



Status of marine biodiversity and community perception on marine conservation in Mantehage Island, Bunaken National Park, North Sulawesi, Indonesia

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Abstract. Indonesia is among the richest in the world in terms of marine biodiversity. The marine biodiversity in Mantehage Island in Bunaken National Park, North Sulawesi, Indonesia is reviewed and a rapid socio-economic survey was conducted to determine community perception and awareness of marine conservation. Thus far, the marine flora consisted of 20 species of mangroves, 7 species of seagrasses, and 45 species of macroalgae. Marine macroinvertebrate fauna comprises 390 species of scleractinian corals, and ~400 species of mollusks (with 215 species of nudibranchs). Marine fishes totaled 368 species. However, long-term studies on fish biomass and density in relation to management interventions (e.g., age of marine reserves) are lacking. Declines in live coral cover may have caused a downward trend in reef fish community. Threats to marine biodiversity include overfishing, increasing population, and coastal development. The above-mentioned threats might prevail, given the lack of alternative income aside from fishing. The perception of the community of the ongoing marine conservation in Mantehage Island was also assessed. Overall, the marine biodiversity of Mantehage Island needs to be conserved through active involvement of the community.

Key Words: coastal resources, diversity, fisheries, management, socio-economic.

Introduction. The marine biodiversity of the Indonesian archipelago is one of the richest in the world (Hutomo & Moosa 2005). A number of authors have quantified diversity of selected marine organisms such as reef fishes (Allen & McKenna 2001), seagrasses (Wagey 2018) for prioritization of sites for conservation purposes. Establishment of marine parks is one of the few management options for developing countries like Indonesia.

The Bunaken National Park (BNP) in North Sulawesi is among the renowned protected areas in Indonesia. This park was established in 1991 by the National government. A number of studies have been done in the BNP, ranging from management practices (Kalalo 2017; Kholil & Sulistyadi 2017; Manumpil et al 2017) to biodiversity assessments (Turak & DeVantier 2003; Schulze Rojas 2010). More comprehensive biodiversity studies sprang from collecting expeditions conducted in collaboration of both local and foreign scientists (Burghardt et al 2006; Eisenbarth et al 2018). In recent years, local researchers have intensified these biodiversity assessments, including modernized taxonomic tools such as genetics (Pratasik et al 2016) as well as studies on larval dispersal (Chungdinata et al 2019), reef degradation (Attamimi & Saraswati 2019a, b), climate resilience (Ampou 2016) and mitigation (Schaduw 2013). Aspects on management, such as enforcement of environmental laws have been reassessed (Kalalo 2017; Schaduw 2015, 2020).

Due to the wide area covered by the BNP, there is also a need to conduct localized (i.e., by island) approach in both management and biodiversity assessment. The goal of this paper is to summarize what is known (in terms of its biodiversity) in Mantehage Island, one of the five islands within the BNP. This is highly necessary to come up with a more focused understanding of the marine biodiversity of Mantehage Island.

Material and Method

Study area. Mantehage Island lays at Wori District, North Minahasa Regency. Geographically, this island is located at 1.7101°N, 124.7575°E, and roughly 27.8 km from Manado City (Figure 1). It has a total land area of 1,856 hectares, surrounded by mangrove forest. As of 2019, the population of Mantehage Island was 2,156 people distributed in the four villages of Bango, Tinongko, Buhias, and Tangkasi. This island is one of the five small islands comprising the world renowned ecotourism site, the Bunaken National Park (established in 1991), with an area of 89,065 hectares (<http://www.mpatlas.org>).

