Tomini Journal of Aquatic Science, Vol 4(1): 18–28, November 2025
Received: 2025-07-15; Accepted: 2025-10-02

e-ISSN: 2722-3787
Tomini Journal of Aquatic Science
Homepage: http://ejurnal.ung.ac.id/index.php/tjas

Evaluation of Tourism Suitability and Carrying Capacity for Whale Shark Ecotourism in Botubarani, Gorontalo Bay

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ARTICLE INFO

Keywords:
Whale Shark, Ecotourism, Carrying Capacity, Botubarani, Gorontalo

How to cite:
Monoarfa, S.F., Yulianda, F., Taryono (2025). Evaluation of Tourism Suitability and Carrying Capacity for Whale Shark Ecotourism in Botubarani, Gorontalo Bay. *Tomini Journal of Aquatic Science, 4*(1): 18–28

ABSTRACT

Whale shark *(Rhincodon typus)* tourism has emerged as a potential marine-based economic activity in several regions of Indonesia, including Botubarani Village, Gorontalo Province. However, sustainable development of this tourism depends on understanding the suitability of the area and its carrying capacity to avoid ecological disturbances. This study aims to determine the resource potential through area suitability and tourism carrying capacity analysis for whale shark tourism in the waters of Botubarani Village. Field research was conducted from April to September 2019, using both primary and secondary data obtained from field observations, transmitter–receiver monitoring, and relevant institutional reports. The suitability analysis was performed using five ecological parameters—frequency and duration of appearance, water transparency, visibility, and current velocity, while the tourism carrying capacity was calculated based on visitor interaction regulations and available observation time.The results showed that the whale shark tourism area, covering approximately 65 hectares, falls into two categories: suitable (75.15%) and conditionally suitable (24.85%), indicating favorable environmental conditions for conservation-based tourism. The average water transparency was 10.76 m, visibility 8.9 m, and current velocity 0.0836 m/s, which are safe and comfortable for marine tourism activities. The tourism carrying capacity (Tourism Carrying Capacity/TCC) is estimated to reach 1,560 visitors during the peak whale shark appearance months (May–July). The carrying capacity is influenced by the availability of resources, whereby an increase in resource availability corresponds to a higher potential carrying capacity within the area. The findings suggest that whale shark tourism in Botubarani has high potential to be developed sustainably through regulated visitor management, conservation fees, and adherence to interaction guidelines. This study provides a scientific foundation for local authorities to design effective management strategies and spatial policies. These efforts aim to balance ecological preservation with the welfare of local communities.

INTRODUCTION

The whale shark (*Rhincodon typus*) is one of the fish species listed as vulnerable on the Red List of Threatened Species by the International Union for Conservation of Nature (IUCN) due to its declining population. The species is also included in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which means that any trade involving whale sharks must be regulated to ensure that it does not threaten the species' survival. In Indonesia, whale sharks are protected under the Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia No. 18/Kepmen-KP/2013 concerning the full protection status of whale sharks (*Rhincodon typus*).

The appearance of whale sharks in the waters of Botubarani Village, Bone Bolango Regency, Gorontalo, has become a spectacle for the local community, attracting crowds who come by boat to see the animals up close. According to Nugraha (2016), whale sharks exhibit surfacing behavior because they are fed by people from the boats. The sharks approach the boats passively to feed, allowing them to be documented through photos and videos, and even touched by people on the boats. After feeding, the whale sharks swim back into deeper waters until they are no longer visible, and later reappear in shallow or coastal areas. The growth of marine nature-based tourism, such as snorkeling and diving, has led to an increase in interactions between humans and whale sharks (Colman, 1997).

Records show that between May and the end of July 2016, whale shark tourism in Botubarani Village attracted around 30,000 visitors (BPSPL Makassar, 2018). This activity has had a significant impact on the local economy. However, tourism activities can also negatively affect the long-term sustainability of whale shark populations. Unsustainable tourism management poses a threat to whale sharks, and disturbances to their conservation can also affect the economic sustainability of whale shark tourism (Quiros, 2007; Rojayati, 2017). Quiros (2007) suggests that community-based ecotourism should be implemented to help conserve whale sharks while improving local socio-economic conditions. Similarly, Djafri and Rahmat (2017) stated that marine tourism development in Botubarani was designed to be community-based ecotourism as a means of rural development through the tourism sector. Therefore, it is necessary to conduct scientific baseline studies on the suitability and carrying capacity of whale shark tourism areas in Botubarani Village to determine appropriate spatial utilization in developing this location as a sustainable whale shark tourism destination.

