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Carrying Capacity of Diving Tourism in Dampier Strait Marine Conservation Area – District of Raja Ampat

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Abstract. Raja Ampat has biodiversity in marine waters so it qualifies as a conservation area as well as a tourism destination. The number of tourist visits to this area has increased significantly, from 998 people in 2007 to 29,653 people in 2016. Increasing number of tourists have become a threat if the behavior of tourist are not concerned on the environment sustainability and damage the attractions for diving. Assessment of the carrying capacity of the area becomes an important factor to know for sure the maximum number of visitors that can be accommodated by the region at any given time without causing disturbance to the environment and human. The study was conducted from September 2015 to August 2016. Data collection of dive sites was conducted by measuring the extent of coral reefs, coral slope, coral reef condition, and water depth. Calculation of carrying capacity used is Physical Carrying Capacity (PCC) and Real Carrying Capacity (RCC). There are 15 main dive sites frequented by divers. The number of people allowed to dive based on physical carrying capacity ranges from 20 to 500 diver/day, for Actual carrying capacity (RCC) of 14 - 335 diver/day. Locations that have the lowest carrying capacity on The Passage site and highest on the Melissa Garden site. The process of integrating dive attractions with other tours and monitoring of travel activities is a key factor in the sustainability of Raja Ampat regency tourism.

1. Introduction

The Raja Ampat Islands is the heart of the world's coral triangle (the heart of the coral triangle) and is recognized to have one of the best coral reefs in the world. In addition to coral reef ecosystems, Raja Ampat also has a vast expanse of seagrass, mangrove forests, and rocky cliff beaches. Various endangered charismatic species are found in this region, such as turtles, sharks, whales, manta rays, dugongs, dolphins, etc. The current conditions have made Raja Ampat become a zone called tourism destination zone. To encourage the sustainability of needed resources, the development of tourism in Raja Ampat regency needs to develop the concept of ecotourism, which is environmentally based education. The number of people visiting this area is very significant, from 998 people in 2007 to 29,653 in 2016 or more than thirty times in the last ten years [1]. This significant increase in the number of visitor is very



promising to improve the economy of the region and the community, but on the other hand it may threaten and degrade the environment. If this happens, it will destroy the development of tourism in Raja Ampat regency in the future. The number of visit in 2019 forecasted to reach to 20 million of tourists consisting of the tourism sector (Tourism Big Leap) that also possible to in impact on tourism Raja Ampat regency. Experiences in some areas serve as a destination for Raja Ampat district to increase the excessive number of tourists. The case in Bunaken, North Sulawesi is experiencing the degradation of the natural environment, especially the coral reefs and some areas of Bali, as well as several other areas.

Therefore, it is necessary to study the carrying capacity of the area to accurately know the maximum number of actual visitors and can be accommodated by the area at any given time without causing any disturbance to the environment and people. The results of this study will support the Raja Ampat District Government's policy of choosing not to create energy (mass tourism) that addresses the environment and the beauty of nature and special tourism (special tourism) on landscapes and seascape.

This research aimed to calculate and analyze the regional carrying capacity of Raja Ampat regency which includes Physical Carrying Capacity (PCC) and Real Carrying Capacity (RCC) of tourism. The benefits of research are that it can be used as a reference for the number of maritime tourists, especially diving attractions in Raja Ampat regency and as important information for tourists and managers so that natural resources of coral reefs and associated biota can be maintained and protected.

2. Research Methods

This research is a survey research conducted in the Raja Ampat Marine Conservation Area specifically in the Dampier Strait Marine Conservation Area. Research implementation in December 2015 to June 2016. Research location can be seen in Figure 1. Data collection consists of primary data and secondary data.

