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

Asep Sahidin, Herman Hamdani, Zahidah, Heti Herawati, Chitra Octavina and M Suhaemi Syawal

DOI: https://doi.org/10.22271/fish.2021.v9.i1e.2421

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, Clisthon ovalaniensis found dominant in muddy shore substrate, Cerithium breviculum, Thais jubilaeus, Anthopleura elegantissima found dominant in rocky shore substrate and Hastula bacillus just found in sand shore substrate. Clibanarius vitinatus 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, 25] and secondary productivity aquatic’s bottom ecosystem [3]. 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]. Nowdays 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 physical-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

International Journal of Fisheries and Aquatic Studies 2021; 9(1): 357-364

E-ISSN: 2347-5129
P-ISSN: 2394-0506
(IVC-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.549
IJFAS 2021; 9(1): 357-364
© 2021 IJFAS
www.fisheriesjournal.com
Received: 01-10-2020
Accepted: 04-12-2020

Asep Sahidin
(1) Fisheries Department, 
Faculty of Fisheries and Marine 
Sciences, Universitas 
Padjadjaran, Indonesia
(2) Aquatic Resources 
Laboratory, Faculty of Fisheries 
and Marine Sciences, Universitas 
Padjadjaran, Indonesia

Herman Hamdani
Aquatic Resources Laboratory, 
Faculty of Fisheries and Marine 
Sciences, Universitas 
Padjadjaran, Indonesia

Zahidah
Fisheries Department, Faculty of 
Fisheries and Marine Sciences, 
Universitas Padjadjaran, Indonesia

Heti Herawati
Fisheries Department, Faculty of 
Fisheries and Marine Sciences, 
Universitas Padjadjaran, Indonesia

Chitra Octavina
(1) Marine Biology Laboratory, 
Faculty of Marine and Fisheries, 
Universitas Syiah Kuala, 
Indonesia
(2) Research Center of Marine 
and Fisheries, Universitas Syiah 
Kuala, Indonesia

M Suhaemi Syawal
Research Center of Limnology, 
Indonesian Institute of Sciences, 
Indonesia

Corresponding Author: Asep Sahidin
(1) Fisheries Department, 
Faculty of Fisheries and Marine 
Sciences, Universitas 
Padjadjaran, Indonesia
(2) Aquatic Resources 
Laboratory, Faculty of Fisheries 
and Marine Sciences, Universitas 
Padjadjaran, Indonesia
resource nutritious, jewelry, ornament, specimen and drugs \cite{25, 51}. Macroinvertebrate that is traded, especially mollusks, has occurred in various countries such as Papua New Guinea \cite{29}, Switzerland \cite{4}, and Mexico \cite{12}. While in Indonesia trade of macroinvertebrate biota found in coastal tourism such as in Bali \cite{31, 30}, Pangandaran \cite{32}, Sulawesi \cite{11}, and Jakarta \cite{7}. Marine food chains leading to seafood species are among the many goods and services generated by marine ecosystems \cite{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 sand 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 \cite{18, 37} and seagrass \cite{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 \cite{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 in the sized of a 1x1 m² 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.

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 in the sized of a 1x1 m² 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.

| Sampling Site            | Coordinate          | Substrate and vegetation       | Sampling time |
|--------------------------|---------------------|--------------------------------|---------------|
|                          | latitude            | longitude                      | 2017 | 2018 |
| Karapyak Coastal (KR)    | -7°42'31.6"       | 108°45'11.9"                  | ✓    | ✓   |
| Karang Nini (KN)         | -7°41'31.0"       | 108°43'45.0"                  | ✓    | ✓   |
| Pasir Putih Coastal (PP) | -7°42'47.0"       | 108°39'05.0"                  | -    |    |
| Pantai Barat (PB)        | -7°42'06.0"       | 108°39'41.0"                  | -    | -   |
| Batu Hiu (BH)            | -7°45'23.1"       | 108°35'29.0"                  | -    | -   |
| Muara Cijulang (MC)      | -7°43'10.1"       | 108°30'04.0"                  | ✓    | ✓   |
| Nusawiru (NW)            | -7°43'23.0"       | 108°29'32.7"                  | ✓    | ✓   |
| Madasari coastal (MD)    | -7°46'35.0"       | 108°30'02.0"                  | ✓    | ✓   |