This study aims to assess the resource potential based on area suitability and tourism carrying capacity for whale shark tourism in the waters of Botubarani Village. The results are expected to provide valuable input for decision-makers in developing and managing sustainable whale shark tourism in Botubarani Village, Bone Bolango Regency, Gorontalo Province, as well as serve as a foundation for future research.

MATERIAL AND METHODS

Study site. The research was conducted from April to September 2019. The study site was located at the Whale Shark Tourism Area in Botubarani Village, Bone Bolango District, Gorontalo Province (Figure 1). The boundaries of the study area followed the Botubarani Marine Conservation Area. Sampling stations were selected based on the whale shark tourism interaction zones.

 http://doi.org/10.37905/tjas.v4i1.35109

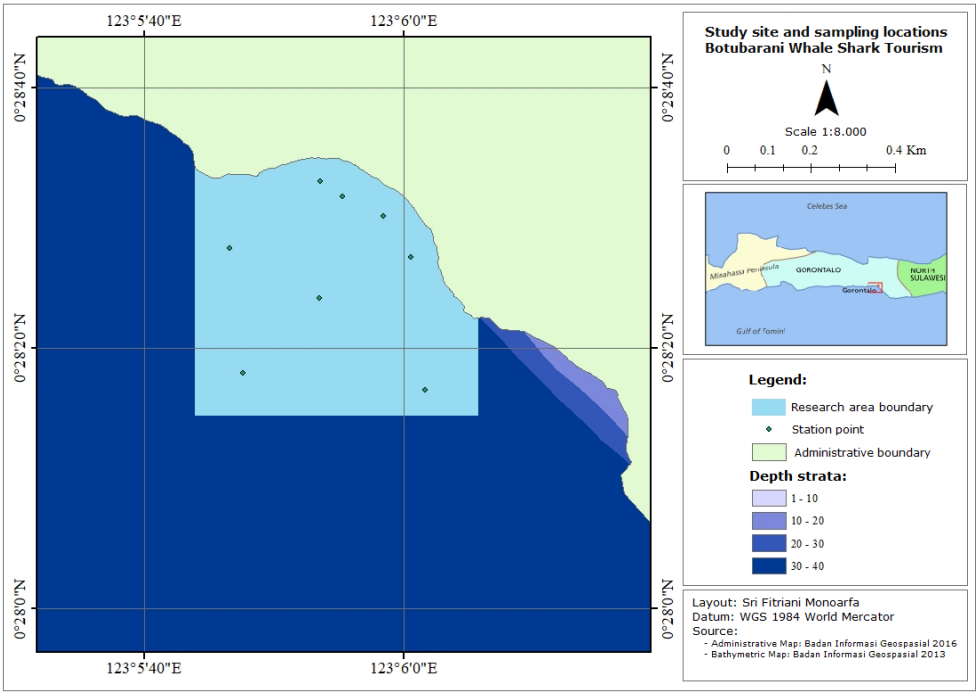


Figure 1. Study site and sampling locations at Whale Shark Tourism

Sampling and Sample Preparation. The types of data used in this study consisted of primary and secondary data (Table 1). Primary data were obtained through field observations, while secondary data were collected from relevant institutions and literature related to the research topic. Secondary data included information on the frequency and duration of whale shark appearances obtained from the transmitter–receiver data of BPSPL Makassar. Primary data included visibility, current velocity, and water transparency.