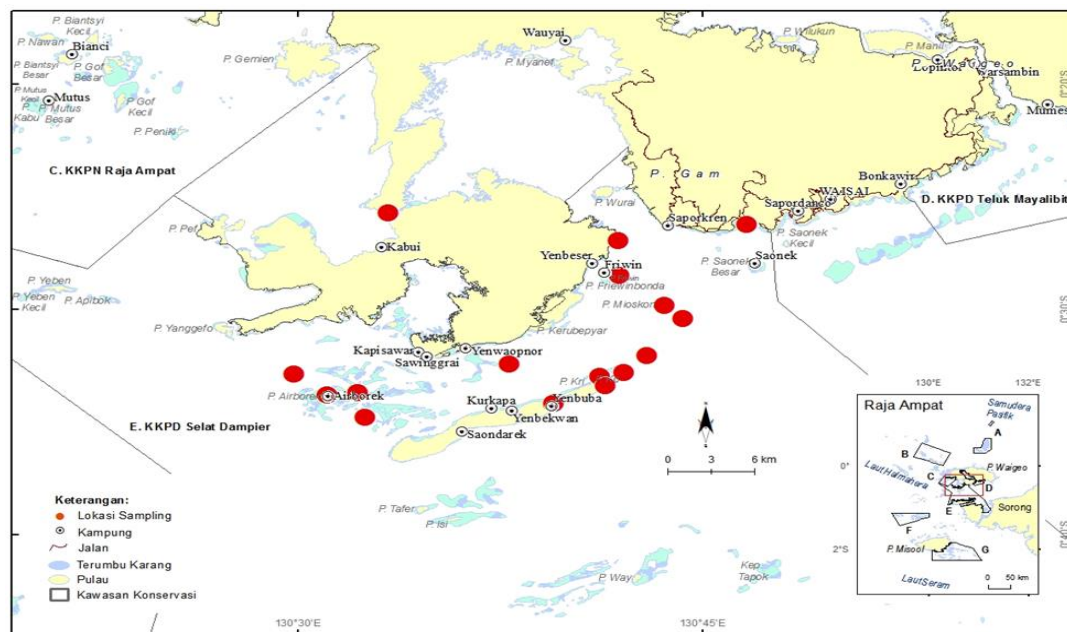


Figure 1. Research Location Map of Diving Carrying Capacity in Dampier Strait

Primary data was collected through direct measurement techniques in the field using SCUBA diving equipment for each diving object, carried out with the LIT (Line intercept transect) method, namely

measurements of length and width of coral reefs with a 100m roll meter, also measured depth of waters and slope of reefs coral. Observations on the condition of coral reefs and specific types of biota are also carried out in each research location, also supported by secondary data that is evaluated at any time through Reef Check Monitoring. Taking the coordinate position in each diving tourism object was also taken using GPS. Data collection on marine tourism, especially marine ecotourism is carried out by in-depth interviews with resort owners and managers consisting of Live aboard (LOB) and Land based resorts and homestays from local communities. Questions are directed at the daily activities of diving tours, the number of visitors, the management applied, and problems in the management of resorts and homestays. Data and information were also collected from tour operator by filling out questionnaires which included room capacity data, time of operation per year, average number of guest visits, types of recreation that were most in demand, and the highest guest visiting time.

Secondary data is collected from various available sources such as research reports, diving guide books, Raja Ampat district government policies and the Central Government on tourism and conservation, Raja Ampat district regulations on tourism and conservation. The framework for assessing the carrying capacity of the tourism environment in protected areas refers to the calculation formula for tourism carrying capacity developed by [2-4]. This framework attempts to determine the maximum number of tourist visits in an area based on physical, biological and management conditions in the area. The calculation of the carrying capacity used in this study is physical carrying capacity (PCC) and real carrying capacity (RCC) by considering the natural correction factor.

i. Physical Carrying Capacity (Physical Carrying Capacity / PCC)

PCC is the maximum number of tourists who can physically enter the designated tourist location, at certain times in a tourist destination with the formula:

$$PCC = A \times \frac{V}{a} \times Rf \quad \dots\dots\dots (1)$$

Where : A : is an area that is used for public, in this case the area for tours are divided into beach tourism, diving and fishing.

V/a : is the area that someone needs (visitors = tourists) to travel nautically, is a coefficient that is adjusted to the type of maritime tourism carried out, for example beach tourism, snorkeling, diving and fishing.

Rf : is a Rotation Factor, which is the average period of open destination divided by the average length of time a person travels.

ii. Real Carrying Capacity (RCC)

The maximum amount that is permitted by users for maritime tourism, after the Correction Factor (Cf) comes from specific characteristics in the physical tourism environment, such as wind (Cf1), waves (Cf2), rain (Cf3) and others (Cfn) have been applied in PCC by [5] [4]). In this study the Cf value used is the accumulation value of environmental factors namely the amount of time (months) that tourists cannot visit to Raja Ampat because of the very large waves that are in May to August or 4 months every year. Thus the actual carrying capacity (RCC) formula is as follows :

$$RCC = PCC \times Cf \quad \dots\dots\dots (2)$$

Where : PCC = is the physical carrying capacity (Physical Carrying Capacity).