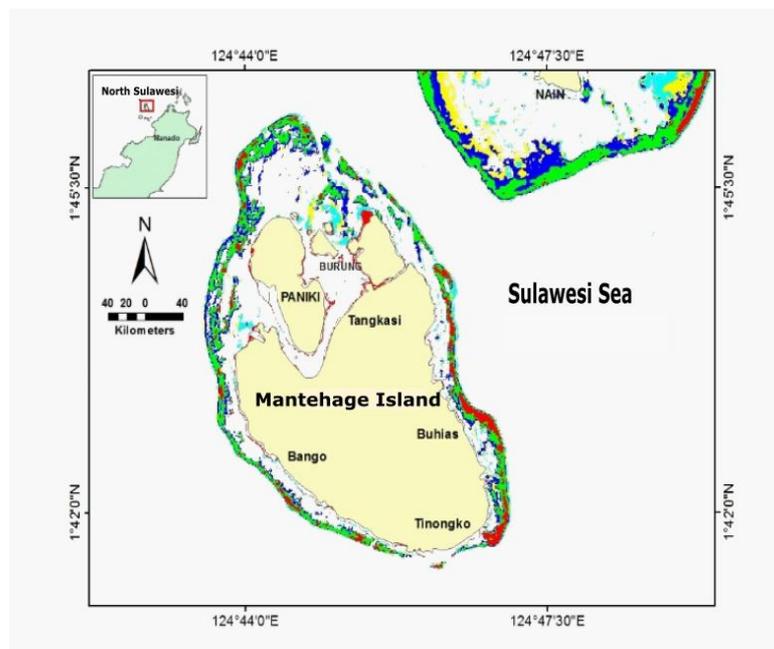


Figure 1. Map of North Sulawesi (inset), Indonesia showing the location of Mantehage Island.

Data gathering. To review the status of biodiversity in Mantehage Island, the published literature was searched through the GoogleScholar search engine with the following keywords: “Mantehage+biodiversity+marine” and additional words such as “mangroves, seagrass, corals, reef fishes, etc”. The resulting references were compiled and examined thoroughly.

Seagrass community assessment. Seagrass community structure was surveyed by B. Wagey in August 25, 2020 using standard protocols in three localities: Bango (1°42'45.7"N, 124°44'04.5"E), Buhias (1°42'35.9"N, 124°46'42.5"E), and Tinongko (1°41'54.9"N, 124°45'07.9"E). In each location, three 50-m transects were deployed perpendicular to the shoreline. In every 5 m interval, a 1x1 m quadrat was laid and the following data were recorded: 1) seagrass cover (%); 2) algal cover (%); 3) type of substrate; and 4) seagrass densities (per species).

Social demographics. Data on social demographic profile (as of 2019) of Mantehage inhabitants was provided by the District Office of Wori. There were a total of 95 respondents who participated during interviews, distributed in the following villages: 35 (Bango), 40 (Tinongko), and 20 (Buhias).

Community perception on conservation. Each of the 95 respondents were interviewed using semi-structured questionnaires. There were 15 key questions asked during each interview (see Table 1). These questions (answerable by “Yes” or “No”) are all related to marine conservation activities in the area. As much as possible, the interviewer allowed the interviewees to express their individual opinion regarding each question.

Results and Discussion. We found a total of 33 published documents (mainly scientific articles) that are highly relevant to Mantehage Island. Of this figure, majority of the studies have focused on macroinvertebrates (8), conservation and management (7; but broadly on the BNP), while the remaining articles tackled climate resilience and spatial mapping of coral reefs (3), mangroves (3), corals (3), macroalgae (2), tourism (2), marine mammals (2; but broad), and only one paper each on seagrass, fish, and marine pollution. Thus far, we have not encountered a single paper devoted to either marine reptiles or shorebirds of Mantehage Island. In the succeeding sections, we describe the status of the biodiversity of Mantehage Island based on some relevant sources.

Marine flora

Mangroves. In the BNP, a total of 27 species in 17 families were documented by Djamaluddin (2018). Of this number, 20 species occur in Mantehage Island. A subsequent study by Opa et al (2019) documented only 8 species of mangroves. The discrepancy might be attributed to site selection and the latter study focused only on the true mangrove species (e.g., Rhizophoraceae). The most abundant mangrove species is *Ceriops tagal* which has a recorded density of 3,020 ind. hectare⁻¹.

Seagrass. In this study, a total of seven species of sea grasses was documented. In terms of per cent cover, Bango and Tinongko sites (55% and 58% respectively) have similar seagrass coverage while lowest in Buhias (32%) (Figure 2).

