Manta ray watching tourism in Eastern Indonesia: Is it sustainable?

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Abstract. Manta ray watching tourism has become a popular tourist attraction over the past two decades, with a number of destinations offering different encounter experiences for tourists. This type of attraction has drawn worldwide attention because it can offer significant contributions to the local economy through snorkelling and diving services. Since its early development, a number of scientists have conducted research on the impacts of manta ray watching tourism, and have reported different findings regarding its sustainability. Based on published scientific articles, this study provides a literature review of manta ray watching tourism and examines the sustainability of its operation. This paper also highlights manta ray tourism hotspots in Indonesia including Nusa Penida, Komodo, and Raja Ampat as the study locations. Interviews with ten key persons including government officials, tourism operators, community, and non-governmental organization were conducted to collect and identify their perceptions. This study demonstrates different impacts of economy, ecology, and social-cultural aspects. Furthermore, different study areas apply different management approach in managing their tourist in terms of manta ray watching tourism operation. In conclusion, good governance, regulations/law enforcement, and collaborative management are significant factors to achieve sustainable manta ray watching tourism.

1. Introduction

Manta rays are charismatic species that symbolize the diversity of marine resources. A recent study [1] using molecular biology (DNA) confirmed the presence of two species, *Mobula alfredi* and *Mobula birostris*. Among the largest fish species in the world, manta rays are gentle giants and charismatic species representing the ecological and social/cultural values of marine biodiversity. According to [2,3] manta rays can weigh 1-2 tons and have broad pectoral fins resembling wings which can span 3-7m. Unique characteristics possessed by manta rays are colour variations, two head lobes (horns), a frontal lobe for filtering plankton, spotted patterns on the lower shoulders which can serve as fingerprints. Marks on the upper shoulders form a pattern resembling the letter "T" (*M. birostris*) or "Y" (*M. alfredi*) and serve as a marker for distinguishing the species [4].

The habitat of *M. alfredi* is generally around coral reefs, tropical islands, atolls, bays, and tropical coastal waters, while *M. birostris* habitats are further offshore in tropical and subtropical oceanic waters. Manta rays spend a lot of time at cleaning stations where these animals are associated with small fish that cleanse the parasites on their skin or cleanse their wounds. According to [5,6], manta rays have a high economic value in the fisheries sector especially the gill-raker trade in international markets. This is indicated by data from FAO in 2013 which recorded global landings of chondrichthyan products (sharks, rays, chimeras) reaching 896,000 tons with a value of US $ 1 billion.
per year. Based on this issue, the conservation status of manta rays is a matter of global concern, with protection under international and national instruments including the IUCN red list, CITES Appendix II, and full protection by the Indonesian government through Decree No. 4/Kepmen-KP/2014 by the Minister for Marine Affairs and Fisheries, which stipulates that both species of manta rays are fully protected in Indonesian waters.

In the past two decades, researchers have conducted studies on the increasing numbers of tourists who are observing marine wild animals, including manta ray watching at sites around the world [7]. According to [8], manta ray watching is a recreational activity to observe manta rays by diving, snorkelling, and other means of observation to view them in their habitat. Their study also documented twenty-five countries with manta ray tourism hotspots worldwide including the Maldives, Mozambique, Australia, Hawaii, and Indonesia.

This type of industry offers economic benefits through non-consumptive activities where the value of a single manta ray can be $1 million while it is still alive but it is only worth $500 when it is dead. Furthermore, a recent study [8] calculated an industry value of US $140 million per year worldwide. An economic valuation study at manta dive sites in the Maldives, estimated 143,000 dives and more than 14,000 snorkel trips each year during the period 2006-2008 [9], with an estimated economic value of around US $8.1 million per year through direct income. The economic value of manta rays in Inhambane Mozambique province was also high, generating $10.9 million per year in direct income through diving activities with an estimated direct economic impact (expenditure during the tour) of US $34.0 million every year [10]. With no manta ray tourism, it was estimated that a value of between $16.1 million and $25.7 million would be lost to the region each year if manta rays are not carried out with a sustainability strategy. The results of a survey of tourists and stakeholders emphasize the importance of increasing protection of manta rays and their habitat through effective conservation area management for tourism [10].

