cijulang site.

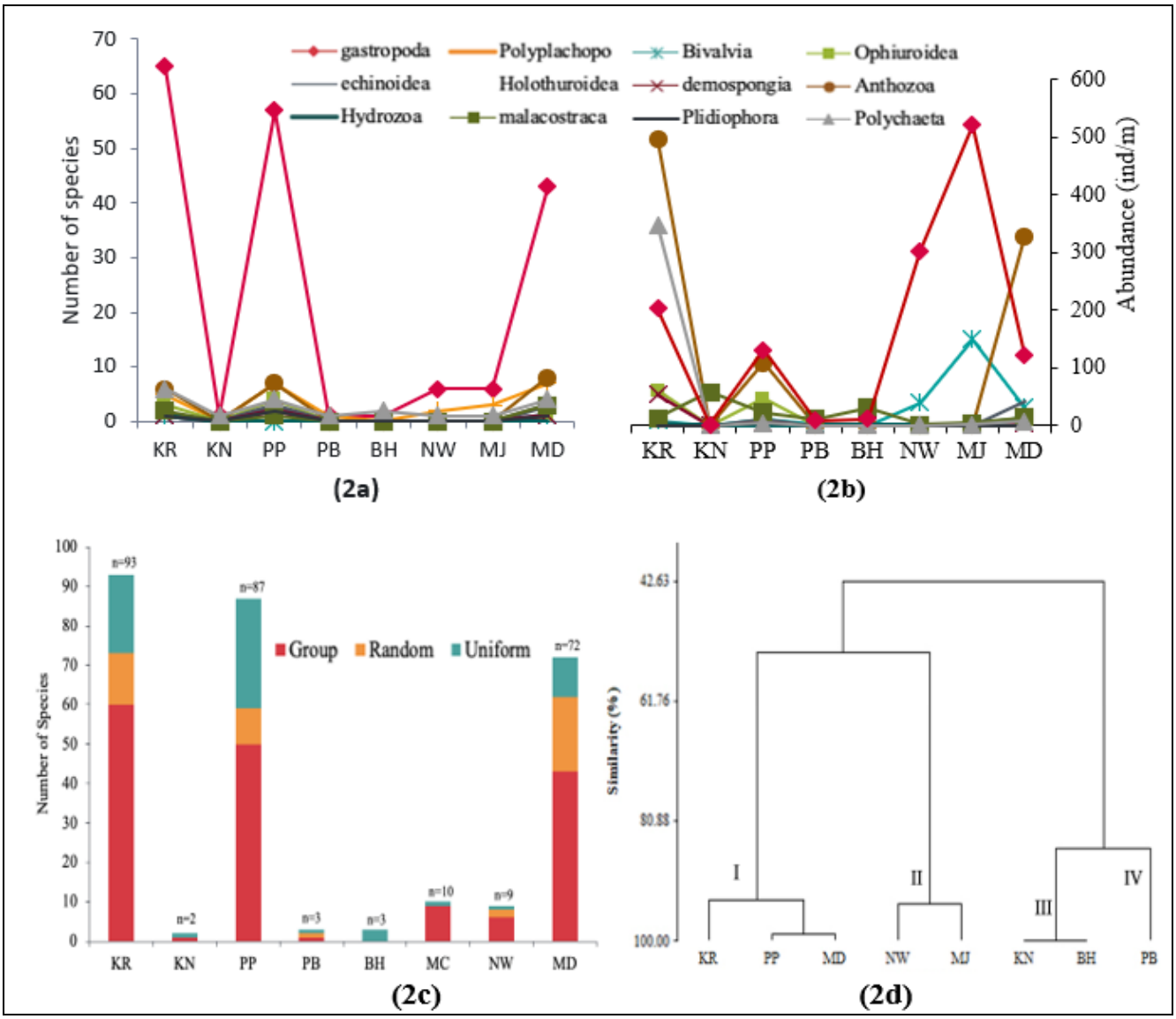


Fig 2: Spatial distribution pattern of Pangandaran invertebrate (2a) number of taxa distribution; (2b) abundance distribution; distribution by analysis of; (2c) Morisita index; (2d) Similarity index.

Species-level of invertebrate's distribution of Pangandaran by Morisita divided into 3 categories, namely group (Gp=86), uniform (Um=16) and random (Rm=37). Pangandaran rocky shore substrate is found high species group categories by Morisita Index (Figure 2c). Similarity analysis of Pangandaran invertebrates divided into 4 major groups (Figure 3d) that is Karapyak, Pasir Putih and Madasari locations formed one group (98%), Karang Nini and Batu Hiu (93%), Muara Cijulang and Nusa Wiru (87%), and Pantai Barat become single sport (89%).