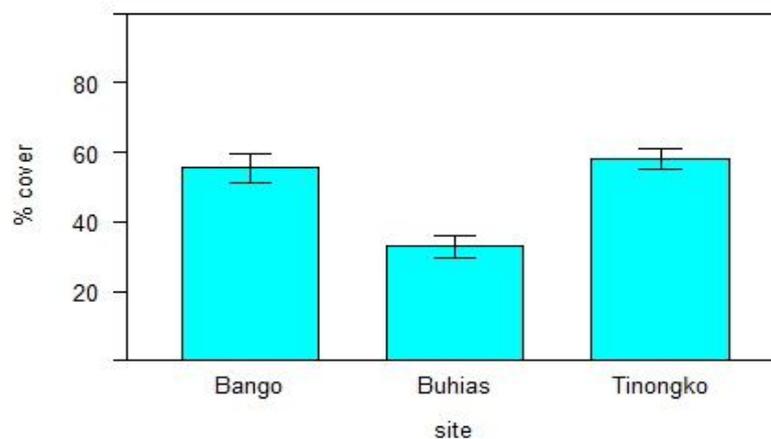


Figure 2. Mean seagrass cover (%) in three sites surveyed in Mantehage Island. Error bars indicate SE (standard errors).

Mean seagrass density (Figure 3) was generally higher in Tinongko site although there seems to be high variability in values, especially on the two species (*Cymodocea rotundata* and *Syringodium isoetifolium*). *Thalassia hemprichii* had consistently high densities in all of the three sites.

Macroalgae. Meriam & Kepel (2016) first assessed the benthic macroalgae of Mantehage Island, of which 44 species in 18 families and 26 genera occur in their sampling sites. This record was later revised (see Kepel et al 2019) as 45 species in 19 families. Green algae (Division Chlorophyta) was composed of 25 species followed by red algae (Rhodophyta) with 16 species while brown algae (Phaeophyta) with only 4 species. The most abundant species included *Gracilaria edulis* (2.96 ind. m⁻²) followed by *Caulerpa racemosa* (0.7-0.9 ind. m⁻²) and *Halimeda opuntia* (0.9-2.05 ind. m⁻²).

In this study, macroalgal cover (%) was generally low (< 10%). Between sites, the highest cover was recorded in Tinongko site (Figure 4). This figure may be underestimates because these were obtained in seagrass-dominated sites. There is therefore a need to assess the macroalgal beds in the area

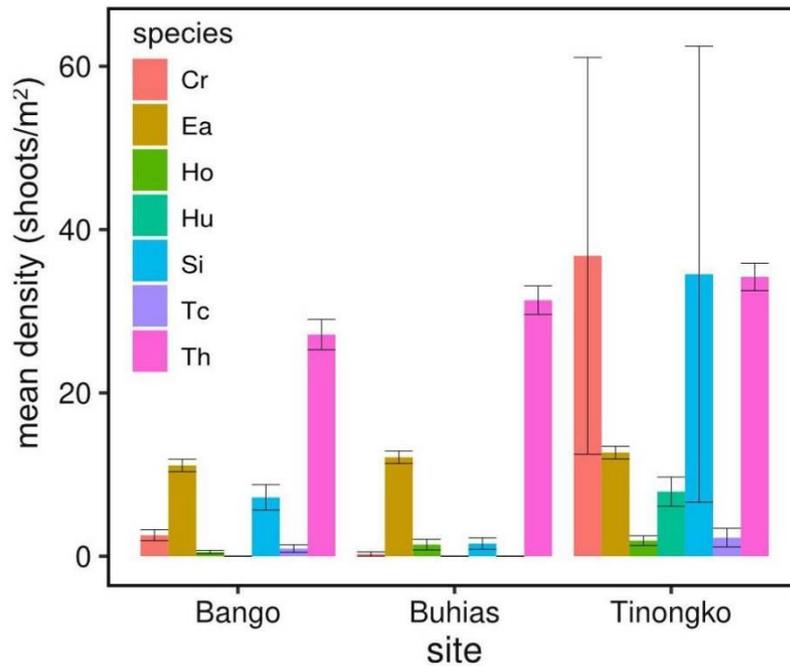


Figure 3. Density of seagrasses in three sites surveyed in Mantehage Island. Error bars indicate SE (standard errors). Species: Cr = *Cymodocea rotundata* ; Ea = *Enhalus acoroides*; Ho = *Halophila ovalis*; Hu = *Halodule uninervis*; Si = *Syringodium isoetifolium*; Tc = *Thalassodendron ciliatum*; Th = *Thalassia hemprichii*.

