The Diversity of Molluscs (Gastropod and Bivalve) In Mangrove Rehabilitation and Natural Area Biak Numfor Regency In Indonesia

Sinery Anton[1*], *Purba* Gandi [1], *Magdalena* Octovyanti[2], Amisah[3], *Budi* Setiawan[4], *Sari* Ice Anugrah[4]

[1]Postgraduate Program Universty of Papua. Jl. Gunung Salju, Manokwari 98314, West Papua, Indonesia.
[2]Master Program of Environmental Science, Universitas Papua. Jl. Gunung Salju, Manokwari 98314, West Papua, Indonesia
[3]University of Caritas Indonesia. Jl. Lembah Hijau, Manokwari 98314, West Papua, Indonesia
[4]Forestry Study Programe, Forestry Faculty, Tadulako University. Jl. Soekarno Hatta KM.9, Tondo, Palu, Central Sulawesi, Indonesia

Abstract. This study aimed to describe the diversity of mollusk species in rehabilitated and natural mangroves. The research variables included of mollusk species and individuals (gastopods and bivalves). The method used was descriptive, with observational techniques. There were 39 species of mollusks and 16 families with 2,922 individuals. There were 39 species of mollusks and 16 families with 2,922 individuals. These included 34 species of snail groups (Gastropod) and 5 species of shellfish groups (Bivalve). In addition, the percentage distribution of mollukc species was 18% (8 species out of 39 species) with diversity index (H) 1,09, dominancy (C) 0,12, and evenness (E) 0,84 (natural), then (H) 1,22, dominancy (C) 0,08, and evenness (E) 1,85 (rehabilitation). In addition, species diversity index values in the two mangrove forests were 2.52 (Ruar Village) and 2.70 (Yenusi Village) in the "moderate" category. A total of 72% of mollusk individuals were found in mangrove forests of Yenusi village, and the remaining 28% were present in Ruar village. This showed good adaptation, considering that the presence of mollusk species and individuals in the mangrove rehabilitation area was higher compared to their natural habitat. This showed that rehabilitation greatly influenced species composition at rehabilitation locations compared with natural locations.

1 Introduction

In Indonesia, the potential mangrove forests had an area of 3,364,076 ha, consisting of 3,121,239 ha (93%), 188,363 ha (5%), and 54,474 (2%) in the dense, moderate mangrove category, and sparse categories, respectively. In this context, the distribution of the dense category reached 1,084,514 ha, spread across Papua Province before 1996 [1]. Several studies have shown that Indonesia's mangrove forests have the highest richness (species diversity) in the world and are found in the coastal areas of Sumatra, Kalimantan, and Papua, which is a characteristic of this ecosystem. Meanwhile, those found in Tanah Papua, which covers the provinces of Papua and West Papua, were found along the coast, including the Biak Numfor Regency area.

The Biak Numfor was formed from the Biak and Numfor Island. In addition, the regency accounted for 0.62% (2,602 km²) of the total land area of Papua Province (421,981 km²). Geographically, it was located at 0° 55'- 1° 27' South Latitude and 134° 47'- 136° East Longitude, comprising the mainland of Biak Island (1,796 km²), Numfor Island (323 km²) as well as a group of small islands with an area of 483 km² [2]. The capital of Biak Numfor Regency was Biak City, which had 19 sub-districts, with 17 located around the coast (12 sub-districts on Biak Island, five sub-districts on Numfor Island). The other two sub-districts were on the Aimando and Padaido Islands, which had four groups of small coral islands.

In line with these results, the Biak Timur Sub-district had an area of 217.68 km2 with 17 villages, including Yenusi and Ruar. The Biak Numfor Regency Government in 2014 through the Environmental Agency carried out the rehabilitation of mangrove forests in several areas along the Biak Timur coast. This activity was conducted in the context of restoring environmental quality in coastal areas affected by the 1996 tsunami, such as Yenusi Village [3]. As the third largest village in the Biak Timur Sub-district, Yenusi has a coastline of 2.75 km and is a location for mangrove rehabilitation.

