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ECONOMIC VALUE AND PUBLIC PERCEPTIONS OF WHALE SHARK TOURISM IN NOSY BE, MADAGASCAR

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Nosy Be in northwestern Madagascar is home to a globally important whale shark (*Rhincodon typus*) aggregation and a growing whale shark tourism industry. However, whale sharks are not protected in Malagasy waters and are threatened by fisheries bycatch, collisions with vessels, and disturbance from tourism. We used tourist questionnaires (n = 488) to assess the economic value of, and tourist perceptions of, whale shark tourism in Nosy Be from September to December 2019. We also surveyed whale shark tour operators (n = 12) in December 2018 to understand their perceptions of tourism management needs in the region. Results suggest the Nosy Be whale shark tourism industry was worth US$1.5 million for the 3-month 2019 whale shark season. "Dedicated" whale shark divers (i.e., those who came specifically to Nosy Be to swim with whale sharks) spent 55% more money overall and six times the amount individually compared to "casual" whale shark divers. Both tourists and operators supported the protection of whale sharks, with the majority (88.9%) of tourists agreeing that they would choose a tourism destination at which whale sharks are protected. However, tour operators did note significant management issues (e.g., overcrowding, lack of regulations/training), recommending the need to better regulate whale shark tourism and interactions. This study emphasizes the economic rationale for protecting whale sharks in Madagascar to safeguard the emerging marine tourism industry and ensure it is being sustainably managed.

Key words: Marine wildlife tourism; Endangered species; Tourism management; Marine conservation; Economic valuation

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Introduction

Madagascar, the world's fourth largest island, is a global biodiversity hotspot with over 90% endemicity among its terrestrial species (Ganzhorn et al., 2001; Mittermeier et al., 2005). Although the country's marine biodiversity is often overlooked in such statistics, due to the lower level of endemism relative to terrestrial species (Harris, 2011), a diverse assemblage of large marine vertebrates is also present in national waters. In northwestern Madagascar, which is a recognized Key Biodiversity Area for marine life (Obura et al., 2012), such species include marine mammals (Cerchio et al., 2015; Kiszka, 2015; Rosenbaum, 2003), sea turtles (Bourjea et al., 2008), and elasmobranchs (Kiszka & van der Elst, 2015). The latter group includes the world's largest fish, the whale shark (*Rhincodon typus*; Jonahson & Harding, 2007).

The area close to the island of Nosy Be in northwestern Madagascar (see Fig. 1) represents an important seasonal foraging habitat for one of the largest-known aggregations of whale sharks in the Indian Ocean, with over 400 individual sharks identified to date (Diamant et al., in press). Whale sharks are listed as Endangered on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species due to human-induced population declines, in particular fisheries bycatch, but with other persistent threats such as collisions with vessels and disturbance from tourism (Pierce & Norman, 2016). The threat to this species is further highlighted by its listing on Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which regulates commercial trade to and from signatory states, and Appendix I of the Convention on the Conservation of Migratory Species of Wild