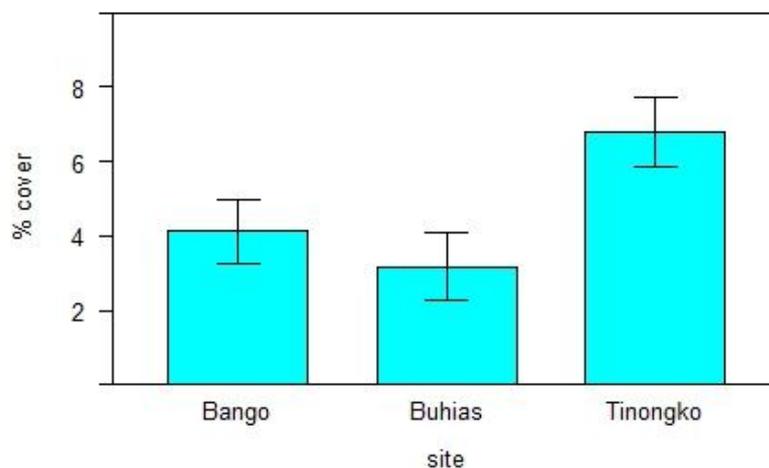


Figure 4. Macroalgal cover (%) in surveyed sites.

Marine fauna

Scleratinian corals. The first comprehensive assessment on stony corals (scleractinian corals) throughout the BNP (including stations in Mantehage Island) was done by Turak & DeVantier (2003). The authors reported 390 species in 63 genera and 15 families. The 7 sites in Mantehage recorded 27 (lagoon in Eastern Mantehage) to 171 species (East Mantehage). Four out of 7 sites had relatively good conditions (> 50%), each site with one rare species while the lagoon site has 4 rare species. Percent cover of live corals in BNP ranged from ~ 10 to > 75%. Subsequent studies, however, reported decline in coral cover in Mantehage reefs. For example, Setiawan et al (2013) showed a declining trend

based on the survey data from 1998 (~65%) to 2013 (17.67-44.33%). Schadow et al (2020) reported a range of live coral cover from 19 to 39.67%.

Macroinvertebrates. A study on sponges by Calcinai et al (2017) showed that there are at least 93 species (33 families) in North Sulawesi. Only one site was surveyed in Mantehage Island and only 7 species were recorded. This might be an underestimate and might soon increase as more studies are conducted in Mantehage Island. Calcinai et al (2017) noted that since 1989, there are about 830 species of sponges known in Indonesia.

A study on mollusk diversity by Burghardt et al (2006) revealed 323 species (but included 11 terrestrial species but occurred near the shorelines) in just 10 days of collecting within the BNP. An additional 94 species was later observed in the field, thus a total of around 400 species were documented in the study area. As to how many species occur in Mantehage it was not specified. Another study by Arbi (2012) showed 163 species (125 were gastropods and 38 pelecypods) in BNP. Eisenbarth et al (2018) focused on the more charismatic mollusks, the nudibranchs (Heterobranchia) in BNP, of which they documented 215 species, lower than that of Papua New Guinea with 538 known species. Of this figure, 31 species occur in Mantehage stations.

Other studies on macroinvertebrates in Mantehage Island included that of Boneka & Mamangkey (2013) on the gastropod *Drupella cornus*, which prey on corals. Sangari & Toloh (2015) studied the growth potential of the mud crab *Scylla serrata*.

Thus far, no study on echinoderms (e.g., sea urchins, sea cucumbers) has been made available to us.