Another area on the east coast of Biak Island, Ruar Village, has been reported to possess several mangrove forests. However, it is currently poor, indicating the need for proper management. The current state was primarily due to the 1996 tsunami disaster, which led to

* Corresponding author: a.sinery@unipa.ac.id

the loss of coastal protective vegetation, specifically in the Oridek and Biak Timur sub-district [3]. These conditions were further exacerbated by the region's major role in meeting the needs of the community. Similar conditions were observed in the two sub-districts in terms of meeting community needs. According to [2], the logging and use of mangroves in the coastal areas of Biak Island were carried out to provide building and residential materials. The Biak Timur Sub-district with a coastline of 2.7 km of natural were was had for determining habitat quality.

The area of mangrove forests on the east coast of Biak Island according to satellite image analysis results was 144.81 ha, including a sparse, moderate, and dense density of 89.64 ha, 26.19 ha, and 28.98 ha, respectively [4]. In addition, mangrove damage was characterized by the rare density caused by the 1996 tsunami. An earthquake (Mw 8.2) 60 km northeast of Biak Island led to a tsunami with water levels (run-up) reaching 7.7 meters [5], [1]. The incident damaged various infrastructure and coastal ecosystems (including mangroves). The direct impact of the tsunami on mangrove forests was very large compared to that on other ecosystems, such as coral reefs and seagrass. Ruar is the fourth largest village in the Biak Timur Sub district, with a coastline of 2.7 km, which represents natural mangrove forests. Based on the results of satellite image analysis, the areas of natural and rehabilitated mangroves in Ruar Village were 40.5 ha and 13.3 ha, respectively. Information regarding ecosystem restoration in term of rehabilitation was reflected in the existence of bioindicators for marine biota that had not been recorded, such as mollusks as an indicator for determining habitat quality [3].

Based on previous results, human factors also play a major role in the changes in mangrove land cover apart from the impact of the 1996 tsunami. Various community activities, such as cutting down trees, building ports/ship moorings, changing the function of residential areas, and fish farming, have been shown to have significant effects. In Yenusi Village, mangrove rehabilitation was carried out in 2014 covering an area of 5 ha, and based on observations, the efforts were 70% successful [1]. Rehabilitation activities through reforestation are efforts to restore ecologically healthy ecosystem conditions. Therefore, this study aimed to determine the diversity of mollusks in Yenusi Village as a representation of rehabilitated mangroves and in Ruar Village as a representation of natural mangroves.

2 Study Methods

2.1 Time and Reseacrh Location

The study procedures were conducted for four months (November 2024 – February 2025) in Yenusi and Ruar Villages, Biak Timur Sub-district, Biak Numfor Regency, Papua Province, Indonesia.

2.2 The equipment and materials

The equipment and materials used were a Global Positioning System (GPS), a meter roller, measuring rope, specimen-making materials, and a mollusks identification book. The research variables consisted of species and individuals of mollusks (gastropods and bivalve).

2.3 Research Procedure

This study was conducted using a descriptive method with survey techniques (observation) and data collection was conducted using purposive sampling (intentionally). Consequently, data collection was based on objectives, representing various species of mangrove forest conditions. Determination of the observation location was conducted deliberately by considering the condition of mangrove forests, both natural and rehabilitated. The collection and identification of mangrove and mollusks species was performed through observation lines using the line plot sampling method, which was placed systematically at a distance of 30 m perpendicular to the ground surface. In the two mangrove forests, three observation lines were made each, which were placed proportionally in three sample plots measuring 10m x 10m. Plots on this route were Yenusi I (lane I), Yenusi II (lane II), and Yenusi III (lane III). These three routes were close the residential areas (± 100 m) and could be reached on foot in the village. In Ruar Village, there were 3 (three) routes, Ruar I (lane I), Ruar II (lane II), and Ruar III (lane III). These three locations were relatively distant from the residential areas and represented natural mangrove forests.

The procedures began with the preparation stage, which included reviewing the location (initial observations), determining the route, and collecting the mollusk data. Preparations were made in the form of coordination with the community by collecting data and information related to the location. For the field surveys, the preparation of equipment and supporting materials in the data collection process was also carried out, followed by analysis. Initial observations were performed to obtain information regarding the conditions of the location. From these results, the route was determined based on the presence both natural and rehabilitated mangrove forests. In addition, the observation plot was determined deliberately according to the condition of the mangrove, specifically thickness and density. The coordinates of the track location and the sample plot were documented.