Research on social and cultural aspects was conducted on the social value of manta ray tours in Hawaii [11]. In 2017, a study of diving and snorkelling of manta rays resulted in conflicts. The survey from 444 participants showed 79% of snorkelling groups experienced conflict with other snorkellers, and 53% of scuba divers reported conflict with other divers. The physical interactions between individuals interfered with the experience. The forms of behaviour during conflicts included crashing into people (up to 92%), unconsciousness (up to 73%), and people dazzling others with underwater flashlights (up to 56%). The level of conflict between groups was found to be less between different activities (snorkelers and divers) with some minimal social conflict such as negative prejudice, and no physical interaction between individuals.

In a different study [12], the importance of the effective role of conservation areas (MPAs) was identified as having implications for the environmental health of ecosystems and the manta ray ecotourism industry. This researcher explained that the manta ray aggregation areas in Sudan are protected by zoning rules and utilized for ecotourism. The ecotourism development involved local communities through employment and capital investment for tourism industry facilities but lead to a dilution of traditional Sudanese culture. A study to analyse the ecological value generated from manta ray viewing by utilizing video recordings to record tourist-manta interactions was carried out six feeding aggregation sites, and six cleaning stations, in Baa Atoll, Maldives Republic [13]. The behaviour of tourists was limited to passive observation, intentional obstruction, diving below or near manta, and deliberating contact with manta.

2. Methods

2.1. Statement of problem and objective
Charismatic species of marine wildlife becomes a driven to economic growth for marine wildlife tourism [14,15]. Visitors want to experience seeing these animals first-hand, in the wild. Because of this reason, conserving marine species has benefits not just from non-consumptive uses, but also from the value of the ecosystem services provided by the species. It has been argued that this type of
tourism can be sustainable with some safeguards to protect the marine environment by limiting physical construction [16]. There is currently a debate among scientists regarding the sustainable operation of manta ray tourism and this paper aims to analyse current development. The aims of this literature review were to critically analyse the gaps, synthesise the findings, and formulate issues for further study on sustainable manta ray watching tourism.

2.2. Location
There were three study locations involved in this research: Nusa Penida, Komodo, and Raja Ampat (Figure 1). Scientific articles from the past ten years and tourism reports were collected, in addition to interviews with ten key informants conducted in 2017, involving government officials, tourism operators, non-governmental organization, and community groups.

Figure 1. Study locations (Google earth, 2017)

Nusa Penida, in Klungkung Regency, Bali Province, is within the world's coral triangle and has high marine biodiversity. According to TNC, within the sub-districts of Nusa Penida, Nusa Lembongan, and Nusa Ceningan there are 1,419 hectares of coral reefs, 230 hectares of mangrove forests, and 108 hectares of seagrass beds. Nusa Penida is famous for manta rays and mola-mola.

Komodo National Park, established in 1980, is located between the islands of Sumbawa and Flores. This park's main purpose is to conserve the Komodo dragon (*Varanus komodoensis*) and its habitat, together with the entire biodiversity of the area. In 1986, UNESCO declared Komodo a World Heritage Site and a Man and Biosphere Reserve due to the Park's biological importance. Komodo National Park has a total (land and water) area of 1817km², with rich marine environments including coral reefs, mangroves, seagrass beds, seamounts, and semi-enclosed bays. More than 1,000 species of fish, some 260 species of reef-building coral, and 70 species of sponges along with dugong, sharks,
manta rays, at least 14 species of whales, dolphins, and sea turtles are found there. Manta rays in Komodo National Park are a popular tourism attraction. In 2014, the Bupati of Manggarai Barat formulated a decree to address the protection of manta rays in Manggarai Barat Regency. Raja Ampat encompasses more than 4 million ha of land and sea and is home to more than 1,400 species of fish and 537 coral species (75% of all known coral species). Raja Ampat is located in the north-western tip of Indonesia’s West Papua Province, and includes the four large islands of Waigeo, Batanta, Salawati, and Misool, with hundreds of smaller islands. This MPA is a globally significant biodiversity hotspot because it provides a vital source of nutrition and a basis for local livelihoods. Manta rays serve as a conservation icon for Raja Ampat regency. Although manta ray populations have been severely depleted elsewhere in the region, they are still abundant in the waters of Raja Ampat and have become a wildlife viewing tourism attraction. In 2012, the Raja Ampat Regency established a decree (No.9/2012) for the protection of manta rays.