Cf = is a correction factor whose value is as follows :

$$Cf = 1 - (Ml / Mt) \dots\dots\dots (3)$$

Where : Ml = Time (months) can not visit Raja Ampat (4 months)

Mt = Total time (months) in one year (12 months)

Thus the Cf value is

$$Cf = 1 - (4/12) = 1 - 1/3 = 2/3 = 0.667$$

3. Results and Discussion

3.1. Description of Research Location

The Dampier Strait is a major area of tourism in Raja Ampat. The name "Dampier" comes from the name of an Englishman William Dampier (1651 - 1715) who first discovered and traced the region in the late 17th century to find a shortcut to the Pacific Ocean. This controversial figure bears various nicknames including as a pirate, navigator, naturalist, ethnographer, and book writer [6] [7]. Data in 2010 for each dive from September to February the number of Manta Ray that can be observed were 20-30 people. But over time due to the increasingly well-known dive sites of Manta Sandy and Manta Ridge, diving activities are getting higher with the number of divers enjoying Manta Ray can be 30-40 people per dive trip with diving behavior that disrupts Manta Ray activities.

This caused a decrease in Manta Ray sightings in both Cleaning Station. Regional Marine Conservation Area the Dampier Strait geographically consists of 3 parts, namely the coast of Gam and Mansuar island, the coast of Batanta Island and the coast of the island of Salawati. The Dampier Strait KKPd is the place of life for various large fishes such as sharks, skipjacks, tuna, snapper, grouper, bobara and barracuda. KKPd Dampier Strait is a place for whales, dolphins and dugongs. International Conservation Researchers noted there were six types of whales, three types of dolphins that crossed the waters of the Dampier Strait (www.birdsheadseascape.com), while the waters of the Dampier Strait itself became a gathering location for Manta Ray for foraging and cleaning stations that made power special tourist attraction observing manta.

3.2. Carrying Capacity for Diving Tourism

The results of the calculation of physical carrying capacity (PCC) and real carrying capacity (RCC) of diving tours at the Dampier Strait KKPd location are shown in Table 1. shows that the number of people allowed to dive at the main diving tourism sites in the Dampier Strait and its surroundings is based on carrying capacity physical (PCC) is around 20 - 500 divers per day. Meanwhile, for the actual carrying capacity (RCC) which considers the season correction factor is obtained around 14 - 335 people (divers) per day, where the location that has the lowest carrying capacity at The Passage site and the highest at the Melissa Garden site. The difference in the amount of carrying capacity is determined by the area and vulnerability of the dive site. The location of the Melissa Garden dive from the calculation results has the largest area of coral reefs which is 50,000 m² with IKW so the choice of diving tourism attractions is to enjoy the area of coral reefs that look like a garden. The types of coral reefs that dominate the Dampier Strait KKPd consist of Hard coral from the genus *Acropora sp.*, a type of coral based on the place of growth, namely the type of edge coral (Fringing reef), barrier reef and patch reef. The location of Manta Sandy and Manta Ridge, the tourism carrying capacity is more considered in the aspect of object vulnerability, namely observation on manta rays. The results of the study of the carrying capacity team in 2015 showed only 3-10 Manta Pays in both dive spots. Based on the results of the study obtained, the results of the actual carrying capacity analysis (RCC) in Manta Sandy and Manta Ridge were 36 and 26 people per day with 3 and 2 times dives each so that only one dive trip was carried out with only 12 and 13 divers / trips. Of the 15 dive sites there were 5 spots (33.33%) that Manta ray observations could take, namely the Blue Magic, Manta Sandy, Jetty Arborek, and Manta Ridge dive sites.