2.4 Data Analysis

Data collection on species and individuals of Gastropod and Bivalves was carried out in the two mangrove forests. Observations were made using the same paths and plots as those used to collect the mangrove data at low tide. Species data were collected by identifying morphological characters according to species recognition guidelines. The observational data were then entered into a table for further analysis. Observations and data collection were carried out using

the line transect plot method by pulling the meter towards the ground surface at a distant of 30 m. Sample plots were made using a rope, which was placed deliberately, perpendicular to the beach. In each lane, a plot measuring 10 m x 10 m was constructed.

a. Mollusks Abundance
Potential or abundance of individual mollusks using the Shannon-Wiener equation [6]:

$$Y = \frac{10000\ x\ a}{b} \quad (1)$$

Description : Y = Abundance (Ind/m^2), a = Number of Mollusks filtered (ind), b = Transect area x number of replications, 10^4 = Conversion value from m^2 to cm^2.

b. Relative Abundance
Relative abundance of mollusks individuals using the equation in [7]:

$$R = (ni/N) \times 100\% \quad (2)$$

Description : R = Relative abundance, ni = number of individuals of each species (heads), N = Total number of individuals.

c. Diversity and Uniformity Index
Mollusks species diversity index used the Shannon-Wiener equation [6]:

$$H' = -\Sigma\ (ni/n)\ x\ In\ (ni/N) \quad (3)$$

Description : H' = Diversity Index, ni = Number of individuals of each species, N = Number of individuals of all species, Diversity index (H') consisted of several criteria, namely : H' > 3,0 = Shows very high diversity, H' 1,6 - 3,0 = Shows high diversity, H' 1,0 – 1,5 = Shows moderate diversity, H' < 1 = Shows low diversity.
The uniformity index (E) was calculated using the Evennes Index equation from Shannon's Index of Diversity [6] as follows :

$$E = H' / LnS \quad (4)$$

Description : E = Uniformity Index, H' = Diversity Index, S = Number of Species. The uniformity index was grouped into 3 criteria, namely: E < 0,4 = The level of population uniformity was small 0,4 < E < 0,6 = The level of population uniformity was moderate E > 0,6 = The degree of population uniformity was large.

d. Dominance Index
The dominance index was calculated using the dominance of the Simpson equation [6], as follows:

$$C = \sum (ni/N)2 \quad (5)$$

Description : C = Dominance index, ni = Number of individuals of each species, N = Total number of Individuals. Dominance is a characteristic or feature of a community that showes the number of species of organisms in an area [6]. The dominance index ranged from to 0-1. The closer the number is to 1, the higher the level of dominance of a particular species. Meanwhile, when the value was close to 0 (zero), no particular species dominated. Dominance index values were grouped into 3 criteria, namely: $0 < C \leq 0,5$ = Low dominance, $0,5 < C \leq 0,7$ = Moderate dominance, $0,7 < C \leq 1$ = High dominance.

3 Result and Discussion

3.1 Species of Mollusks

The morphological characterization results of mollusk species based on identification and previous studies showed that mangrove forests of Yenusi and Ruar Villages, Biak Timur Sub-district had a relatively large mollusks potential. This potential is good for mollusks and individuals in both areas. In the two mangrove forests, 39 mollusk species from two classes and 19 families were identified with a total of 2,922 individuals.

The results of identification and analysis showed that there were 39 species of mollusks, with 34 belonging to the snail group (gastropod), and five species in the shellfish group (Bivalvia). This number was different when compared to other studies, which showed differences in habitat characteristics, presence of species and individuals and environmental conditions. According to [8], the composition of mollusks in the Waranggui mangrove forests was higher (nine gastropods and four species of bivalves) than that in [10] who reported 10 species in the Kaisu Sarmi mangrove forests. The results of the current study were lower than those of [10] who identified 75 gastropods and 19 bivalves in southern Biak, Papua.

Information on various mollusks species in mangrove forests has been obtained from various studies in Indonesia. According to [11] there were 14 species of gastropods and one species of bivalves were found in the mangrove forests of Dedap Tasikputripuyu village, Meranti Islands, Riau. Meanwhile [12] identified 15 species of gastropods in TPI Parit 7, Tungkal I Village, West Tanjung Jabung. [13] found 33 species in the mangrove ecosystem of the Pari Island group and16 species in Teluk Awur [14]. The high number of species and individuals in the gastropod class indicated that the species could adapt well to mangrove conditions. Several species have waterproof skin that functions as a barrier and allows air to pass through and feed on plankton or organic matter.

