Carrying capacity analysis in Bunaken National Park to support marine tourism activity (dive and snorkelling tourism)

Mini Farida Farhum\textsuperscript{1}, Jamaluddin Jompa\textsuperscript{2}, Muhammad Restu\textsuperscript{2} and Darmawan Salman\textsuperscript{2}

\textsuperscript{1}Post Graduate Student, Fisheries Science, Hasanuddin University, Indonesia, 90245
\textsuperscript{2}Hasanuddin University, Makassar, Indonesia, 90245

Email: j.jompa@unhas.ac.id

Abstract. The carrying capacity of an area for tourism is the number of tourists that can be physically present/undertaking certain activities in the area at a given time without significant disturbance to nature and other humans. This study estimated the potential environmental carrying capacity of Bunaken National Park for marine tourism, specifically for snorkelling and diving activities. This research was conducted from October 2019 to March 2020 in Bunaken National Park. The results showed a concentration of diving and snorkelling in the National Park around Bunaken Island (50% of all tourists) with other islands receiving 10% to 25% of tourist volume. This level could have a negative impact on the sustainability of the coral reef ecosystems around Bunaken Island; therefore, diving and snorkelling activities around this island need to be managed appropriately.

1. Introduction
Bunaken National Park (BNP) is a predominantly marine protected area in North Sulawesi, Indonesia established by decree of the Minister of Forestry No.730/Kpts-II/1991 with an area of 89,065 Ha. Managed by a government agency (BPTNB), the terrestrial portion of the BNP includes the islands of Bunaken, Manado Tua, Siladen, Mantehage, and Nain, as well as the Tongkaina Coast, Tiwoho, and Arakan-Wawontulap on the Sulawesi mainland. Bunaken National Park has world-renowned potential for marine tourism; however, as a conservation area it is particularly vital to develop and implement a suitable concept of marine tourism. Ecotourism can be defined as nature-based tourism that is able to contribute both to environmental sustainability, generate economic benefits and provide benefits to the social life of the local community [1–3]. Marine ecotourism is highly dependent on the condition of underwater natural resources and the coastal zone. These natural assets need to be preserved through the conservation management of Bunaken National Park.

The development of Bunaken National Park as a marine conservation area can contribute substantially to local and national government income from tourism, especially water-based tourism activities such as snorkelling and diving. The BNP is a prima donna site for marine tourism, attracting local, national and foreign snorkelling and diving tourists [4]. In terms of employment, the tourism business in North Sulawesi is a major source of employment in the Bunaken region, with around 600 locals working in the Bunaken National Park diving industry [4]. The ways in which snorkelling and diving tourism is developed in the BNP can directly impact sustainability in terms of ecosystem condition, especially the coral reef ecosystems in the waters of the BNP. If poorly managed, tourism...
industry can cause environmental, social and economic losses; therefore, the ideals of ecotourism must be maintained in order to maintain environmental conditions and improve the socio-economic welfare of the local community sustainably [5,6]. In this context, managers need to know the carrying capacity of the areas used for tourism, and in particular marine ecotourism activities, as a basis for effective and efficient tourism management. This study estimated the potential carrying capacity of the marine environment of Bunaken National Park in providing diving and snorkelling tourism activities.

2. Methods
This research was conducted from October 2019 to March 2020 in the Bunaken National Park. Data were collected for all five islands (pulau in Indonesian) in the area: Bunaken, Manado Tua, Mantehage, Nain and Siladen. Carrying capacity for snorkelling and diving tourism activities were estimated using the methodology developed by [7]. Purposive sampling methods were used based on the conditions at the time of data collection. Data collected included biophysical data on the areas suitable for diving and snorkelling as well as data on the diving and snorkelling tours that were currently operating in the waters of the Bunaken National Park at the time of the study. The carrying capacity methodology used [7] is based on calculating the carrying capacity for tourism development so that the specific activities being studied do not significantly damage the resource or limit individual visitor space to an uncomfortable degree. The equation used to calculate the carrying capacity, based on [7], was:

\[ ACC = K \times \frac{Ap}{At} \times \frac{Tt}{Tp} \]

where:
- ACC = Area Carrying Capacity (people/day)
- K = Ecological visitor potential per unit area (people)
- Ap = Extent of area for a given category
- At = Unit of area required for a given category
- Wt = Time (hours) available for a given activity in one day
- Wp = Time (hours) used by visitors for a given activity