3. Results

3.1. Manta ray populations

In Indonesia, there are a number of widely known manta ray sub-populations: in Raja Ampat – West Papua, Komodo National Park – East Nusa Tenggara, and Nusa Penida – Bali. These locations have also become the hotspots for manta ray tourism in Indonesia, and combined make the second-largest manta ray watching industry in the world [8]. A study on the frequency of occurrence and number of individual manta rays [17] indicated more sightings of manta every year for both species of manta ray in Nusa Penida and Komodo (Table 1). In 2013, the highest occurrence of manta rays was 1,092 times, in the waters of Nusa Penida.

| Region                      | Year         | Nusa Penida & Komodo | West Manggarai | Raja Ampat | Total |
|-----------------------------|--------------|----------------------|----------------|------------|-------|
| Total sighting records      | 2006 - 2014  | 2007                 | 426            | 171        | 2,604 |
| Yearly sighting records     | 2006 - 2010  | 83                   | -              | -          | 83    |
|                             | 2011         | 84                   | 49             | -          | 133   |
|                             | 2012         | 544                  | 37             | -          | 581   |
|                             | 2013         | 1,092                | 329            | 53         | 1,474 |
|                             | 2014         | 203                  | 11             | 133        | 327   |

M. alfredi

| Region                      | Year         | Nusa Penida & Komodo | West Manggarai | Raja Ampat | Total |
|-----------------------------|--------------|----------------------|----------------|------------|-------|
|                             | 2006 - 2014  | 417                  | 303            | 100        | 820   |

The following year marked the beginning of manta ray research incorporating satellite tagging technology in four main manta ray sighting locations. This program, which tagged 33 individuals in Raja Ampat (West Papua), Nusa Penida (Bali), Komodo (East Nusa Tenggara), and Sangalaki (East Kalimantan), was the biggest manta ray tagging achievement to date in Southeast Asia (Pers. com, 2018). The use of SPLASH tags with Fastloc-GPS technology enabled the program to capture accurate locations for tagged manta rays every time they broke the water surface even for a split second. This tagging program has successfully provided preliminary data on manta behaviour and movements in Indonesia. There are three key findings, in particular, which will be useful for the management and protection of this gentle species. The observation of manta behaviour and movements in Raja Ampat unveiled the presence of a nursing ground for pregnant female manta rays and their juveniles in Wayag Lagoon, located in the heart of the Wayag Islands. This discovery marks the first known nursery and pupping ground in Southeast Asia. These young animals are observed to take shelter in the sanctuary of the lagoon, but occasionally travel out of the lagoon into the deep sea for few hours before coming back to their “home.” On the other hand, there are several major routes for mature manta rays. Some remain in the Dampier Strait area or around the Island Chain in Northwest Raja Ampat (Wayag and Kawe, Seprang to North Waigeo). Although some observed manta rays perform
long-range movements, in general, the tagged manta rays throughout the program sites tended to remain at close range, which indicates that manta rays have strong residency rates inside the area. All of the six tagged manta rays in Komodo exhibited varying movements, most of them resided inside the area of national park, and some made a constant back and forth movement across the narrow straits that are exposed to the strong currents between Rinca and Komodo Islands. In Bali, almost all mantas spend time only along the south coast of Nusa Penida Islands and never went north. The observation of manta movements in Nusa Penida (Bali) to the east, and the movement westward from mantas in Komodo, show that they can expected to go through one of the largest manta fishing grounds in Indonesia, namely Tanjung Luar, South Lombok, located between Nusa Penida and Komodo.

3.2. Manta rays in the study areas

According to the above findings, manta rays are found in the waters of the study areas throughout the year but easily found at certain periods when 90% of tourists have the opportunity to see this fish. This condition makes the waters of the study locations very unique and interesting to visit. In Nusa Penida, there are two manta points in the southern part of the island, including Manta Bay and Manta Point. Komodo has three popular manta spots including Karang Makassar, Manta Alley, and Mawan, while Raja Ampat offers a number of snorkelling and diving sites to view manta ray including Manta Ridge, Manta Sandy, Eagle Rock, Wayag Lagoon, Blue magic, and Magic mountain. The study locations each have a different conservation status with respect to biodiversity protection.