The presence of species and individuals was more dominant in Yenusi Village, which showed the stability of the habitat to support the life of macrobenthic species compared to Ruar Village natural. Not only limited to species and individuals but also class and family categories, the differences in the presence of mollusks in these two mangroves were characteristic. These two regions are geographically separated by more than 1 km and have different characteristics. Mangrove forests in Ruar village natural had a thicker mud substrate with a beach width of approximately 150 – 250 m. Compared to Ruar village, Yenusi village as a rehabilitation area had a sandy substrate accompanied by light rocks with a beach width of 200 – 300 m and a distance of 300 – 500 m from the settlement. The communities around these two regions depend on the Ruar mangrove forests. Small snails (gastropods) are used as raw materials for handicrafts in the form of decorations (necklaces, bracelets), souvenirs, and several other species for consumption.

The results of the analysis showed that 72% of mollusks individuals were found in mangrove forests of Yenusi village and the remaining 28% were obtained in Ruar village. This condition showed that there was a good adaptation of species considering that the presence of mollusk species and individuals in the mangrove rehabilitation area (Yenusi village) was much higher than in their natural habitat (Ruar village). The existence of species and individuals is closely related to habitat stability, which can be seen from the presence of rehabilitated mangroves and environmental conditions. Naturally, these two mangrove ecosystems had similar environmental conditions and the structure of the mangrove vegetation was not significantly different.

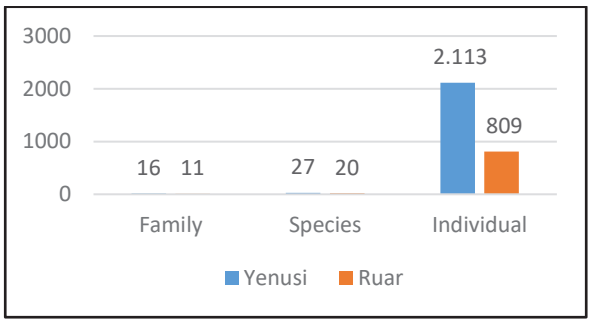

Fig 1. Mollusks in Yenusi and Ruar Village

Several species of mollusks in the gastropod class had a dominant number of individuals and were found in only one area, such as Nerita plicata the species with the highest number of individuals found in Yenusi Village, but not in natural mangroves (Ruar village). Several species were found in the two mangrove forests, including Semiricinula sp., and Clypeomorus sp., showing good adaptation. According to [8], the mud and sand habitat makes several species of gastropods dominant in terms of the number of individuals in Oransbari mangrove forests. Several gastropods have been found, including Nerita sp., which stuck to rocks (dead coral) around the trunk and roots of mangroves [15].

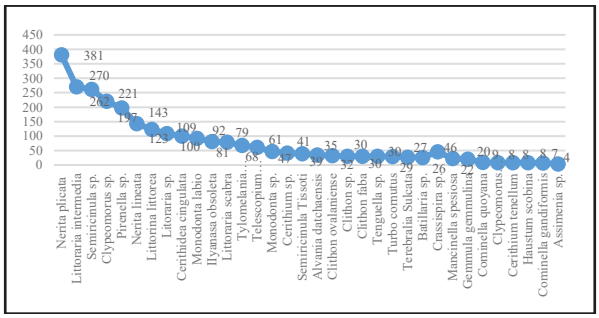

Fig 2. Dominant individual gastropods species

The dominance of Nerita plicata individuals (13 %) showed that species was able to adapt well to mangrove forests. [8] stated that Nerita plicata is a species of gastropod that has adapted well to the Waranggui mangrove forests, totaling 192 individuals (15.29%) compared with other species. The potential of gastropods was not only limited to their function in the environment but also more to their economic function through their use for consumption and as raw materials for handicrafts (decoration) by the community, specifically in Ruar village.

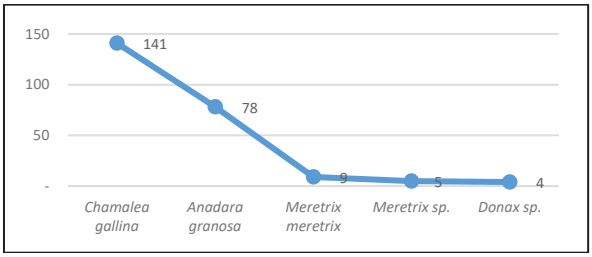

Fig 3. Dominant individual bivalve species

The individual dominance of Chamalea gallina reached 59.49% and Anadara granosa (32.91%), showing that the existence of the two species had good potential from an environmental aspect and also provided benefits from the economic benefits considering that both were consumed and had the potential to support the community's economy. Balancing individual equality between the two crab species was a very good condition both environmentally and economically considering that both species supported the community's economy. In addition, there is a balance between the even distribution of individuals of the two species of marine worms in terms of environmental quality.