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{image1}
\caption{GIS location of sampling site in Pangandaran Tourism, West Java Province, Indonesia}
\end{figure}
Analysis Data
Sample of invertebrate identified based on comparation between real morphology manual and book identification of aquatic invertebrates such as Echinodermata [2] (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.

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  | 51  | 64  | 2  | 1   | 9   | 6   | 51 |
| Echinodermata   | 9 (6.5)           | 5   | 7   | 2   |  |    |     |     |    |
| Porifera        | 2 (1.4)           | 1   | 2   |    |   |    |     |     |   |
| Cnidaria        | 11 (7.9)          | 7   | 7   |    |   |    |     |     |   |
| Annelida        | 5 (3.6)           | 2   | 1   |    |   |    |     |     |   |
| Nemertea        | 2 (1.4)           | 1   | 2   |    |   |    |     |     |   |
| Arthropoda      | 10 (7.2)          | 6   | 4   | 2   | 2 |    |     |     |   |
| Total species   | 139 (100)         | 93  | 39  | 87  | 3 | 2   | 10  | 9   | 72 |
| 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 found 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 pauperca, Morula granulata, Plakobranchus ocellatus and Thais tuberosa. They are cosmopolitan species from the mollusca phyla. Another cosmopolitan species, namely Cibbanarius vitatus and Grapsus tenuicrataus from Arthropoda phyla, and Ophiocoma scolopendra 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 found 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, but high found of abundance with 303 ind.m⁻² and 521 ind.m⁻². Anthopleura elegantissima found dominant in Karapyak dan Madasari, while Fauius ater from Gastropod found dominant in Nusawiru and Muara Cijulang site.
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 Nusa Wiru 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. Fanaus 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 Niño 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 [46, 30, 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.

![Figure 3a: Number of visitors in Pasir Putih location, OW Pangandaran, by up to 150% (Pangandaran District Tourism Office 2019).](image1)

![Figure 3b: Illegal trade of invertebrate fossil (mypangandaran.com).](image2)

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 treasured 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 intertidal of Pangandaran is clearly illegal under the Indonesian law, 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., Karapuy, 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.m²). 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 elegantissima 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 scolopendrina* and *Ophiocoma Erinaceus* are the dominant species, they are opportunistic 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 Chordata with 7.9%. *Fauna ater, Terebia sp. Clithon oualaniensis* found dominant in muddy shore substrate, *Cerithium breviculium, Thais jubilaeus, 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.

**Acknowledgment**

This research supported by a Lecturers Research Internal grants (HU) scheme at Research of Fundamental Universitas Padjadjaran (RFU) 2018.