3. Results
3.1. Coral reef area suitable for Snorkelling and SCUBA diving
The Bunaken National Park has an area of 89,065 hectares of which 97% is marine waters. The islands in BNP are divided into the northern group (75,265 Ha) and the southern group (13,800 Ha). Bunaken Island is the centre of economic and social activity in the BNP. The percentages of the BNP coral reef areas suitable for diving and snorkelling tourism around 5 islands (Bunaken, Manado Tua, Mantehage, Nain and Siladen) are shown in Figure 1. Bunaken Island had the most extensive area of suitable reefs, while Siladen Island had the smallest proportion for both activities.

![Figure 1](image_url)
3.2. Carrying Capacity for Snorkelling and SCUBA diving

The carrying capacity for snorkelling and SCUBA diving varies between the islands and between these two marine tourism activities (Figure 2). The suitability of the reefs took into account the condition of corals, reef fish, the depth and the physical environment. Locations suitable as snorkelling tourism sites had stretches of coral reefs with a depth of 1-3m; sites considered suitable for SCUBA diving tourism had coral reefs at depths in excess of 5m.

Figure 2. Daily carrying capacity of five islands in Bunaken National Park, North Sulawesi, Indonesia for snorkelling and SCUBA diving visitors.
The assumption used for snorkelling tourism was that snorkellers required a coral reef area of 500 m\(^2\)/person, based on the likely impact and range of visitors. Snorkelling activities on each island are carried in the morning and the afternoon. One snorkelling trip takes a total of 3 hours, so the maximum number of trips that can be done in one day is 6 hours or 2 trips. In the BNP, snorkelling tourism activities provided by tourism industry players include the reefs on all sides of each island in the area, with a total area of coral reef ecosystems used of approximately 497,087.17 hectares (Table 1).

Bunaken Island had the largest coral reef area used for snorkelling tourism activities, comprising around 50% of the total area used for this purpose in the BNP, while Siladen Island had the smallest area used for snorkelling, representing 2% of the BNP coral reefs used (Figure 1, Table 1).

| No | Island          | Usable coral reef area (m\(^2\)) | Carrying capacity (people/day) | Number of visitors/trip | % of capacity used/trip |
|----|----------------|----------------------------------|--------------------------------|-------------------------|-------------------------|
| 1  | Pulau Bunaken   | 248,358.81                       | 892                            | 464                     | 52%                     |
| 2  | Pulau Manado Tua| 39,613.66                        | 147                            | 35                      | 24%                     |
| 3  | Pulau Mantehage | 88,356.09                        | 323                            | 84                      | 26%                     |
| 4  | Pulau Nain      | 107,874.68                       | 381                            | 88                      | 23%                     |
| 5  | Pulau Siladen   | 12,883.93                        | 51                             | 6                       | 12%                     |
|    | Total           | 497,087.17                       | 1,794                          |                          |                         |

The assumption used for SCUBA diving tourism is that the coral reef area required is 2000 m\(^2\)/2 people (buddy pair), that the time available for the use of each site in one day is 8 hours (4 hours in the morning and 4 hours in the afternoon), and each trip takes 2 hours. This gave a maximum of 4 trips/day per site. Based on the suitability analysis, an area of 495,815 m\(^2\) was considered suitable for SCUBA diving tourism (Table 2). The total carrying capacity of the area for SCUBA diving tourism activities in Bunaken National Park was estimated at 1,936 people/day (Table 2).