As show in Figure 3, the rehabilitated mangrove forests (Yenusi Village) had relatively good habitat conditions for various species of biota. This condition is supported by the presence of rehabilitated mangrove vegetation. However, the quantity was still different from that of mangrove vegetation in Ruar Village. The environmental conditions were also reflected in the water quality parameters analyzed, which were good for the existence of its components. According to [8], the population would naturally increase with the availability of wild animals known as animal welfare, but the process of adaptation to changes in habitat (in this case low carrying capacity) could increase the population as well as the relationship between wild animals, secondary forests, and community gardens on Numfor Island and several other areas. This is also thought to be related to the presence of mollusk species in the two mangrove forests.

Among the 34 gastropod species found in the two mangrove forests, such as 8 species, including Clypeomorus sp., Littoraria intermedia, Littoraria scabra, Semiricinula sp., Tylomelania patriarkalis, Pirenella sp., Telescopium telescopium, and Crassispira sp. 11 species were found confined to the Ruar mangrove forests and 15 other species in the Yenusi mangrove forests. There were 19 species of gastropods in the Ruar mangrove forests and 24 species in the mangrove forests of Yenusi Village, showing an even distribution of species.

Table 1. Distribution of Mollusks Species in Mangrove forests

Class	Family	Species	Rehabilitation (Yenusi)	Experience (Ruar)
G	Assiminidae	*Assimenia* sp.	√	
a	Batillaridae	*Batillaria* sp.		√
s	Cerithiidae	*Cerithium* sp.	√	

t r o p o d		*Cerithium tenellum*	√	
		Clypeomorus clypeomorus		√
		Clypeomorus sp.	√	√
	Cominellidae	*Cominella gandiformis*	√	
		Cominella quoyana	√	
	Littorinidae	*Litoraria* sp.	√	
		Littoraria intermedia	√	√
		Littoraria scabra	√	√
		Littorina littorea	√	
	Muricidae	*Haustum scobina*		√
		Mancinella spesiosa		√
		Semiricinula sp.	√	√
		Semiricinula tissoti	√	
		Tenguella sp.		√
	Nasariidae	*Ilyanasa obsolete*	√	
		Clithon sp.		√
	Neritidae	*Clithon faba*		√
		Clithon ovalaniense		√
		Nerita lineata	√	
		Nerita plicata	√	
	Pachychilidae	*Tylomelania patriarchalis*	√	√
	Potamididae	*Cerithidea cingulate*		√
		Pirenella sp.	√	√
		Telescopium telescopium	√	√
		Terebralia sulcata	√	
	Pseudomelatomidae	*Crassispira* sp.	√	√
	Rissoidae	*Alvania datchaensis*	√	
	Trochidae	*Monodonta labio*		√
		Monodonta sp.	√	
	Turbinidae	*Turbo cornutus*		√
	Turridae	*Gemmula gemmulina*	√	
B i v a l v e	Arcidae	*Anadara granosa*	√	
	Veneridae	*Chamalea gallina*	√	
		Meretrix meretrix		√
		Meretrix sp.	√	
	Donacidae	*Donax* sp.	√	

The research location was small and limited to mangrove forests that had been rehabilitated, leading to differences in the number of species found in the anathor area. In addition, rehabilitation activities generally use fewer mangroves species, which affects species diversity. Usually only one species of mangrove is used in the rehabilitation of mangrove forests (Rhizophora sp). Therefore, the mangroves species that grew were more uniform and species diversity was low.

3.2 Species Dominance Index (C)

The levels of dominance, diversity, and evenness of macrozobenthic species as indicators of community stabilization in mangrove forests studied were analyzed using indices of dominance, species diversity, and species evenness. The dominance index of mollusks species in the two mangrove forests was relatively low. Species diversity index values were on "moderate" criteria for both mangrove forests and when combined. In addition, the species evenness index value in the two mangrove forests were moderate (natural mangrove forest), and high criteria and when combined were in the moderate criteria.