**References**

1. Agustín R, Sarong MA, Yuliandra F, Suhendaryatna, Rahmadi, Lelijafir. Accumulation of heavy metal in *Fauna ater* and is population structure in Bale River Lhoknga Aceh Besar, Indonesia. Pakistan Journal of life and Social Science 2018;16(2):106-112.
2. Amsler MO, Hidang YM, Engl W, McClintock JB. Abundance and diversity of gastropods associated with dominant subtidal macroalgae from the Western Antarctic Peninsula. Pollution Biology 2015;38(8):1-11.
3. Arribas LP, Martinez MI, Brogger MI. Echinoderms in San Matías Gulf, Southwestern Atlantic Ocean. Thalassas 2016;32(1):1-18.
4. Biondo MV. Quantifying the trade in marine ornamental fishes into Switzerland and an estimation of imports from the European Union. Global Ecology Conservation 2017;11:95-105.
5. Bissoli LB, Bernardino AF. Benthic macrofaunal structure and secondary production in tropical estuaries on the Eastern Marine Ecoregion of Brazil 2018
6. Capa M, Murray A. Combined morphological and molecular data unveils relationships of Pseudobranchiomma (Sabellidae, Amnelida) and reveals higher diversity of this intriguing group of fan worms in Australia, including potentially introduced species. Zookeys 2016;622:1-36. [https://doi.org/10.3897/zookeys.622.9420](https://doi.org/10.3897/zookeys.622.9420)
7. Cappenberg HAW. The composition of species and structure of benthic mollusk of Jakarta Bay. Ocea and Limno di Indonesia 2017;2(3):65-79.
8. Chertoprud ES, Garliatska LA, Azovskiy AI. Large-scale patterns in marine harpacticoid (Crustacea, Copepoda) diversity and distribution. Marine Biodiversity 2010;40(1):301-315.
9. Christensen V, de la Puente S, Sueiro JC, Steenbeek J, Majluf P. Valuing seafood: The Peruvian fisheries sector. Marine Pollution 2014;44(1):302-311.
10. Dhama B, Recent & fossil Indonesian shells. Hackenheim, Germany, Conch Books 2005, 198pp
11. Fesse SCA, Knittweis L, Krause G, Maddusila A, Glaser M. Livelihoods of ornamental coral fishermen in south Sulawesi/Indonesia: implications for management. Coast Manag 2013;40:525-555.
12. Garza RF, Iñáñez SG, Rodríguez PF, Ramirez CT, Rebollodo LG, González AV, et al. Commercially Important Marine Mollusks for Human Consumption in Acapulco, México. Natural Resources 2012;3:11-17.
13. Gholizadeh M, Yahya A, Talib A, Ahmad O. Effects of environmental factors on polychaete assemblage in Penang National Park, Malaysia. Word Acad Sci, Eng and Tech J 2012;72:669-672.
14. Giln H, Haruka Y, Daly M, Nakaoka M. Temperature and salinity survival limits of the fluffy sea anemone, *Metridium senile* (L.), in Japan. Hydrobiologia 2019;830: 303-315.
15. Griffiths JR, Kadin M, Nascimento FJA, Tamelander T, Roos AT, Bonaglia, et al. The importance of benthic–pelagic coupling for marine ecosystem functioning in a changing world. Glob Cha Biol 2017;23: 2179-2196.
16. Hale SS, Giancarlo C, Christopher DF. Eutrophication and Hypoxia Diminish Ecosystem Functions of Benthic Communities in a New England Estuary. Frontier Marine Science 2016;3(1):249-259.
17. Hamza W, Hameli SA, Ramadan G, Hameli MA. Coastal alternation and its impact on diversity of macrobenthic fauna in the intertidal zone of Abu Dhabi Western Coast (UAE). Journal of Marine Biology & Oceanography 2018;7(1):1-11.
18. Hanifah S, Sahidin A, Hamdani H, Yuliadi LP. Diversity of Chlorophyta on Karapayak beach, Pangandaran, West Java Province, Indonesia. World Sci News 2019;117 (1):158-174.
19. Harris PT. On seabed disturbance, marine ecological succession and applications for environmental management: a physical sedimentological perspective. International Association Sedimentology 2012;44: 387-404.