Tabel 1. Types and methods of data collection

Objective	Variables	Type of Data	Data Source	Collection Method
To determine resource potential through area suitability	Frequency of whale shark appearances, duration of appearance, visibility, current velocity, water transparency	Primary and secondary	Research site and BPSPL Makassar	Sampling and literature review
To calculate the carrying capacity of whale shark tourism in Botubarani waters	Average frequency of whale shark appearances, available time in the area, time spent by tourists	Primary and secondary	Research site	Sampling and literature review

***Data Analysis. Whale Shark Tourism Suitability Assessment*.** Tourism activities should be aligned with the available resources and their designated functions (Yulianda, 2007). The matrix analysis of site suitability for whale shark tourism was carried out using five parameters and three assessment categories. The suitability parameters included the frequency of appearance, duration of appearance, visibility, current velocity, and water transparency (Table 2). Weighting was assigned based on the relative importance of each parameter, while scoring was determined according to the quality of each parameter. The frequency and duration of appearance serve as

the primary indicators of tourism feasibility, as they determine the probability of encounters and the stability of habitat use (Araujo et al., 2014). Meanwhile, visibility, current velocity, and water transparency are indeed important for safety and the quality of tourist interactions; however, these parameters do not directly determine whale shark presence, and therefore receive lower weights compared to frequency and duration of appearance (Hearn et al., 2022; Rohner et al., 2022).

Tabel 2. Matrix of whale shark tourism area suitability

Parameter	Weight	S1	Score	S2	Score	S3	Score	S4	Score
Frequency of appearance (times/day)	5	> 5	3	3 – 5	2	1 – 3	1	< 1	0
Duration of appearance (hours/day)	5	> 6	3	3 – 6	2	1 – 3	1	< 1	0
Visibility (m)	4	> 8	3	4 – 8	2	1 – 4	1	< 1	0
Current velocity (m/s)	4	0–0,17	3	0,17–0,34	2	0,34–0,51	1	> 0.51	0
Water transparency (m)	3	>10	3	6 – 10	2	2 – 6	1	< 1	0

Yulianda (2007) explained that marine tourism suitability refers to the resource and environmental criteria required or needed for the development of marine tourism. The Tourism Suitability Index (TSI) is a continuation of the whale shark tourism suitability matrix analysis. The estimation used for marine tourism suitability (Yulianda et al., 2019) is calculated using the following equation:

$$TSI = \sum_{i=1}^{n} (\mathrm{Bi} \times \mathrm{Si})$$

n is the number of suitability parameters, *Bi* is the weight of the i-th parameter, and *Si* is the score of the i-th parameter. The assessment categories are as follows: Highly Suitable with a value of 53–63, Suitable with a value of 42–52, Conditionally Suitable with a value of 32–41, and Unsuitable with a value of 21–31.

***Spatial analysis*.** Spatial analysis in this study consisted of mapping the zoning area for marine tourism. The use of spatial analysis to identify spatial utilization was carried out using a Geographic Information System (GIS) approach. The zoning map was processed using ArcMap 10.1 software.

***Tourism Carrying Capacity Analysis (TCC)*.** The Tourism Carrying Capacity (TCC) is defined as the maximum number of visitors that can be physically accommodated in a given area at a specific time without causing disturbance to the environment or to humans. The method used in this study was a modification of that proposed by Yulianda (2019), employing the following formula:

$$\mathrm{TCC} = K \times \left(\frac{Wt}{Wp}\right)$$

TTC represents the carrying capacity of the area (people per day); *K* is the potential number of visitors based on the interaction regulations of the area; *Wt* is the total time available in the

area for tourism activities per day (hours); and *Wp* is the time spent by visitors to observe whale sharks (hours).

RESULTS AND DISCUSSION

Suitability of Whale Shark Tourism Area in Botubarani Village. The whale shark tourism area in Botubarani Village covers approximately 65 hectares and is classified into two categories of suitability based on the Tourism Suitability Index (TSI). The first category is "Suitable", with an TSI value of 48 (75.15%), while the second category is "conditionally suitable", with an TSI value of 41 (24.85%) (Figure 2). The "conditionally suitable" classification includes three specific areas, Area 1 (1.11 ha), Area 5 (4.49 ha), and Area 7 (3.19 ha). While the total area classified as "suitable" covers 26.57 hectares.