| No | Island          | Usable coral reef area (m\(^2\)) | Carrying capacity (people/day) | Number of visitors/trip | % of capacity used/trip |
|----|----------------|----------------------------------|--------------------------------|-------------------------|-------------------------|
| 1  | Pulau Bunaken   | 315,972.75                       | 1,273                          | 649                     | 51%                     |
| 2  | Pulau Manado Tua| 42,535.13                        | 146                            | 18                      | 12%                     |
| 3  | Pulau Mantehage | 43,317.79                        | 153                            | 38                      | 25%                     |
| 4  | Pulau Nain      | 74,725.93                        | 287                            | 43                      | 15%                     |
| 5  | Pulau Siladen   | 19,263.66                        | 77                             | 8                       | 10%                     |
|    | Total           | 495,815.26                       | 1,936                          |                          |                         |

4. Discussion

Diving and snorkelling in the waters of Bunaken National Park have been ongoing for a long time as these activities are in high demand by tourists visiting the area. The natural beauty of the underwater scenery, with colourful corals and fishes as well as megafauna such as marine turtles and many more diverse marine organisms are a major attraction drawing tourists to diving and snorkelling tours in Bunaken National Park. According BNP records, in 2019 the Park was visited by 30,774 foreign and domestic tourists, equating to around 2,562 per month. More than 50% of these visitors engaged in diving and/or snorkelling activities, with a daily average of 85 visitors taking snorkelling and diving trips in BNP. The results show that all five islands in the national park have locations that can be used for SCUBA diving and snorkelling tourism. Furthermore, the average daily visitation rate is well below the carrying capacity, even if the visitors each make more than one trip per day.
In recent years, the determination of the carrying capacity of diving tourism in the world has varied widely where there are 5,000 to 500,000 people per location per year (300 days) [8,9]. Diving and snorkelling activities that are not evenly distributed can occur if there is no plan to spread tourist activities, and can have a disproportionate impact on the resilience of the coral ecosystem at the more popular or frequently visited sites. Diving activities with a high intensity have a high likelihood of direct contact between diver and the substrate; such intentional or unintentional contacts damage corals and other benthic organisms, so that there is a high risk of substantial negative impacts on the condition of the coral reefs [7,10].

The snorkelling and diving tourism activities in the Bunaken National Park are centered around Bunaken Island (on average around 50%). This concentration could pose a threat to the sustainability of the coral ecosystems around Bunaken Island. The capacity used around other islands ranged from around 10% to 25% per trip. This indicates that the management authority (BPTNB) needs to promote marine tourism, especially snorkelling and diving, around the other four islands. This should help spread the load and make the activities more sustainable by avoiding excessive pressure on any one site.

The process of marine tourism development in Bunaken National Park needs to focus on holistic socio-ecological sustainability, maintaining the ecosystems and biotic communities as well as creating a favourable climate from a business perspective and generating income for the communities and the region from the tourism sector [11,12]. The condition of coral reefs is easily damaged due to diving activities, whether done intentionally or unintentionally, for example due to the pressure of coping with the equipment carried during diving activities, especially for novice divers or those using unfamiliar equipment [13]. Based on the carrying capacity data, the Bunaken National Park managers can determine spatial, temporal and user limits that can be used as benchmarks for regulating tourism activities, specifically snorkelling and SCUBA diving, so as to avoid damage and maintain ecological sustainability.

In addition to regulating the density of diving and snorkelling tourism activities and paying attention to activities that can damage the environment, the role of tourism industry players must be enhanced for example with respect to the provision of competent and reliable guides and facilitators in the marine tourism sector. Diver competence is a key factor, where specific training for low impact diving can make a significant contribution [10]. Dive tourism in Bunaken is open to the public and uncertified or insufficiently competent divers can still engage in diving activities, raising serious concerns regarding the deterioration of coral condition in Bunaken National Park. Therefore, tourism service providers need to ensure that competent instructors and guides can provide suitable guidance for diving and snorkelling activities and apply suitable protocols to guard against damage to the underwater ecosystem [14–16]. Although this indicator was not used as a major factor in estimating the carrying capacity of Bunaken National Park in this study, it should be a major consideration reflected in the requirements for tourism industry players to open businesses operating in the BNP.