Discussion

Diversity

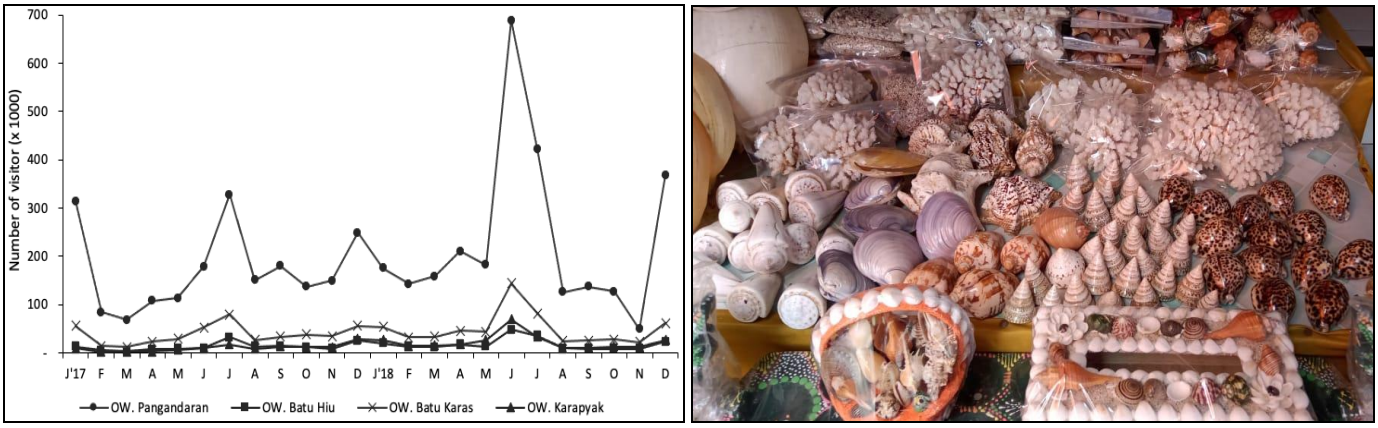
Diversity of invertebrates affected directly to the substrate type [5]. The coastal with the mixing of rocky substrates, stoons, muddy, sand and corals are the areas most inhabited by marine organisms and have a great diversity both for animals and plants [47], including the marine invertebrate organisms, especially in Mollusca and Cnidaria phyla. This fact is proven that in the Karapyak, Pasir Putih and Madasari found high diversity (Table 2), its locations have similar characteristics, which have a low slope, coral, rocky, a little mud and little sand substrate, and overgrown by various types of algae and seagrass (Table 1), that are ideal for the life of most invertebrates. Gastropods are inhabiting hard-substrate [42] and most of them search for food with alga grazing [2, 47]. Other research by Hutomo and Moosa (2005) that on the coastal Pangandaran invertebrate organisms have identified 31 species of Echinoderms and 63 species of Mollusca. While the extreme habitat at the Karang Nini and Batu Hiu s with large and steep crag substrates with large wave impact shows the lowest diversity with H values of 0.5 and 0.65, respectively and included in the low diversity category.

The number of species found in one location is not always coherent with high or low of abundance. The results showed the highest abundance and low number of species was found in the Muara Cijulang and Nusawiru with an abundance of 342 ind.m^{-2} (10 species) and 230 ind.m^{-2} (9 species). The cause of the high abundance is the very high dominance of one species, namely *Fanaus ater* with an abundance of 148 ind.m^{-2}. Both of these locations are located in an estuary with mud substrate and mangrove. *Faunus ater* is an invertebrate that is very tolerant of changes in water quality, living in estuaries and associating with mangroves [23], and as a bioindicator of organic pollution and heavy metal accumulators [1]. Invertebrate affected directly to the and ecological pressure by water pollution and anthropogenic activities [5].

Decrease of invertebrate diversity

The intertidal of Pangandaran is one of the tourist destinations on the southern coast of the Java Island that has a predominantly steep crag, rocky and sandy substrate [46, 34]. The coastal with rocky substrates and corals are the areas most inhabited by marine organisms and have a great diversity both for animals and plants [44], including the marine invertebrate organisms, especially in Mollusca and Cnidaria phyla. The problem of intertidal shore are susceptible areas to external interference both naturally and due to anthropogenic disturbance [55, 49, 47] which can decrease the biodiversity of marine organisms, especially invertebrates that have limited movement. Natural events that can decrease the diversity and population of marine invertebrates such as climate change, tsunamis, temperature changes due to el-Nino and la Nina and predation [28]. As for anthropogenic that can decrease diversity and invertebrate populations – waters pollution [55, 47], tourists [56], capture [26] and sale of biota ornaments [31, 30, 32].