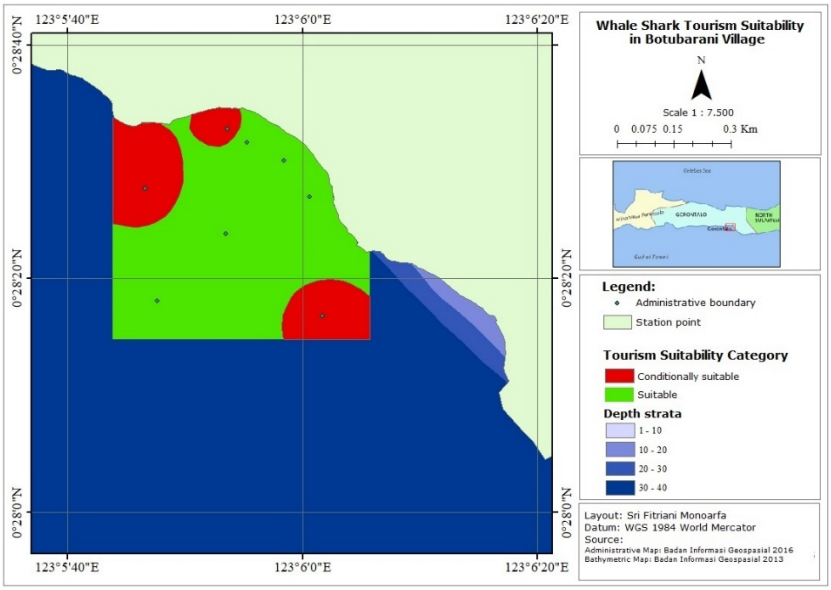


Figure 2. Map of Whale Shark Tourism Suitability in Botubarani

Conceptually, marine tourism suitability reflects the level of compatibility between marine resources and specific tourism activities. Each form of marine tourism has its own environmental requirements that must align with the characteristics of the tourism object being developed (Ketjulan, 2010).

Areas categorized as suitable require careful management to maintain ecological sustainability. Certain restrictions are necessary to preserve ecosystem balance, even though they may reduce tourism intensity and potential economic gains. Management strategies may include limiting the number of visitors based on the calculated Tourism Carrying Capacity (TCC) and implementing a conservation fee dedicated to supporting whale shark protection and habitat management programs.

In contrast, conditionally suitable areas face more complex environmental challenges but can still be optimized through adaptive management approaches. In these areas, whale sharks generally pass through rather than remain at the surface, leading to limited observation opportunities. Moreover, wave conditions often hinder boat-based tourism activities. Consequently, managing these areas requires greater intervention efforts and cannot be achieved through conventional or low-cost management models.
From the perspective of natural resources, the suitability of whale shark tourism areas is determined by several ecological parameters, including appearance frequency, duration of appearance, water transparency, visibility, and current velocity. These parameters serve as the foundation for evaluating Botubarani's potential as a sustainable whale shark ecotourism destination.

***Frequency of Appearance*.** The frequency of whale shark appearances was analyzed using transmitter tagging data installed by the monitoring team within a 1-kilometer observation radius. This method aimed to determine the average daily appearance rate over a 24-hour period. Results indicated distinct patterns between 2017 and 2018 (Figure 3).

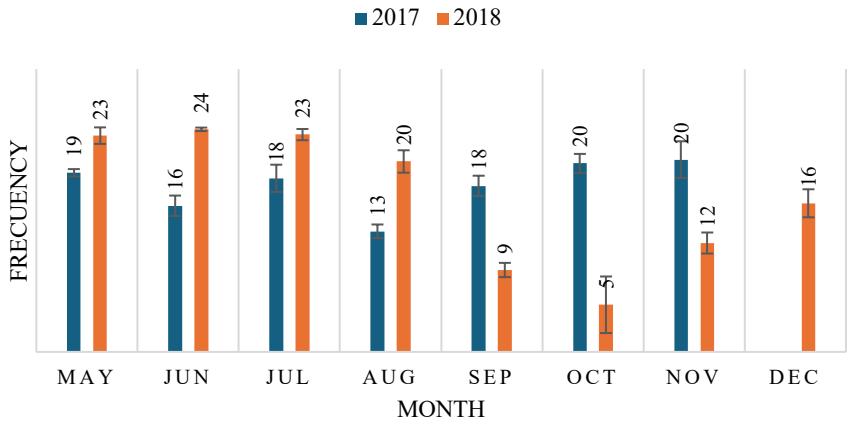


Figure 3. Frequency of whale shark occurrences recorded through transmitter tagging

In 2017, whale sharks were more frequently observed between September and November, while community-based monitoring recorded higher sightings in May and Juni (Figure 4). This difference is likely due to variations among the tagged individuals. In 2018, transmitter data showed that whale sharks appeared most frequently from May to August.