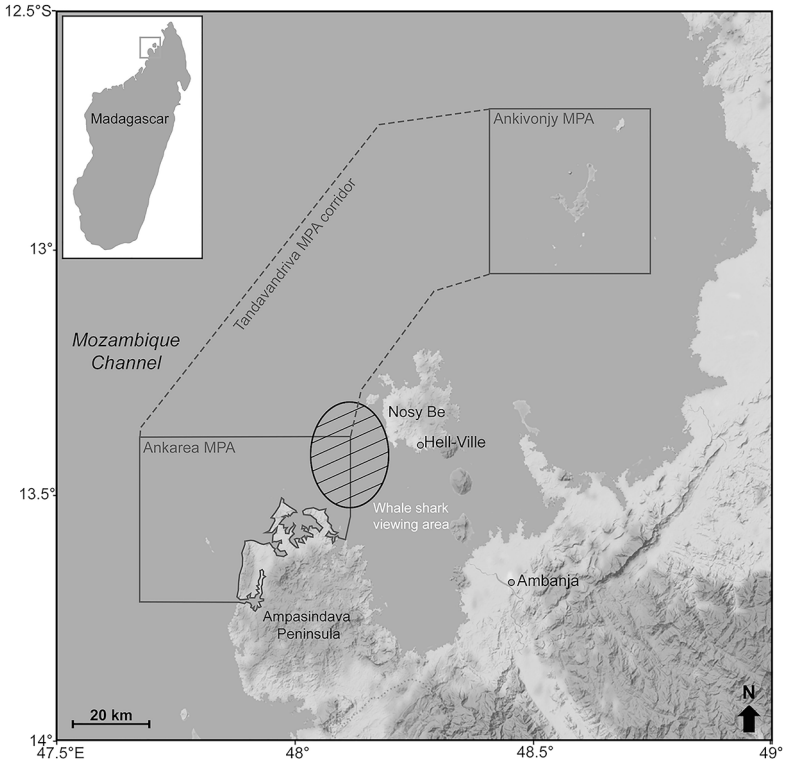

Figure 1. Map of the study area in northwestern Madagascar, showing the location of the island of Nosy Be, the boundaries of the existing Ankarea and Ankivonjy Marine Protected Areas (solid lines), the proposed boundaries of the Tandavandriva Marine Protected Area corridor that will link the two existing MPAs (dashed lines), and the whale shark viewing area (shaded polygon).

Animals (CMS), which emphasizes the need for effective protection within and between signatory states. However, though Madagascar is a signatory to CMS, whale sharks have not yet been protected; in fact, no shark or ray species are currently protected in the country (Humber et al., 2015).

Whale sharks' large size, placid nature, predictable presence, accessibility, and growing popularity as charismatic megafauna have made "swim-with" whale shark tourism activities one of the fastest-growing sectors of the marine wildlife tourism sector overall (Dearden et al., 2008; Gallagher & Hammerschlag, 2011). Globally, whale shark tourism occurs at 35 sites, attracting an estimated 980,000 participants annually, and was worth over US$139 million in 2019 (Ziegler & Dearden, 2021). The direct use value from tourism can bring significant economic returns to the communities that host these activities (Ziegler & Dearden, 2021). Moreover, working in wildlife tourism can improve community attitudes toward conservation (Ziegler et al., 2020, 2021).

Tourism is a major source of income for the Malagasy economy—worth nearly a fifth of the nation's gross domestic product in 2018—and is viewed as an important incentive for increased protection for endangered species in the country (Jones et al., 2019). Nosy Be is considered Madagascar's main flagship destination domestically, and the major tourism hub for the country (Rafidiarisoa, 2020), attracting nearly 100,000 tourists in 2019. Tourism to Nosy Be has risen dramatically in recent years following the opening of an international airport and the addition of the fast-growing international carrier Ethiopian Airlines in 2018 (Liu, 2018). The government is planning to increase the capacity of the airport in Nosy Be to accommodate up to 500,000 tourists per year (Emerging Africa Infrastructure Fund [EAIF], n.d.). However, no economic data are available on marine wildlife tourism from Nosy Be or elsewhere in Madagascar. As the Nosy Be area hosts an important seasonal whale shark aggregation during peak tourism season, and a growing whale shark tourism industry (Diamant et al., in press), this study aimed to: (1) quantify the economic value of the industry, (2) determine the importance of the sharks' presence to the tourists and tourism industry, and (3) identify the perceived management issues and needs at this site.

Methodology

Study Site

Nosy Be is an island on the northwest coast of Madagascar (Fig. 1). Dedicated whale shark tourism operations started in 2011 and have since grown to an estimated 8,000 tourists participating in tours from Nosy Be in 2018 (Ziegler & Dearden, 2021). Although only two operators solely dedicate their activities to swimming with whale sharks during the peak season between September and December, most scuba diving centers also offer this activity as part of their diving package, allowing their customers to swim with whale sharks between dives. As of 2019, there were ~20 dive operators based in Nosy Be, mainly owned by French or Italian nationals employing a mix of Malagasy and European seasonal tour guides and Malagasy boat captains. An unknown number of unofficial local operators, working opportunistically on a day-to-day basis, also host whale shark trips during the peak tourism season (October–November) when they can access boats.