Increase of tourism harms to the ecosystem and diversity of coastal organisms in Pangandaran (Figure 3a). One of the tourist activities that can decreased the population of invertebrate organisms is the habit of taking objects (that are considered attractive by them) including fossils, invertebrate shells and also invertebrates that are still alive [56, 24]. The evidence shows in Pasir Putih locations that have number of species with high deviations (± 20). This shows that there are fluctuations in the number of species found in the sampling period. Fluctuations in species found occur during holidays, both national and school holidays i.e., January, June, July, and December (Figure 3a). Work and school holidays increase the number of visitors to tourism place [48, 20, 39]. There was an increase in visitors at the Pasir Putih location, OW Pangandaran, by up to 150% (Figure 3a; Pangandaran District Tourism Office 2019). The effect of an increase in both local and foreign tourists will increase the number of biotas that is disturbed, dead or taken by tourists. This is under the statement of Zahedi (2008) that many tourist behaviors are not cooperative towards nature such as littering, damaging and taking organisms as collections. Types of mollusca phyla are taken more by tourists than other types [56, 24] because mollusca phyla, especially the Gastropod class, have large size and more attractive shapes so they are more visible to tourists.



a) b)

Fig 3: Factor of Invertebrate diversity decreased in Pangandaran Coastal Tourism (a) number of visitors in 2017-2018 (adapted from gvpangandaran.com), (b) illegal trade of invertebrate fossil (mypangandaran.com).

Other evidence that Pangandaran Tourism is one of the places for selling fossil ornaments or invertebrate shells, especially the Mollusca class (Fig. 3b), other research mention that found 750 individual legally protected species treaded in Pangandaran Tourism [32]. The many vendors in Pangandaran Tourism claimed the sales prices were not dependent of the species' protection status. Extremely, some vendors took live biota from the coastal, then killed it to sell fossils for ornament. It happened because local communities have a job to be a guide, but in addition, they also sell fossils, shells, living organisms to be made ornamental and domesticated [31, 30]. The trade of invertebrate fossil and specimen in the Pangandaran is clearly illegal under the Indonesian low, but it is massive trade in the Pangandaran Turism. If these activities continue to be carried out in Pangandaran, it will accelerate the reduction of the diversity of marine invertebrate in Pangandaran Turism.

Spatial distribution

Substrate texture become key of determine spatial distribution of mollusk –part of the classes of invertebrate community— in the coastal area [44]. Those reasons show in this research which location with have more stone and rockier substrate has a high diversity e.g., Karapyak, Pasir Putih and Madasari (Table 1, 2). Mostly, mollusk class in Pangandaran Tourism has high diversity and low of species abundance, except in the muddy substrate – Muara Cijulang and Nusawiru— have low diversity and high abundance on one species, namely *Faunus ater* (230-342 ind.m^{-2}). Both locations have organic traps, namely mangrove (Table 1) and *F. ater* have correlated with the organic matter [23].

Spatial distribution coastal invertebrate also determined by species movement. Generally, invertebrate organism has slow movement and/or sessile on the substrate due to species distribution become grouping. The evidence be show in this research (Fig. 2c), spatial distribution with the group category by Morisita index are highest. In addition, every species has best visibility substrate for live, as *Anthopleura elegentissima* from Cnidaria Phyla only found form a group on rocky shores locations in the near of sea edge. Cnidaria is a species has character very susceptible to environmental conditions that are seawater exposed, salinity, currents and depth [35, 14].

Invertebrate organisms with has actively moving – Echinodermata and Arthropod phyla— found random distribution category by Morisita index. Echinodermata is one of species found in the highest tides coastal [22, 3], capable of

reproducing in the intertidal zone [54, 40] and adapting to rock crevices as a hiding place from predators. *Ophiocoma scolopendrine* and *Ophiocoma Erinaceus* are the dominant species, they are opportunist species in coastal intertidal zones mixing hard substrates and sand. While *Clibanarius vittatus* from Arthropod phyla found dominant in each location, it is active and scattered malacostraca in the rocky and sandy shore [53], good migration capability [50, 41], and resistant to environmental temperatures and salinity [53].

Conclusion

A total of 139 species invertebrates found that belong to 12 classes and 7 phyla. A phylum Mollusca dominated with 71.2%, followed by Cnidaria with 7.9%. *Faunus ater*, *Terebia* sp, *Clithon oualaniensis* found dominant in muddy shore substrate, *Cerithium breviculum*, *Thais jubilaea*, *Anthopleura elegentissima* found dominant in rocky shore substrate and *Hastula bacillus* just found in sand shore substrate. *Clibanarius vittatus* is a cosmopolitan crustacea species found in every substrate characteristic with abundance (69±15) ind.m^{-2}. High diversity shows in rocky shore substrate with range H' (3.99-5.08) and low diversity shows on steep crag substrate with range H' (0.50-0.65). Diversity and abundance decrease of invertebrate communities influenced by pressure from anthropogenic activities, turism activities, illegal trade fossil and invertebrate as live, capture and water pollution. Substrate type and anthropogenic activities found to be a key cause in spatial distribution of invertebrate in Pangandaran Tourism, West Java, Indonesia.

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