Table 2. Species Dominance Index (C)

Area	Species (S)	Individual (N)	Dominance (C)
Natural (Ruar)	20	809	0,12
Rahabilitation (Yenusi)	27	2,113	0,08

3.3 Species Diversity Index (H)

The highest dominance index for mollusks species was in gastropod (moderate criteria) and bivalves (low criteria). The highest species diversity index value was found in the gastropod group with the "moderate" criteria, where as other groups were in the low category. In addition, species evenness index value in the 2 groups was classified as "moderate". According to [6] the dominant value was high when the value of $C = 0.75 < C \leq 1$, while $C = 0.5 < C \leq 0.75$, and low when $C = 0 < C \leq 0.5$. Odum (1971) in [8] showed that the dominance index is inversely proportional to the diversity index. This shows that the higher the dominance index, the lower the species diversity index and vice versa.

Table 3. Species Diversity Index (H)

Mollusks group	Species (S)	Individual (N)	Diversity (H)
Gastropoda	34	2685	1.31
Bivalvia	5	237	0.41

In general, the presence of more species and individuals increased the influence of mastery of certain species and showed greater concentration on one or several species in the area. According to [6], when the dominance value reaches 1, only one species is dominant in the community. Meanwhile, when result = 0, no species in the community were dominant. Based on the calculation of the species dominance index, no mollusk species in the mangrove forests were significantly dominant. This was illustrated by the C value ranging from 0.07 – 0.11 in the two mangrove forests, with the highest being gastropod (0.86).

The highest species diversity index was obtained by combining the species diversity of the two mangrove forests studied (moderate criteria), followed by mangrove rehabilitation (Yenusi village) and natural mangrove (Ruar village), with each having moderate criteria. The mollusck species diversity index in mangrove forests of Ruar and Yenusi village was in the moderate category (1.09 -1.22), and two areas were combined. According [6], the high, moderate, and low species diversity indices ere more than 3 ($H \geq 3$), 1 and 3 ($1 < H < 3$), and less than 1 ($H < 1$), respectively. Based on these criteria, the diversity of mollusks species in the mangrove forests of Ruar and Yenusi villages was classified as moderate.

[6] stated that a community is said to have high species diversity when it consist of many species with the same or almost the same abundance. Meanwhile, when a community consisted of very few species and only a few were dominant, diversity was low.

3.4 Species Evenness (e)

The evenness index of mollusks species in the 2 mangrove forests studied was 0.84 and 0.86, which were in the high category. The species evenness values according to [19] ranged from 0 to 1. The species evenness index shows the proportion of individuals in each species in a community. When each species had the same number of individuals, the community had the highest species evenness index.

Table 4. Species Evenness Index (E)

Mollusks group	Species (S)	Individual (N)	Evenness (E)
Gastropoda	34	2685	0.86
Bivalvia	5	237	0.59

3.5 Analysis Results

The analysis results showed that there were eight species of mollusks were spread across two mangrove forests. The percentage distribution of mollusks species was 18% (8 species out of 39 species) with diversity index (H) 1,09, dominancy (C) 0,12, and evenness (E) 0,84 (natural), then (H) 1,22, dominancy (C) 0,08, and evenness (E) 1,85 (rehabilitation). In addition, species diversity index values in the two mangrove forests were 2.52 (Ruar Village) and 2.70 (Yenusi Village) in the "moderate" category. A total of 72% of mollusk mollusk individuals were found in mangrove forests of Yenusi village, and the remaining 28% were present in Ruar village. This value describes the adaptation of mollusks species to habitat conditions, which were influenced by habitat components, such as the distribution of vegetation and substrate. In general, evenness was influenced more by the presence of vegetation species as a place for activities (eating and other activities) and differences in substrate. In addition, the presence of forest vegetation species was explained in the mangrove vegetation section.

4 Conclusion

There were 39 species of mollusks and 16 families with 2,922 individuals. These included 34 species of snail groups (Gastropods) and 5 species of shellfish groups (Bivalves). The percentage distribution of mollusks species was 18% (8 species out of 39 species) with diversity index (H) 1,09, dominancy (C) 0,12, and evenness (E) 0,84 (natural), then (H) 1,22, dominancy (C) 0,08, and evenness (E) 1,85 (rehabilitation). In This shows that rehabilitation greatly influences species composition at rehabilitation locations compared with to natural locations. The recovery of the mangrove ecosystem following the tsunami can be achieved through rehabilitation activities to accelerate the growth of mangrove vegetation and its components.