Table 1. Results of measurement of physical carrying capacity (PCC) and real carrying capacity (RCC)

No	Dive Site	Area (m ²)	Rotation Time (hour)	Time of Day (hour)	Space Criteria (m ² /person)	PCC (person/hour)	Correction Factor (Season)	RCC (person/day)	Amount Trip/day	Number Diver (person/trip)	Total Diver/year (person/site)
1	Manta Sandy	5000	2	10	500	50	0.67	33,5	3	11	6030
2	Manta Ridge	3750	2	10	500	37,5	0.67	26,1	2	13	4523
3	Lalosi reef	12500	2	10	500	125	0.67	84,8	5	17	30150
4	Cape Kri	10000	2	10	500	100	0.67	65,0	5	13	24120
5	Yenbuba Jetty	7500	2	10	500	75	0.67	50,3	5	10	18090
6	Mioskon	10000	2	10	500	100	0.67	68,6	5	14	24120
7	Blue Magic	5000	2	10	500	50	0.67	33,5	5	7	12060
8	Sardine Reef	12500	2	10	500	125	0.67	83,8	5	17	30150
9	Chicken Reef	12500	2	10	500	125	0.67	83,8	5	17	30150
10	Melisa Garden	50000	2	10	500	500	0.67	335,0	5	67	120600
11	Otdima	15000	2	10	500	150	0.67	105,0	5	21	36180
12	Friwen Bonda	12500	2	10	500	125	0.67	83,8	5	17	30150
13	Arborek Jetty	4000	2	10	500	40	0.67	26,8	5	6	9648
14	Five Rock's	2500	2	10	500	25	0.67	16,8	5	4	6030
15	The Passage	2000	2	10	500	20	0.67	13,4	5	3	4824
Total PCC and RCC Diving Tour KKPD Dampier Strait						1648		1104			
Total Potential Number of Divers at 15 dive sites in the Dampier Strait Conservation Area										386.825	

Source : Primary Data, 2017

In Indonesia there are more than 130 elasmobranch species, including both species of manta rays, Manta oceanic (*Mobula birostris*) and coral Manta (*Mobula alfredi*). Both species of manta rays are categorized as 'vulnerable' endangered species in the International Union for Conservation of Nature (IUCN) List of Endangered Species, and in 2013, included in the Appendix II Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). The entry of these two types of manta rays in this list emphasizes that the extinction of manta rays will occur if international trade continues without regulation [8]. The results of the Conservation International Indonesia study in 2015 show that the only area that is the location of migration is two (2) types of manta rays, namely manta oceanic and coral reefs. The presence of various types of endemic fish and migratory fish found in Raja Ampat in large numbers cannot be separated from the high level of aquatic fertility with the potential of marine natural resources, such as coral reefs with high species diversity in 6 KKPD and 1 KKPN, as well as seagrass beds and Mangrove forests on every beach in Raja Ampat. Mainly are in Kabui Bay and Teluk Mayalibit on Waigeo Island and Batanta and Salawati Island regions. These four regions have the widest 3 main coastal habitats in Raja Ampat district. Boli acknowledged that the types of ecosystems in Raja Ampat district generally include coral reef ecosystems, seagrass ecosystems, mangrove ecosystems and salt lake (marine lake). There are 4 types of coral reefs found in Raja Ampat Regency, namely: fringing reef, barrier reef, gosong reef / taka (patch reef), and ring coral (atoll reef) [9]. According to DeVantier, the Raja Ampat water area has a diversity of reefscape (reefscape) as many as 14 regions and reef habitats as many as 75 locations [10].

Diving tours are the most popular tourist activity for tourists visiting Raja Ampat Regency. The tourism spectrum category is "First Dark Blue" because it is dominant in coloring travel activities with the number of destinations and the large number of tourists. The area of the Marine Conservation Area of the Dampier Strait which is a diving tourism destination is 336,200 ha. Diving tours in the Dampier Strait Marine Protected Area in its activities are divided into 2: First, step-by-step observing activities such as Manta Rays, Whales, Sharks, Wobbegong, and so on. Second, observing coral, reef fish and other small animals associated with coral reefs. The number of tourists observing manta on Manta Sandy spot in 2012 research can reach 30-40 divers per observation trip. This greatly affects the presence of manta that are very disturbed and the fact that manta rays are increasingly difficult to observe [11]. Research on the carrying capacity of diving tours conducted by Zulfikar [12] in the Mentawai Islands shows that the carrying capacity of diving tourism in 13 dive sites obtained a total number of diver of 941,591 / year physically which orientation of the tour is to coral reefs. Khairunnisa's [13] research on the Management of the Marine Tourism Landscape in Bunaken National Park in North Sulawesi shows that the maritime tourism landscape in TNB has excess carrying capacity in diving and snorkeling spots so there is a need to limit the number of maritime tourists, as well as alternative use of tourist landscapes other than underwater are such as beach and land tourism.