| MPAs            | Manta ray tourism hotspots | Conservation status                                                                 | Species       |
|-----------------|----------------------------|-------------------------------------------------------------------------------------|---------------|
| Komodo          | Karang Makassar             | 1977: Man & biosphere reserve                                                      | M. alfredi    |
| 173,300ha       | Manta alley                | 1980: National park                                                                 | M. birostris  |
|                 | Mawan                      | 1991: World heritage UNESCO                                                        |               |
|                 |                            | 2000: MPAs                                                                          |               |
|                 |                            | 2011: Seven wonders of the world                                                    |               |
|                 |                            | 2014: Shark and ray sanctuaries                                                     |               |
| Nusa Penida     | Manta point                | 2014: MPAs                                                                          | M. alfredi    |
| 1,419ha         | Manta bay                  |                                                                                     |               |
| Raja Ampat      | Manta Ridge, Manta Sandy   | 1993: MPAs                                                                          | M. alfredi    |
| 1,358,170ha     | Eagle Rock, Wayag Lagoon,  | 2007: KKPD Ayau Asia 101.440ha                                                      | M. birostris  |
|                 | Blue magic, Magic mountain | 2007: KKPD Kofiau 170,000ha                                                         |               |
|                 |                            | 2008: KKPD Mayalibit 53,100ha                                                       |               |
|                 |                            | 2009: KKPN Waigeo Barat 271.630ha                                                    |               |
|                 |                            | 2009: KKPD Selat Dampier 336,000ha                                                   |               |
|                 |                            | 2009: KKPD Misool 366,000ha                                                         |               |
|                 |                            | 2014: KKPN Raja Ampat 60,000ha                                                      |               |
|                 |                            | 2012: Shark and ray sanctuaries                                                     |               |

In 2010, Indonesia adopted the National Plan of Action for Conservation and Management of Sharks and Rays 2010—2014 as guidance and a documented commitment to implement sustainable management of sharks and rays in Indonesia. In alignment with policy at the national level, initiatives to protect the species at the regency level are also on the rise. Shark and ray protection and sustainable management policies are being formulated and implemented in several regions in Indonesia, mainly in areas where marine tourism is flourishing as a top tourist attraction, and plays an important role in
maintaining a healthy ecosystem. Pioneered in 2010, the Raja Ampat Regent (Bupati) enacted a decree to establish Raja Ampat waters as a shark and ray sanctuary, the first of its kind in the Coral Triangle. In 2012, the decree was then upgraded to Raja Ampat Regency Regulation (Perda) Number 9 of 2012, leaving no loop-holes in the law. Following this, in 2013 the Bupati of Manggarai Barat formulated a similar decree addressing the protection of whale sharks and manta rays in Manggarai Barat Regency. Furthermore, in 2014 the Indonesian government declared full protection for both manta ray species and declared the entire Archipelago as a Manta Ray Sanctuary to support conservation and development of sustainable manta ray watching tourism.

3.3. Manta ray watching tourism

Tourist volumes are increasing every year in Nusa Penida, Komodo, and Raja Ampat (Table 3). According to [18], approximately 70% of all tourists visiting Komodo view manta rays. This number was confirmed by the dive operators in Labuan Bajo, who stated that their trip packages included manta ray watching, komodo viewing, and trekking. The best season to dive or snorkel with manta rays varied between study locations but manta rays can be found year round. The estimated average sightings of 1-10 rays applied for diving and snorkelling, viewing from a speed boat, fisherman's boat, or a live-aboard. The user fee system also varied between study areas from IDR50,000 to IDR1,000,000. The involvement of local community members ranged from boat rental, equipment rental, making or selling manta ray souvenirs, providing accommodation, working as employees in tourism, and diving businesses.

| Parameter                          | Raja Ampat       | Komodo             | Nusa Penida        |
|-----------------------------------|------------------|--------------------|--------------------|
| Main season                       | October to May   | March to December  | August to October  |
| Boat type and capacity (to manta spot) | Speed boat, live-aboard (2-10pax) | speed boat, live-aboard (2-20pax) | Fishermen boat, speed boat (2-10pax) |
| Encounter activities              | Diving, snorkelling | Diving, snorkelling, viewing from boat | Diving, snorkelling |
| Average number of manta sightings | 1-10 rays        | 1-10 rays          | 1-5 rays           |
| User fee (IDR)                    | 500,000-1,000,000 | 10,000-250,000     | 10,00-50,000       |
| Community engagement              | Kader manta, homestay, dive operator, souvenir (manta ray handicraft and accessories), tourism employee | Boat rental, souvenir (manta ray pendant), tourism employee | Boat & snorkelling rental, tourism employee |