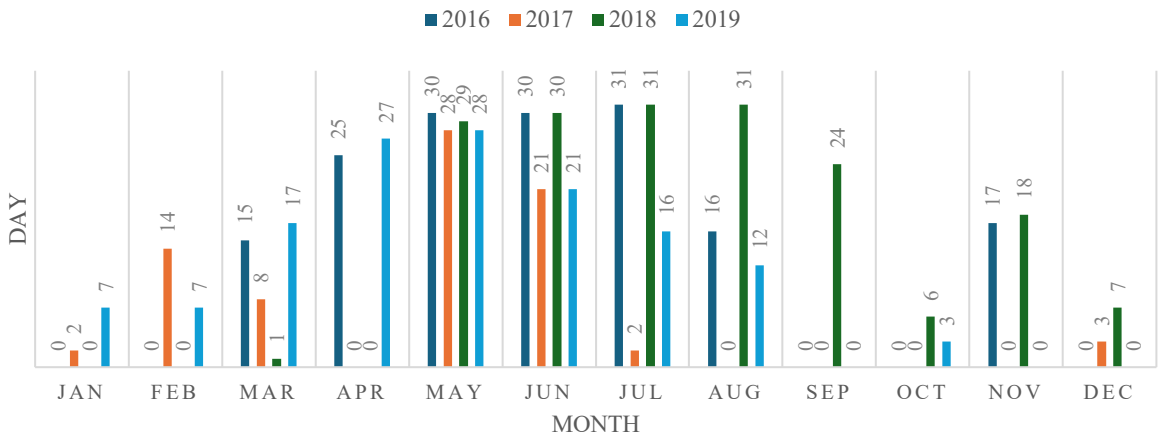


Figure 4. Whale shark sightings recorded through community monitoring calendar

The occurrence of whale sharks in Botubarani waters is seasonal, with higher appearance frequencies during specific months. This differs from Kwatisore waters, where whale sharks are known to reside throughout the year and surface almost daily (Maruanaya et al., 2019). Overall, the movement and migratory patterns of whale sharks remain unclear, but it is strongly suspected that during months of absence in Botubarani, the species migrates to other regions, consistent with its nature as a highly migratory species.

***Duration of Appearance*.** Whale sharks often surface to feed or thermoregulate, making this behavior a key attraction for tourism activities. They typically feed passively with a vertical or near-vertical posture close to the surface (Murdani, 2017).

In Botubarani, the average appearance duration during June was approximately five hours per day, suggesting prolonged visibility throughout the observation period. However, field observations indicated that at certain times, whale sharks remained at depths of around 10 meters without surfacing. Generally, they rise to the surface in the morning to feed and return to deeper waters by midday (Motta et al., 2010).

Water Clarity and Visibility. The environmental conditions of Botubarani waters are highly suitable for whale shark tourism. The average water clarity of 10.76 meters reflects excellent transparency, while the average visibility of 8.9 meters allows tourists to clearly observe whale sharks swimming near the surface. Such high levels of clarity and visibility make the area ideal for marine tourism activities such as snorkeling or observation from boats. In addition, water depth also influences the presence of whale sharks. Gonzalez-Pestana et al. (2020) reported that whale sharks are typically found in shallow coastal areas where chlorophyll-a concentrations—indicative of plankton abundance are higher.

Current Velocity. Current velocity plays an important role in both visitor safety and ecosystem balance. Strong currents can endanger swimmers by pulling them away from observation areas, while moderate currents help distribute nutrients and plankton, which are vital components of the marine food web. The average current speed in Botubarani's whale shark tourism area is 0.0836 meters per second, which is classified as weak and safe for tourism activities. These calm conditions enhance the comfort and safety of visitors engaged in swimming or snorkeling while observing whale sharks

***Whale Shark Tourism Carrying Capacity*.** The whale shark appearance period in the waters of Botubarani Village lasts approximately six hours per day, from 06:00 to 12:00 WITA, while visitors typically spend about three hours at the site. According to the established interaction guidelines, each boat accommodates three tourists per whale shark individual, resulting in a potential capacity of 12 visitors per session and a Tourism Carrying Capacity (TCC) of 24 visitors per day (Table 3). The carrying capacity is influenced by the availability of resources, whereby an increase in resource availability corresponds to a higher potential carrying capacity within the area.