20. Hartati ST, Rahman A. Current state of reef health and resources of reef fish in pangandaran beach waters, west java. BAWAL 2016;8(1):37-48.
21. Hutomo and Moosa. Indonesian marine and coastal biodiversity: present status. Indian Journal of Marine Science 2005;34 (1):88-95.
22. Iken K, Konar B, Benedetti-Cecchi L, Cruz-Motta JJ, Knowlton A, et al. Large-scale spatial distribution patterns of echinoderms in nearshore rocky habitats. PloSone 2010;5 (11) e13845.
23. Indra, Sahidin A, Zahidah, Andriani Y. Macrozoobenthos community structure Cij ulang River Pangandaran District, West Java Province, Indonesia. World Science News 2019;128(2):182-196.
24. Kartika S, Mu Y. A Study on Indonesian Mollusk Fishery and its Prospect for Economy. International Journal of
Marine Science 2014;4(5):61-66.
25. Leal MC, Puga J, Seródio J, Gomes NCM, Calado R. Trends in the discovery of new marine natural products from invertebrates over the last two decades – where and what are we bioprospecting? PlosOne 2012;7(1):1-17.
26. Mather J. Marine Invertebrates: Communities at Risk. Biology 2013;2(2):832-840.
27. Mears AJ, Bissel M, Morrison AM, Rempel-Hester MA, Arthur C, Rutherford N. Effects of pollution on marine organisms. Water Environment Resources 2019;9(10):1229-1252.
28. Michael TB, Amanda E, Bates, Mark J, Costello, Martin E. et al. Ocean community warming responses explained by thermal affinities and temperature gradients. Natural Climate Change 2019;9(1):959-963.
29. Militz TA, Kinch J, Southgate PC. Aquarium trade supplychain losses of marine invertebrates originating from Papua New Guinea. Environment Management 2018;61:661-670.
30. Nijman V, Lee PB. Trade-in nautilus and other large marine mollusks as ornaments and decorations in Bali, Indonesia. Rafflesia Bulletin of Zoology 2016;64:368-373.
31. Nijman V, Spaan D, Nekaris KAI. Large-scale trade in legally protected marine mollusc shells from Java and Bali, Indonesia. PLoS One 2015;10(12):e0140593.
32. Nijman V, Spaan D, Sigaud M, Nekaris KAI. Addressing the open illegal trade in large marine mollusc shells in Pangandaran, Indonesia. Journal of Indonesian Natural History 2016;4(1):12-18
33. Nurhayati A, Aisah I, Supriana AK. Model Development of a Synergistic Sustainable Marine Ecotourism - A Case Study in Pangandaran Region, West Java Province, Indonesia. Sustainability 2019;11(12):3418.
34. Nurhayati A, Purnomo AH. An environmentally friendly fisheries resource use pattern in Pangandaran based on its bioecological condition: A case study in Pangandaran, West Java Province, Indonesia. Journal of Ocean Resources 2019;4(1):1-5.
35. Oualid JA, Gonzales PJL, Alla AA, Moukrim A. Geographical distribution of Eunicella gazella (Studer, 1878) (Aplysiaidae: Octocorallia: Anthozoa; Cnidaria) in Atlantic West Africa: First record in Moroccan Atlantic coasts. Journal of Materials and Environmental Science 2016;7(11):4262-4268.
36. Palomo M, Bagur M, Calla S, Dalton M, Soria S, Hawkins S, et al. Biodiversity and Interactions on the Intertidal Rocky Shores of Argentina (South-West Atlantic). In Hawkins S, Bohn K, Firth L, Williams G (Eds.). Interactions in the Marine Benthos: Global Patterns and Processes (Systematics Association Special Volume Series 2019; pp.164-189. Cambridge: Cambridge University Press.
37. Pamungkas ER, Hamdani H, Liviawaty E, Sahidin A. Temperature shock of the growth of Ulva lactuca in Pangandaran, West Java Indonesia. International Journal of Fisheries and Aquatic Research 2019;4(1):61-66.
38. Petrovic S, Gvozdenovic S, Ikica Z. An annotated checklist of the marine molluscs of the south Adriatic sea (Montenegro) and a comparison with those of Neighbouring area. Turkist Journal of Fisheries and Aquatic Science 2017;17:921-934.