3.4. Nusa Penida

To reach Nusa Penida, the trip starts from Sanur by a fast boat costing around $35 USD return including pickup and drop-off from around Kuta, Seminyak, Ubud or Canggu areas. The boat trip itself takes twenty-five minutes from Sanur to Lembongan. On arrival in Lembongan, there are many accommodation options, from homestays to luxury hotels. The local homestays cost $10 a night for
basic facilities (a private room with a bathroom) while beach resorts with more facilities cost a minimum of $50 a night. Dive shops also offer different packages to explore Nusa Penida, including manta ray viewing snorkeling tours for about $20 with a fishermen's group. Another alternative is to join a live-aboard trip that includes meals, drinks, snorkeling/diving gear, accommodation, and guide.

3.5. Komodo
The journey to Komodo starts with a flight from Denpasar, Jakarta, or Kupang to Labuan Bajo ($75 to $200 return) or a bus from Lombok or Bima ($20-$50). For accommodation, there several live-aboards as well as local homestays and hotels with resident dive shops ($10-$100). The one day trips to Komodo or live-aboard trips cost $100-$3000 depending on the facilities/services and the number of days, including the boat, accommodation, food, drinks, snorkeling/diving, and island hopping. The Manta alley site is relatively shallow; whereas Karang Makassar is great for manta ray viewing from a boat, on the other hand Mawan is the combination of two sites. The best time to visit Komodo is from March to December. A number of local organizations including World Wildlife Foundation, Manta Watch, and Dock community group work with the National Park Agency to implement a number of best practices for manta ray watching tourism in terms of carrying capacity, capacity building, monitoring strategy, provision of mooring buoys, and a code of conduct, while involving tourists in citizen science. The goal of this collaborative management is to raise awareness and improve management strategies for sustainable development of manta ray watching tourism.

3.6. Raja Ampat
Getting to Raja Ampat is quite a long journey. After getting to Sorong by plane from Jakarta (4hrs) and transfer to the harbour, a fast boat to Waisai takes 2 hrs with another hour to two of inter-island transfer to reach Manta Sandy, a popular manta ray viewing dive site. Manta sandy is located in Dampier strait between Arborek island and Mansuar island; a white sandy bottom with a small bommies, it is a cleaning station for manta rays. A code of conduct for divers and snorkelers includes a demarcation code to keep some diver-free space for manta rays. This involves 16m rocks set in a line that serve as a marker for viewing mantas and taking pictures while the visitors hold on to their hooks to fight against the currents. Furthermore, a ranger station was established in Manta Sandy in 2017, so every operator has to report beforehand. The Rangers are responsible for ensuring that every diver/snorkeler has their marine parks tags, monitoring tourist volume based on carrying capacity and boat traffic, enforcing the code of conduct for manta ray interaction, designating entry/exit points of boats with divers/snorkelers, and managing reservations (it is mandatory for every operator to make reservations one day before they visit Manta Sandy). Any violation including disturbing behaviour (touching, chasing, feeding mantas), trespassing, etc. will result in sanctions. This ranger station is part of collaborative management between all stakeholders in Raja Ampat, including Conservation International, Marine Mega Fauna, Raja Ampat Biodiversity, Raja Ampat Divers, Papua Divers, Raja Ampat Liveaboard association, Local Government and villagers to achieve sustainable management of manta ray watching tourism.

4. Discussion and Conclusion

4.1. Discussion
The term sustainable tourism as used by the World Tourism Organization is “envisioned as leading to the management of all resources in such a way that economic, social and aesthetic needs can be fulfilled while maintaining cultural integrity, essential ecological processes, biodiversity, and life support systems” [19]. This definition refers to the suitable balance between environmental, economic and socio-cultural aspects of tourism development with regards to long-term sustainability. The concept of biodiversity is relevant when sustainable tourism affects the landscape, ecosystem, social and/or cultural processes where in this study manta ray as the charismatic species is the main tourism object. Charismatic species of marine wildlife become a driver for economic growth through marine
wildlife tourism [14, 15]. Visitors want to experience seeing these animals. For this reason, conserving marine species provides benefits from non-consumptive uses, but also from the value of the ecosystem services provided by the species. Wildlife viewing has been considered as a form of tourism based on the principles of making an active contribution to the conservation of natural and cultural heritage [20], emphasizing local participation in its planning and operation, so that it contributes to their wellbeing and empowers them in interpreting natural and cultural heritage to visitors. Significant economic generation from wildlife viewing, especially for remote island communities, has also been highlighted [21].