Reef fishes. A study on reef fish communities in Bunaken National Park by Setiawan et al (2013) surveyed 26 locations, including 4 stations around Mantehage Island. A total of 368 species in 46 families were documented. The reef fish fauna was dominated by the damselfishes (family Pomacentridae with 60 species) followed by wrasses (Labridae) with 58 species, butterflyfishes (Chaetodontidae) with 31 species, surgeonfishes (Acanthuridae) and parrotfishes (Scaridae) with 23 species each, and groupers (Serranidae) with 19 species. The authors also noted a downward trend in reef fish community structure, which might be attributable to the decline in live coral cover. They did not present, however, data on fish biomass, which is a crucial indicator of reef fish condition. Studies on fish biomass and density trends in relation to duration of protection have not been done in the study area.

As already mentioned, there seems a lack of detailed studies on marine reptiles (seasnakes and turtles), shorebirds and marine mammals (dugongs, dolphins, and whales). Two studies on marine mammals of a much broader area of Indonesia are available (Dharmadi & Wiadnyana 2011; Mamayu Utami et al 2018).

Threats to biodiversity. Turak & DeVantier (2003) have pointed out earlier certain threats to the marine resources of BNP such as impacts from fisheries, development, tourism, and pollution (e.g., garbage and heavy metals). These threats are expected given the high rate of development in surrounding areas such as Manado City (Tenthof van Noorden et al 2013). The impact of pollution on seaweed farming has been assessed by Tombokan et al (2020). Prior to the establishment of the park in 1991, Salm (1985) pointed out the tourism potential of areas of Bunaken, including Mantehage Island. There are several issues and threats to tourism in the BNP as highlighted by Kairupan & Sendouw (2018). Likewise, Kalalo (2017) described the lack of strong enforcement of environmental laws within the park.

To understand these threats, it is necessary to come up with a demographic profile of the communities that are dependent on the natural resources of Manatehage Island.

Demographic profile. The above-mentioned threats are reasonable due to the high population in Mantehage Island (2,156 as of 2019), majority of which belong to Bango village (732 people) while the lowest was in Tinongko village (390 people). The breakdown of population by village and gender (sex) is presented in Figure 5. Increasing

population is coupled by high proportion of people living under poor conditions, both in terms of the number of individuals and the number of families (Figures 6 and 7). Majority of the individuals and families identified as “poor” by the District Office of Wori belong to the village of Tinongko.

A summary of the socio-economic profile of the respondents is shown in Table 1. Majority of the respondents were male (68) while only a third were female (27). Age distribution was varied but highly represented in ages between 46-65 years old. A large proportion were married (78). It is noteworthy that monthly income of the all respondents fall below 2 Million Rupiah (equivalent to < 136 USD monthly or maximum daily income of 5.0 USD). These incomes were mainly derived from fishing as the main livelihood available in the island (60 respondents). Lack of higher educational attainment (all respondents never went to college or tertiary level) might further aggravate the present socio-economic situation of the residents of Mantehage Island.

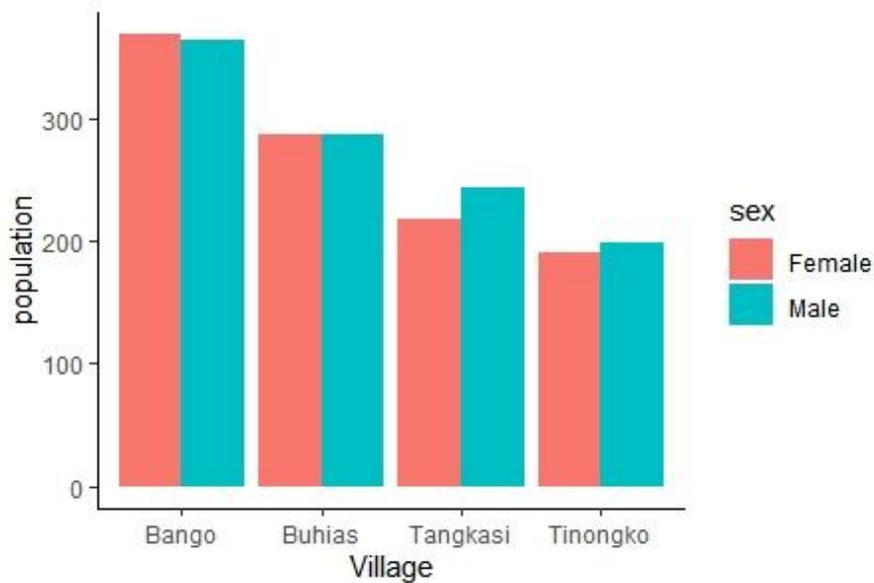


Figure 5. Population of the villages in Mantehage Island according to sex (as of 2019).