Table 3. Tourism Carrying Capacity (TCC) of the Whale Shark Tourism Area in Botubarani Village

Parameter	Description	Value
TCC per Day	Maximum number of visitors that can be accommodated per day	24 people
TCC per Month	Estimated number of visitors based on an average of 22 whale shark appearance days per month	528 people
TCC per Year (May–July)	Estimated number of visitors during the peak whale shark appearance months	1560 people

One of the key attractions in Botubarani is whale shark feeding, where guides attract the sharks by tapping the boat paddles before offering small shrimp (500 g per bag). Based on boat activity data, feeding occurs 36 times per day, amounting to approximately 18 kg of shrimp daily. By comparison, the estimated daily food intake of juvenile whale sharks is around 50 kg (Motta et al., 2010). A similar practice is found in Oslob, Philippines, where whale sharks are fed between 06:00 and 13:00, with 50–150 kg provided per session (Araujo et al., 2014; Meekan & Lowe, 2019). Due to their passive feeding behavior, these interactions can easily be documented through photos and videos (Nugraha, 2016).

However, findings from other provisioning sites provide important insight into the potential long-term impacts of feeding practices. Studies in Oslob, Philippines, show that routine provisioning can alter the natural behavior of whale sharks, particularly by increasing their residency in shallow waters and reducing the seasonal migration patterns they would normally undertake, with some individuals documented remaining at the site for more than 500 days (Araujo et al., 2014). Provisioned whale sharks also tend to spend more time at the surface waiting for food,

which decreases their natural diving frequency and weakens avoidance responses toward boats and tourists, thereby increasing the risk of stress and physical injury (Legaspi et al., 2020). Recent biotelemetry research further indicates that even non-feeding tourism activities can elevate swimming activity and energetic demands in whale sharks (Reynolds, 2022), suggesting that the impacts in feeding-dependent sites may be considerably greater. Given that whale sharks are a protected and migratory species, the potential disruption to their movement patterns and long-term well-being should be a key consideration in managing whale shark tourism in Botubarani to ensure alignment with sustainability principles.

During the research period, visitor counts recorded in May, June, and July totaled approximately 844 people. However, this number does not fully represent the actual condition, as no standardized visitor monitoring system has been implemented. The calculated TCC value is notably higher than the recorded visitor count, indicating that the utilization of the Botubarani whale shark tourism area remains below its optimal capacity.

The concept of carrying capacity serves as a foundation for sustainable resource management, emphasizing two key principles: (1) The ecosystem's ability to tolerate human-induced disturbances, and (2) The preservation of the natural authenticity of resources (Hutabarat et al., 2009). Both factors are influenced by the extent of potential environmental impacts from tourism activities and the area's natural resilience to recover from such pressures.

CONCLUSION

This study demonstrates that the waters of Botubarani Village possess high potential for the sustainable development of whale shark tourism. The suitability and carrying capacity analyses indicate that the ecological and physical conditions of the area are favorable for conservation-based tourism, with utilization levels still below the optimal threshold.

This potential can be further optimized through effective management strategies that align with the area's carrying capacity, regulate visitor numbers, and implement conservation-based fees to support whale shark and habitat protection. Consequently, whale shark tourism in Botubarani could serve as a model of marine ecotourism that harmonizes environmental preservation with community welfare.

Further research is recommended to explore the socioeconomic dimensions of local communities and assess the long-term implications of tourism activities on whale shark behavior, providing a foundation for strengthening community-based ecotourism management policies.

REFERENCES

Araujo, G., Lucey, A., Labaja, J., So, L. C., Snow, S., & Ponzo, A. (2014). Population structure and residency patterns of whale sharks, Rhincodon typus, at a provisioning site in Cebu, Philippines. *PeerJ, 2*(e543). DOI 10.7717/peerj.543

Bengen, D. G. (2002). *Development of the carrying capacity concept in the management of small island environments.* Final Report. Office of the State Minister for the Environment and Faculty of Fisheries and Marine Sciences, IPB. Jakarta (ID).