References

1. Yudhicara, Tsunami Characteristics along The Coast of Biak Island based on the 1996 Biak Tsunami Traces. Indonesian Journal of Geoscience. 7.1.55-66 (2012). https://doi.org/10.17014/ijog.7.1.55-66
2. B. Katiandagho, Analysis and Status of Mangrove Ecosystems in the Eastern Waters of Biak Numfor Regency. Scientific Journal of Agribusiness and Fisheries.8: 10 – 11 (2015).
3. M. Warpur, Mangrove Forest Vegetation Structure And Its Utilization In Ababiaidi Village, South Supiori District, Supiori Regency. Journal of Biodjati. 1.1. 19-26 (2016).
4. V.Tablaseray, M.Pairin, N.Fakdawer, B. Hamuna, Mapping the Distribution and Density of Mangroves on the East Coast of Biak Island, Papua Using Landsat 8 Satellite Imagery. Journal of Fisheries and Marine Sciences, 8.1: 35 – 36 (2018). https://jurnal.untirta.ac.id/index.php/jpk/article/view/3682
5. F. Løvholt, S. Glimsdal, C.B. Harbitz, N. Zamora, F. Nadim, P. Peduzzi, Hy Dao, H. Smebye, Tsunami hazard and exposure on the global scale. Earth-Science Reviews. 110: 1-4: 58-73.(2012). https://doi.org/10.1016/j.earscirev.2011.10.002
6. E.P. Odum, P. Fundamentals of ecology. 3rd ed. Gajah Mada Univ. Press, Yogyakarta, Indonesia. (1993).
7. Sugiyono, Quantitative, Qualitative, and R & D Research Methods. Bandung: Alfabeta (2019)
8. M. Waran, M.I. Aipassa, J.Manusawai, A.Sinery, Diversity of Mollusacs (Gastropod and Bivalve) In Mangrove Ecosystem of Oransbari District, South Manokwari Regency, West Papua Provinsi Indonesia. Journal of Environmental Treatment Techniques. 8. 3.1220-1224 (2020). jett.doormaj.com/docs/Volume8/Issue 3/HTML/Diversity of Molluscs (Gastropod And Bivalve) In Mangrove Ecosystem of Oransbari District, South Manokwari Regency, West Papua Province, Indonesia.html
9. J.Manusawai, A.Sinery, R. Jowey, Diversity of Gastropod and Bivalve Molluscs in Kaisu Mangrove Forest of Sarmi Regency, Papua Province, Indonesia. Journal of Environmental Treatment Techniques. 3.3.1176-1181 (2020). jett.doormaj.com/docs/Volume3/Issue 3/HTML/Diversity of Gastropod And Bivalve In Kaisu Mangrove Forest of Sarmi Regency, Papua Province, Indonesia.html
10. L.P. Aji, A. Widyastuti, Y. Fatrwas, Mollusk Catalog of the Technical Implementation Unit of the Biak Marine Life Conservation Center Series 1 Gastropoda: Strombidae. Oceanographic Research Center. Indonesian Institute of Sciences. (2015).
11. Wahyuni S. The types of moluscs (Gastropoda dan Bivalvia) in the mangrove ecosystem of Dedap village, district of Tasikputripuyu Kepulauan

Meranti regency, Riau. Journal of FKIP, Pasir Pangaraian University.2.1. 2016

12. Nurrudin, Hamidah A, Kartika W.A. The Diversity of Gastropods Species Around Parit Fish Auction, Tungkal I Village, West Tanjung Jabung. Biospecies.8.2:51-60.(2015).
13. R. Ayunda. The structure of the gastropod community in the mangrove ecosystem of the Gugus Pulau Pari Island group, Thousand Islands. Indonesia University, Depok, Indonesia. 2011.
14. I.F. Silaen., B. Hendrarto, M. Nitisupardjo. Distribution and Abundance of Gastropods in the Mangrove Forest of Teluk Awur, Jepara. Management of Aquatic Resources Journal (MAQUARES) 2.3. 93-103 (2013). https://doi.org/10.14710/marj.v2i3.4187
15. S. Liline, M.T. Kubangun, T.S. Kurnia, W.N.M.J.Heremba, Kepadatan Nerita sp Di Perairan Pantai Negeri Suli Teluk Baguala Kabupaten Maluku Tengah. Jurnal of Biology Science & Education, 9.2. 10-114.(2020)