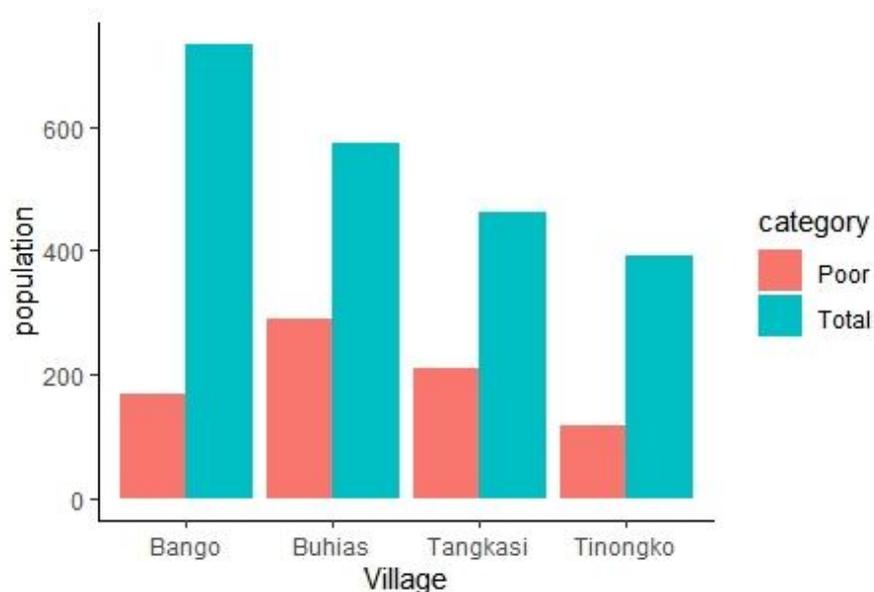


Figure 6. Number of poor people in relation to total population per village in Mantehage Island.

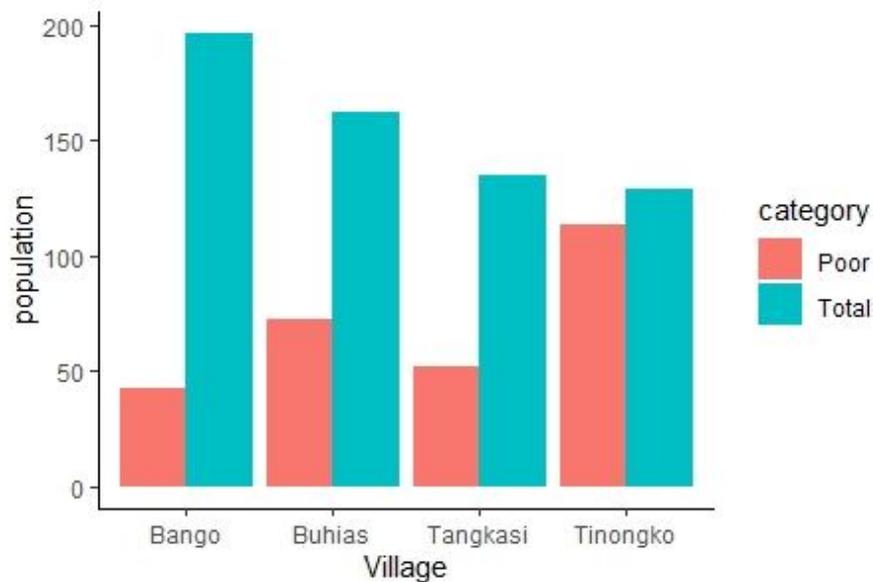


Figure 7. Number of poor families in four villages in Mantehage Island.