Especially for Manta observations, the government through the conservation area management in Raja Ampat applies visitor restrictions by forming a monitoring team for manta rays recruited from the surrounding communities who maintain guard posts and also from DKP, BLUD, related NGOs, Dive operators, LoB, Jangkar, and others. This institution regulates quotas for manta ray observation and has a surveillance post for tourists who dive on the Manta Sandy site. Kasmidi [14] said that armed with sufficient skills and knowledge, this post is the Manta Cadre on duty every day to provide information to tourists about the Standard Operating Procedure (SOP) at Manta Sandy Post, Code of Conduct in interacting with Manta Ray for divers and snorkelers, as well as knowledge about Manta Ray itself. In addition to providing information, Manta cadres tried to control the number of people and the number of ships in a visit to the Manta Sandy dive site according to the carrying capacity that had been investigated by the Raja Ampat Tourism Supporting Study Team. The fact that needs to be known is that on the policy side there are two special regulations that aim to protect manta rays.

Conservation International - Indonesia when conducting research on Manta Rays giving satellite tagging (Satelite Tagging) to monitor migration patterns and behavior. Until 2017, a total of 33 manta rays have been successfully marked with a marker, which consists of 29 coral manta and 4 oceanic mantas to find out how the fish migration moves. The tagging results show in the Raja Ampat region, the manta ray migration pattern shows interesting findings that manta rays from the area generally do not travel too far and will return to the same area. This study has confirmed that the Wayag lagoon is a breeding ground and rearing of the nursery area. These two stingray species makes the marine waters in Raja Ampat district a Feeding ground, Nursery ground especially in the Wayag Islands KKPN and as a Cleaning Station, especially in the Dampier Strait KKPD and KKPD South Misool [8].

Manta rays are charismatic animals that have great potential to contribute income through the tourism industry. A study from O'Malley, et al., on The Global Economic Impact of Manta Ray Watching Tourism, shows that a manta ray can contribute as much as US\$ 1,000,000 during its life as a tourism asset, whereas, if killed and traded throughout body parts especially gills will only be worth less than US\$ 461.5 or Rp.6,000,000/head. In 2013, Indonesia had the second largest manta tourism industry in the world after Japan, with a potential revenue value of US\$ 10,655,022, - /year or IDR. 138,515,286,000, - (US \$ 2013 rate = IDR. 13,000, -)[15] [16].

The results of Romadhon, et al [17] research in the Sapeken archipelago indicate that the assessment of the carrying capacity of ecotourism based on ecological footprint must be integrated in tourism activities planning, to provide existing infrastructure. Regarding the planning of ecotourism activities in

the Sapeken islands, by looking at the status of the availability of ecosystem services, the budget allocated needs to be developed. The condition of some resources as natural capital and assets that are still able to provide service ecosystems can be used as tourist attractions.

4. Conclusion

Total potential number of divers at 15 dive sites for a year at The Dampier Strait KKPD equaled 386,825 diver with PCC = 1648 diver and RCC = 1104 diver. The biggest dive site actual carrying capacity is the Melissa Garden site with capacity of 120.600 diver/year or 67diver/trip, while The Passage dive site has power the smallest support is 4824 diver/year or 3 diver /trip. Attraction in diving activities by tourists is observing Manta Rays, enjoying Panorama View of coral reefs and observing organisms associated with coral reefs.

5. Recommendation

- i. Raja Ampat district government can make regulations on Tourism Supporting Capacity and Rules and Ethics Diving tours in the form of Regional Regulations that will guide the implementation of sustainable tourism in Raja Ampat district.
- ii. Every study result, especially the quota, needs to be informed to business actors based on the carrying capacity of diving tourism, especially in the Dampier Strait Marine Conservation Area and its surroundings.
- iii. This Research to Carrying Capacity of diving tourism in the Dampier Strait marine conservation area needs to be socialized to the Element Pentahelix (Community, Business Actors, Academics, Mass Media) in the area to be known and carried out.

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