Whale shark tours in Nosy Be are exclusively "swim-with" snorkel experiences, although scuba diving with whale sharks is not actually banned as it is in most other whale shark sites globally (Ziegler & Dearden, 2021). Tourists pay an average of US$60–70 per person for their whale shark tour. Dedicated whale shark tours start with a safety briefing and then spend approximately 4 hr searching for and swimming with whale sharks if found. Once a whale shark is sighted, almost always at the surface associated with "bait balls" of small fish and seabirds (Diamant et al., 2018), the guide enters the water followed by up to 10 tourists. A shorter period of searching and swimming is offered to scuba divers during their interval between dives.

A voluntary code of conduct was introduced in 2017, based on the Marine Megafauna Foundation's guidelines from Mozambique (from Haskell et al., 2015; Pierce et al., 2010), to codify interactions between whale sharks, boats, and swimmers, and thereby reduce tourism impacts on the whale sharks. The operational code of conduct broadly covers international best-practice standards for whale shark tourism (outlined in Ziegler & Dearden, 2021).

Tourist Survey

A self-administered questionnaire was used as the primary data collection method. The questionnaire consisted of 19 mainly closed-ended questions regarding the tourists' experience with the whale shark tour, the importance of whale sharks in their decision to visit Nosy Be, their expenditure during their visit to Nosy Be, and demographic data (see Appendix A). Respondents were also asked if they would be more likely to choose a destination where whale sharks are protected, and whether they believe whale sharks should be protected, using a 5-point Likert scale ranging from 1 "*strongly disagree*" to 5 "*strongly agree*." The survey questions were trialed in 2018, after which the survey was shortened to increase the completion rate. The 2019 survey focused on questions pertaining to the economic value of the industry and the importance of whale shark presence at Nosy Be for the tourists that joined a tour. Questions were added to identify "dedicated" whale shark divers based on Huveneers et al. (2017) (see Analysis section), and instructions for completing the economic valuation section were modified to maximize clarity. Surveys were provided in either French or English for the multilingual audience. Data collection occurred over a 3-month period from October to December 2019.

Two main approaches were used to collect survey data: on site and online. On site, tourists were selected opportunistically as they returned to the dive shops after the tour and invited to participate. Willing respondents were given a laminated survey sheet that they completed on their own. A team member then entered that information into a tablet using KoBo Toolbox software (Harvard Humanitarian Initiative, USA). An online survey was also created and e-mail sign-up sheets were displayed at various dive shops in Nosy Be. These respondents were then contacted and asked to complete the online survey. A total of 488 surveys (~10% online and ~90% on site) were collected with a 70% response rate. The literature suggests a response rate of 60% can be considered sufficient in accurately representing the population being sampled (Dolsen & Machlis, 1991), while 70% is considered very good (Babbie, 2007). Survey data were input in SPSS 25 for analysis (IBM, USA).

No previous information was available on whale shark tourist demographics for the site to compare against our results. Therefore, it was not possible to determine if the sociodemographics of our sample match those for the wider whale shark tourist population in Nosy Be. However, our 488 surveys represent a 4% sampling error at the 95% confidence level based on the estimated total number of whale shark tourism participants: 8,000 (Ziegler & Dearden, 2021).

Tour Operator Survey

Twelve whale shark tour operators in Nosy Be participated in an online questionnaire in December 2018 to better understand their perceptions of management issues in the area and their thoughts on whale shark conservation needs in Madagascar (see Appendix B). This information was first translated into English by the lead author and then input into NViVO 10 (QSR International, USA) for thematic analysis using a qualitative approach. The lead author performed an initial round of exploratory coding for each of the two open-ended questions regarding whale shark conservation and tourism management using in vivo coding (Saldaña, 2016). These in vivo codes were grouped into categories using descriptive coding (e.g., too many people, poor operator training, etc.) during a second round of coding and themes were then identified (e.g., overcrowding, better regulate the interactions) (Saldaña, 2016).