Table 1

Socio-economic profile of the 95 respondents

Criteria	Number			
Sex	Male = 68	Female = 27		
Age (years)	15-25 yrs = 13	26-45 = 19	46-65 = 37	> 65 = 26
Status	Married = 78	Not married = 17		
Monthly income (Rupiah)	< 1 Million = 48	1-2 Million = 29	2-3 Million = 0	> 3 Million = 0
Occupation	Fishing = 60	Household = 23	Civil servants = 2	N/A = 10
Education	Elementary = 63	Junior High School = 22	Senior High School = 9	Tertiary = 1

N/A = no answer.

Community perception on marine conservation. Based on the overall responses of the 95 respondents (Table 2), majority of them were aware of the on-going marine/coastal conservation efforts in the area, including the existence of BNP. However, many of them did not know the concept of sustainable fisheries and policies related to coastal management. In addition, despite the gaining popularity of the concept and practice of marine protected area (MPA), a high number (72) of respondents did not know about MPAs in general.

Majority of the respondents expressed that they are involved in marine conservation efforts as well identified local resources (e.g., seagrasses), including those protected by existing laws (e.g., dugong, Napoleon wrasse, etc). Many of the respondents showed positive inclination toward the idea of making their area (village level) as ecotourism area. A considerably high number also expressed that the existing fisheries and marine conservation policies are not enough to ensure sustainability of coastal management in Mantehage Island.

Table 2

Summary of responses of the 15 key-questions during interviews o the 95 respondents

Questions	Responses			
	Yes	No	Both	No clue
Q1. Do you know about the term "coastal conservation"?	36	59		
Q2. Do you know the term of "Bunaken National Park"	81	14		
Q3. Do you know about the term "sustainable fisheries"	11	84		
Q4. Do you know the term of "policy of coastal management"	0	95		
Q5. Have you ever knew Marine Protected Area/MPA	23	72		
Q6. Does Mantehage Island belong to National Bunaken Park	3	92		
Q7. Have you ever know about seagrass	18	77		
Q8. Do you have a vehicle (motor or car) for transportation	29	66		
Q9. Are you involved in coastal conservation	2	93		
Q10. Have you ever know or involve in socialization of coastal conservation	2	93		
Q11. If so which organization: A = Fisheries service office (92); B = Bunaken National Park (3); C = University; D = NGOs				
Q12. Is there any involvement of the local leaders/local government in coastal conservation?	3	0		92
Q 13. Do you agree if you village/coastal area become area for ecotourism?	95	0		
Q14. Please state/mention the key marine animals protected: A = dugong; B = Napoleon wrasse; C = both (95)				
Q15. What do you think, fisheries and marine development policy are good enough for supporting coastal area management in your area?	24	71		

Conclusions. As far as can be ascertained, the marine biodiversity of Bunaken National Park is notably high. However, there seems to be a lack of a more comprehensive assessment, especially in Mantehage Island. To date, no comprehensive studies have been done on other marine fauna such as seasnakes, turtles, shorebirds, and marine mammals. So far, only a single study on reef fishes has focused only on community structure. There is also a need to monitor other parameters such as fish biomass (especially for targeted species) that are useful for resource managers.

While majority of the respondents are aware of the marine conservation efforts in the area, they also expressed that the existing policies are not enough to ensure sustainability of fisheries and conservation management. Most of the local residents derived their income from fishing, which falls below 2 Million Rupiahs a month. Lack of alternative income and lack of education to tertiary levels might even exacerbate the existing threats to the marine biodiversity of Mantehage Island.

It is also recommended that a more in-depth study be conducted to verify the initial responses of the respondents. Where possible, fish catch monitoring should also be done to determine actual income derived from fishing.

Here we reiterate the need for a more efficient enforcement of environmental laws governing the Bunaken National Park. Studies on impact of pollution such as that of macro and microplastics and organic pollutants remain to be done in the area. The impact of plastic wastes is expected to exacerbate in the following years or decades as a result of intensive utilization brought upon by the coronavirus pandemic such as widespread use of plastic-based personal protective equipment or PPEs and face masks, apart from dependence to single-use domestic plastic products. Moreover, there is also a need to actively involve the local communities in conservation.

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