39. Pramanik PD, Ingkadijaya R. The Impact of Tourism on Village Society and its Environmental. IOP Conf. Series: Earth and Environmental Science 2018;145:012060.
40. Rahman MA, Molla MHR, Megwalu FO, Asare OE, Tchoundi A, Shaikh MM, et al. The Sea Stars (Echinodermata: Asteroidea): Their Biology, Ecology, Evolution and Utilization. SF Journal of Biotechnology and Biomedical Engineering 2018;1(2):1007
41. Rodrigues GFB, Ballarín CS, Françozo A, Amorim FW. Structural patterns of a coastal hermit crab-gastropod shell interaction network: new insights from a unique relationship. Marine Ecology Progress Series 2020;640(1):117-126.
42. Rumahlatu D, Leiwakabessy F. Biodiversity of Gastropoda in the coastal waters of Ambon Island, Indonesia. AAACL Bioflux 2017;10(2):285-296.
43. Sahidin A, Isdradjad S, Wardiatno Y. Macrozoobentos Community Structures of Tangerang Coastal Water, Banten. Depik 2014;3(3):226-233.
44. Sahidin A, Wardiatno Y, Setyobudiandi I. Biodiversity and special distribution of molluscs in Tangerang coastal waters, Indonesia. AAACL Bioflux1 2019;12(6):2051-2061.
45. Sahidin A, Yusli W. Spatial distribution of Polychaeta at Tangerang coastal water, Banten Province. Journal of Fisheries and Marine 2016;6(2):83-94. [Indonesian]
46. Sahidin A, Zahidah, Hamdani H, Riyantini I, Sewiko R. The Biodiversity of Gastropods in Karapayk Rocky Shores, Pangandaran Region, West Java Province, Indonesia. Omni-Akutika 2018a;14(2):79-85.
47. Sahidin A, Zahidah, Herawati H, Wardiatno Y, Setyobudiandi I. Macrozoobenthos as bioindicator of ecological status in Tanjung Pasir Coastal, Tangerang District, Banten Province, Indonesia. Biodiversitas 2018b;19(3):1123-1129.
48. DOI: https://doi.org/10.13057/biodiv/190347.
49. Schänzle H, Yeoman I. Trends in family tourism. Journal of Tourism Futures 2015;1(2):141-147.
50. Sharma SD, Behera RR, Mohapatra U, Panda CR, Nayak L. Effect of estuarine effluents on benthic faunal communities in relation to tidal dynamics of Dhamra estuary. Journal of Pharmacy and Life Sciences 2018;4(2):127-134
51. Souza ECF, Gorman D, Leite FPP, Turra A. Offactory selectivity in intertidal hermit crabs: aggregation Pagurus criniticornis (Decapoda, Anomura) in response to simulated predation on the gastropod Cerithium atratum. Hydrobiologia 2016;772:31-43.
52. Torres VR, Encinar JA, Lópe MH, Sánchez AP, Galiano V, Catalán EB, et al. An Updated Review on Marine Anticancer Compounds: The Use of Virtual Screening for the Discovery of Small-Molecule Cancer Drugs. molecules 2017;22(1):1-37.
53. Van Loon WMGM, Boon AR, Gittenberger A, Walvoort DJJ, Lavaleye M, Duineveld GCA, et al. Application of the benthic ecosystem quality Index 2 to benthos in Dutch transitional and coastal waters. Journal of Sea Research 2015;103(1):1-13.
54. Vogt EL, Model JFA, Vinagre AS. Effects of Organotins on Crustaceans: Update and Perspectives. Frontiers in Endocrinology 2018;9(65):1-8.
55. Walag AMP, Layaug AG, Garcia GU. Survey of echinoderms in the intertidal zone of Goson-on and Vinapor, Carmen, Agusan del Norte, Philippines. Environal and Expert Biological Science 2018;16:31-38. DOI: https://doi.org/10.22364/eeb.16.04
55. Wardiatno Y, Qonita Y, Mursalin, Zulmi R, Effendi H, Krisanti M, et al. Determining ecological status of two coastal waters in Western Java using macrozoobenthic community: A comparison between North Part and South Part. IOP Conf Ser: Earth Environmental Science 2017;54(1):01207

56. Zahedi S. Tourism impact on coastal environment. WIT Trans on built environment 2008;99(7):45-57.