5. Conclusion
The analysis of the Bunaken National Park carrying capacity for diving and snorkelling tourism activities indicates the need for special attention to the ways in which visitor activities are managed in order to maintain the coral reef ecosystems and thus the sustainability of these activities. The estimates show that visitor density is still well below the thresholds based on previous studies in other areas. The unequal distribution of visitor SCUBA diving and snorkelling activities suggests that the managers of the National Park could allow and promote a larger quota for tourists by spreading the diving and snorkelling tourism activities across the islands and reefs of the Park, reducing the current major focus on the waters of Bunaken Island. Limiting quotas to half the estimated maximum carrying capacities when determining visitor quotas for diving and snorkelling activities in the Bunaken National Park could be an effective management tool to help maintaining marine ecosystems, especially coral reefs, thus promoting the sustainability of marine tourism. In applying these approaches it will be necessary to have a balanced strategy taking into account ecological, social and economic aspects, in particular
to ensure that opportunities for local community involvement remain open, empowering local people to become direct actors in tourism and the management of Bunaken National Park.

References
[1] Krüger O 2005 The role of ecotourism in conservation: panacea or Pandora’s box? Biodivers. Conserv. 14 579–600
[2] Hoyt E 2005 Sustainable ecotourism on Atlantic islands, with special reference to whale watching, marine protected areas and sanctuaries for cetaceans Biol. Environ. 105 141–54
[3] Aciksoz S, Bolukcu P and Celik D 2016 Ecotourism and ethics in protected areas: Barton-Sogutlu village Oxid. Commun. 9 3621–3636
[4] Manumpil A W, Mandagi S V and Lasut M T 2019 The effectiveness of Bunaken National Park management Aquat. Sci. Manag. 5 11–7
[5] Garrod B and Wilson J C 2003 Marine ecotourism: Issues and experiences (Clevedon: Channel View Publications)
[6] Butler R W 1999 Sustainable tourism: A state-of-the-art review Tour. Geogr. 1 7–25
[7] Yulianda F 2007 Ekowisata bahari sebagai alternatif pemanfaatan sumberdaya pesisir berbasis konservasi Makalah Seminar Sains vol 21 (Bogor: Institut Pertanian Bogor) pp 119–29
[8] Davis D and Tisdell C 1996 Economic management of recreational scuba diving and the environment J. Environ. Manage. 48 229–48
[9] Luna B, Pérez C V and Sánchez-Lizaso J L 2009 Benthic impacts of recreational divers in a mediterranean marine protected area ICES J. Mar. Sci. 66 517–23
[10] Hammerton Z 2017 Low-impact diver training in management of SCUBA diver impacts J. Ecotourism 16 69–94
[11] Bagindo M P, Sanim B and Saptono T 2016 Model Bisnis Ekowisata di Taman Nasional Laut Bunaken dengan Pendekatan Business Model Canvas Manaj. IKM J. Manaj. Pengemb. Ind. Kecil Menengah 11 80–8
[12] Santoso H, Harini Muntasib E K., Kartodihardjo H and Soekmadi R 2015 Peranan dan kebutuhan pemangku kepentingan dalam tata kelola pariwisata di Taman Nasional Bunaken, Sulawesi Utara J. Penelit. Sos. dan Ekon. Kehutan. 12 29163
[13] Schleyer M H and Tomalin B J 2000 Damage on South African coral reefs and an assessment of their sustainable diving capacity using a fisheries approach Bull. Mar. Sci. 67 1025–42
[14] Barker N H L and Roberts C M 2004 Scuba diver behaviour and the management of diving impacts on coral reefs Biol. Conserv. 120 481–489
[15] Roche R C, Harvey C V., Harvey J J, Kavanagh A P, McDonald M, Stein-Rostaing V R and Turner J R 2016 Recreational Diving Impacts on Coral Reefs and the Adoption of Environmentally Responsible Practices within the SCUBA Diving Industry Environ. Manage. 58 107–16
[16] Worachananant S, Carter R W, Hockings M and Reopanichkul P 2008 Managing the impacts of SCUBA divers on Thailand’s coral Reefs J. Sustain. Tour. 16 645–63