Coastal and Marine Resources Management Agency of Makassar. (2018). *Monitoring results of whale shark appearances in Botubarani (Part 1).* Coastal and Marine Resource Management Center, Directorate General of Marine Spatial Management [Internet]. [time and place unknown]. Makassar (ID): Maros. [accessed 2018 Nov 20]. Available from: https://kkp.go.id/djprl/bpsplmakassar/artikel/4181-hasil-monitoring-kemunculan-hiu-paus-botubarani-bagian-1

Convention on International Trade in Endangered Species of Wild Fauna and Flora. (2007). *Appendices I, II & III of CITES.* Available from: www.cites.org/eng/app/appendices.php

Colman, J. G. (1997). A review of the biology and ecology of the whale shark. *Journal of Fish Biology,* 51:1219–1234.

Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 18/Kepmen-Kp/2013 on the determination of full protection status for the whale shark (*Rhincodon typus*).

De Santo, R. S. (1978). *Concept of Applied Ecology.* Heidelberg Science Library: Springer-Verlag.

Djafri, N., & Rahmat, A. (2017). Mapping of leadership species protection for the sustainable economic growth of local communities. *European Research Studies Journal,* 20(4A):432–442.

Hearn, A. R., Green, J. R., Penaherrera-Palma, C., Reynolds, S., Rohner, C. A., Roman, M., & Sequeira, A. M. M. (2022). Whale Shark Movements and Migrations. In A. D. M. Dove & S. J. Pierce (Eds.), *Whale sharks: Biology, ecology, and conservation* (pp. 105–128). CRC Press.

International Union for Conservation of Nature and Natural Resources. (2018). *The IUCN Red List of Threatened Species.* Available from: http://www.iucnredlist.org

Ketjulan, R. (2010). Analysis of suitability and carrying capacity of marine ecotourism in Hari Island, Laonti District, South Konawe Regency, Southeast Sulawesi Province. [Undergraduate thesis, IPB University]

Motta, P. J., Maslanka, M., Hueter, R. E., Davis, R. L., de la Parra, R., Mulvany, S. L., Habegger, M. L., Strother, J. A., & Mara, K. R. (2010). Feeding anatomy, filter-feeding rate, and diet of whale sharks (*Rhincodon typus*) during surface ram filter feeding off the Yucatan Peninsula, Mexico. *Zoology (Elsevier),* 113:199–212.

Nugraha, Y., & Rudi, A. (2016). Observation of whale shark (*Rhincodon typus*) appearances around the waters of Tomini Bay, Gorontalo Province. *Buletin Teknik Litkayasa* [Internet]. Available from: http://ejournal-balitbang.kkp.go.id/index.php/btl

Patil, D. Y., & Patil, L. S. (2008). Environmental carrying capacity and tourism development in Maharashtra. *Tourism Society and Environmental Issues,* 2:95–101.

Quiros, A. L. (2007). Tourist compliance to a code of conduct and the resulting effects on whale shark (*Rhincodon typus*) behavior in Donsol, Philippines. *Fisheries Research,* 84:102–108.

Reynolds, S. D. (2022). The movement ecology of whale sharks Rhincodon typus in the Anthropocene ocean [Undergraduate thesis, The University of Queensland]

Rohner, C. A., Norman, B., Araujo, G., Holmberg, J., & Pierce, S. J. (2022). Population Ecology of Whale Sharks. In A. D. M. Dove & S. J. Pierce (Eds.), *Whale sharks: Biology, ecology, and conservation* (pp. 105–128). CRC Press.

Rojayati, A. (2017). *Conservation- and community-based whale shark ecotourism: A case study at Bentar Beach, Probolinggo Regency, East Java* [thesis]. Bogor (ID): Bogor Agricultural University.

Maruanaya, Y., Noor, B. A., & Tania, C. (2019). Behavior of whale sharks (*Rhincodon typus*) in the waters of Kwatisore, Yaur District, within the Cenderawasih Bay National Park, Papua. *TABURA,* 1(1):43–53.

Shelby, B., & Heberlein, T. A. (1987). *Carrying Capacity in Recreation Settings.* Oregon State University Press. Oregon.

Yulianda, F. (2007). Marine ecotourism as an alternative utilization of coastal resources based on conservation. *Presented at the Science Seminar*. Faculty of Fisheries and Marine Sciences, IPB. Bogor.

Yulianda, F. (2019). *Aquatic Ecotourism: A Concept of Suitability and Carrying Capacity of Marine and Freshwater Tourism.* IPB Press. Bogor.