Manta ray tourism stakeholders in the study areas have recognized the importance of implementing sustainable tourism development, however, according to [22], it is always a challenge when it comes to facing the economic, social, and physical issues that pose great hindrances to sustainable development. In the implementation of manta ray watching tourism in Nusa Penida, foreign companies typically dominate the tourism industry and design tourism development to specifically meet the interests of the tourists they seek to attract to their business. There is a marginalization of local companies and investors; leakages and repatriation of tourism revenue; a failure of tourism to promote coastal development and poverty alleviation; and, all too often, a failure to observe local environmental regulations to conserve the related areas as a natural ecosystem” [23]. Up to this time, there is only one locally-owned dive operator in Nusa Lembongan. It has been argued by [24] that the implementation of sustainable tourism requires co-management in tourism planning, wherein Komodo and Raja Ampat show coordination between a number of stakeholders that have initiated management strategies for manta ray watching tourism, in terms of enforcement, monitoring, education, and provision of facilities, that have been implemented by both public and private sectors.

The above review illustrates a number of challenges that have to be taken into account to attain sustainability in manta ray watching tourism. Ecotourism has been suggested [25] as a potentially effective model to achieve sustainable development in any form of tourism which integrates the economic, environmental, and socio-cultural aspects. The planning and decision-making process should require active involvement of local residents to achieve a balance between conservation and welfare [26]. Furthermore, [27] emphasizes that the existence of committed institutions and individuals supported by effective policies and strategies are essential in order to maintain the balance between local communities, charismatic species, and cultural values.

4.2. Conclusion
The role of government plays a significant role in obligating private operators to implement wildlife watching codes of practice [28]. In addition, marine wildlife tourism offers an educational experience, encouraging awareness, knowledge, and appropriate attitudes regarding marine species and their environment, as well creating an incentive for conservation to minimize human impacts [16, 28, 29]. Recreational activities including manta ray watching tourism within the study locations are compatible with codes of conducts, utilization under the zonation system, education/interpretation programs, partnership establishment, permits, regulations, monitoring, and applied research [4, 30]. Human-animal interactions identified by [31] are mainly offered in MPAs and have been run since early 1990; they can be considered as environmental friendly tourism because they provide multiple benefits.

Based on this literature review, there are a number of further studies that will be conducted to support the sustainability of manta ray watching tourism in Eastern Indonesia, including:

- Behaviour analysis of manta ray tourists in Eastern Indonesia
- Tourist trends in manta ray watching tourism: Implications for visitor management in Manta Sandy - Raja Ampat, West Papua
- Utilization of citizen science for manta ray monitoring: A case study in Manta Sandy - Raja Ampat, West Papua
- The economic benefits of manta ray watching tourism: The impacts to local community welfare in Dampier Strait – Raja Ampat, West Papua - Indonesia
References
[1] White W T, Corrigan S, Yang L, Henderson A C et al 2018 Phylogeny of the manta and devilrays (Chondrichthyes: mobulidae), with an updated taxonomic arrangement for the family Zool. J. Linn. Soc. 182 50-75
[2] Deakos M H 2010 Ecology and Social Behavior of A Resident Manta Ray (Manta alfredi) Population off Maui, Hawaii (University of Hawaii)
[3] Marshall A D, Pierce S J and Bennett M B 2009 Morphological measurements of manta rays (Manta birostris) with a description of a foetus from the east coast of Southern Africa Zootaxa 30 24-30
[4] Notarbartolo-di-Sciara G, Serena F and Mancusi C 2006 Mobula mobular (IUCN Red List of Threatened Species, http://www.iucnredlist.org/apps/redlist/details/39418/0)
[5] Couturier L I, Marshall A D, Jaine F R, Kashiwagi T et al 2012 Biology, ecology and conservation of the Mobulidae J. Fish. Biol. 80 1075-1119
[6] Croll D A, Dewar H, Dulvy N K, Fernando D et al 2016 Vulnerabilities and fisheries impacts: The uncer- tain future of manta and devil rays Aquat. Conserv. 26 562-575
[7] Reynolds P C and Braithwaite D 2001 Towards conceptual framework for wildlife tourism Tourism Manage. 22 31-42
[8] O’Malley M P, Lee-Brooks K and Medd H B 2013 The global economic impact of manta ray watching tourism PlosOne 8 e65051
[9] Anderson R C, Adam M S, Kitchen-Wheeler A M and Stevens G 2011 Extent and economic value of manta ray watching tourism in the Maldives Tour. Mar. Env. 7 15-27
[10] Venables S, Winstanley G, Bowles L and Marshall 2016 A giant opportunity: the economic impact of manta rays on the mozambican tourism industry – an incentive for increased management and protection Tour. Mar. Env. 12 51-68
[11] Needham M D, Brian W S, Mora C, Lesar L and Anders E 2017 Manta ray tourism: interpersonal and social values conflicts, sanctions, and management J. Sustain. Tour. 25 1367-1384
[12] Kessel S T, Elamin N A, Yurkowskij D J, Chekkchak T et al 2017 Conservation of reef manta rays (Manta alfredi) in a UNESCO World Heritage Site: large-scale island development or sustainable tourism? PlosOne 12 e0185419
[13] Atkins R 2012 Manta ray (Manta alfredi) tourism in Baa Atoll, Republic of Maldives: human interactions, behavioural impacts and management implications (Master Thesis Marine Environmental management: University of York)
[14] Krüger O 2005 The role of ecotourism in conservation: panacea or Pandora’s box? Biodivers. Conserv. 14 579-600
[15] Gallagher A J, Lazarre D M and Hammerschlag N 2011 Global shark currency: the distribution, frequency, and economic value of shark ecotourism Curr. Issues. Tour. 14 797-812
[16] Lück M 2003 Education on marine mammal tours as agent for conservation – but do tourists want to be educated? Ocean. Coast. Manage. 46 943–956
[17] Germanov E S and Marshall A D 2014 Running the Gauntlet: Regional Movement Patterns of Manta alfredi through a Complex of Parks and Fisheries PlosOne 9 e110071
[18] Prabuning D, Setiasih N, Priyantoro A and Harvey A 2015 Management alternative of shark and manta tourism: A case study of economic valuation. Symposium Hiu dan Pari di Indonesia
[19] World Tourism Organization 2004 Sustainable Development of Tourism Conceptual Definition (http://www.world-tourism.org/sustainable/concepts.htm)
[20] Cater C and Cater E 2007 Marine Ecotourism: Between the Devil and the Deep Blue Sea (Wallingford, UK: CAB International)
[21] Orams M 2013 Economic activity derived from whale-based tourism in Vava'u, Tonga Coast. Manage. 41 481-500
[22] Teh L and Cabanban A S 2006 Planning for sustainable tourism in southern Pulau Banggi: An assessment of biophysical conditions and their implications for future tourism development. *J. Environ. Manage.* **85** 999-1008

[23] Mbaiwa J E 2005 The problems and prospects of sustainable tourism development in Okavango Delta, Botswana *J. Sustain. Tour.* **13** 203-227

[24] Moscardo G 2005 Peripheral tourism development: Challenges, issues and successful factors *Tour. Recr. Res.* **30** 27-43

[25] Wood M E 2002 *Ecotourism: Principles, practices and policies for sustainability* (Paris: United Nations Environmental Program)

[26] Blackman A, Foster F, Hyvonen T, Kuilboer A and Moscardo G 2004 Factors contributing to successful tourism development in peripheral regions *J. Tour. Stud.* **15** 59-70

[27] Dowling R K and Fennell D A 2003 *Ecotourism Policy and Planning* (New York: CABI Publishing)

[28] Lück M 2007 *Marine Wildlife and Tourism Management* (India: Pondicherry)

[29] Lien J 2000 *The Conservation Basis for the Regulation of Whale Watching in Canada by the Department of Fisheries and Oceans: A Precautionary Approach* (Newfoundland, Canada: Department of Fisheries and Oceans)

[30] NOAA 2014 *Hawaiian Islands Humpback Whale Marine Sanctuary: Resource Protection*. (http://hawaiihumpbackwhale.noaa.gov/res/regulations.html)

[31] Orams M 1999 *Marine Tourism Development, Impacts and Management* (London: Routledge)