Analysis

The economic value of the industry was estimated using a series of questions regarding respondents' expenditures in Nosy Be following the approach outlined by Catlin et al. (2010) and Huveneers et al. (2017). Categories included the cost of the whale shark tour (i.e., ticket cost and any equipment rental fees), other tours and activities, accommodation, food and beverages, souvenirs and other retail purchases, and domestic travel (e.g., taxis). International or domestic flight information was not included, as these are usually purchased elsewhere. Respondents were also asked how many people were included in the values provided, the number of days they planned to spend in Nosy Be,

and the currency used. All values were converted to USD per person.

Huveneers et al. (2017) used the concept of a "dedicated shark diver" to estimate the value of the shark tourism industry in Australia by including additional expenditures on site only if the respondent stated they came to the site specifically to dive with the sharks. In the current study, two questions were used to define "dedicated whale shark divers" to cross-validate the results—the importance of whale sharks in their decision to visit Nosy Be (possible answers: not at all important, slightly important, important, very important, extremely important) and the main reason for visiting Nosy Be (possible answers: general diving, mainly whale sharks, only whale sharks, mainly marine wildlife, only marine wildlife, diving and sightseeing, beach holiday, other). A "dedicated whale shark diver" was defined as someone who stated that whale sharks were an "extremely important" reason in their decision to visit Nosy Be and that the main reason for visiting Nosy Be was "mainly" or "only" to see whale sharks. The total value of the whale shark tourism industry in Nosy Be was calculated as follows:

> Value for dedicated whale shark divers = (mean expenditures in Nosy Be per person) × proportion of population dedicated whale shark divers × 8,000 visitors

> Value for casual whale shark divers = (mean whale shark tour expenditure per person) × proportion of population casual whale shark divers × 8,000 visitors

The total value of the whale shark tourism industry to Nosy Be was estimated by summing the values for the two groups.

Results

Survey Results

The Whale Shark Tourist. Respondents were mainly young (18–35: 53.5%), European (92.0%), female (63.2%), with a university degree (86.8%), and an income of US$22,001–50,000 (52.7%) (see Table 1), spending a median number of 7 days in Nosy Be. Most respondents were aware that Nosy Be was an important area for whale sharks prior to their arrival (n = 366, 75.2%), with 40.7% (n = 188) stating that whale sharks were the main or only reason for visiting Nosy Be and 28.3% (n = 138) stating that whale sharks were an extremely important reason in their decision to visit Nosy Be. A fifth of respondents (20.5%) were classified as "dedicated whale shark divers" (i.e., respondents stated whale sharks were their main or only reason for visiting Nosy Be, and that whale sharks were an extremely important reason in their decision to visit Nosy Be).

Table 1
Sociodemographics of Survey Respondents of a Whale Shark Tourism Questionnaire in Nosy Be, Madagascar, in 2019 (n = 488 Respondents)

Respondent Demographics	% Response
Gender	
Male	34.8%
Female	63.2%
Age	
18–25	12.4%
26–35	41.1%
36–45	19.3%
46–55	13.6%
56–65	9.6%
>65	4.0%
Education	
Primary school	0.6%
High school	4.8%
College/university	35.4%
Advanced degree	51.4%
Trade or apprenticeship	5.5%
Annual income (in US$)[a]	
<2,200	7.5%
2,200–22,000	15.9%
22,001–55,000	52.7%
55,001–88,000	17.4%
>88,000	6.5%
Tourist origin	
Europe	92.0%
North America	5.1%
Other	2.9%

Note. [a]Annual income values were converted from Euros to US$ for the purposes of this table using the historical conversion rate for October 2019 of 1 Euro: 1.1 US$.

Whale Shark Experience. The top three species/species groups respondents wanted to see in Nosy Be were, in descending order, whale sharks, rays (mainly manta rays, *Mobula* spp.), and whales (particularly humpback whales,

Table 2
Proportions of Respondents Who Saw and Swam With "Other" Marine Wildlife During Whale Shark Tour in Nosy Be, Madagascar (n = 488 Respondents)

	Total [n (%)]
Saw other marine life during the tour	
No	8 (1.6%)
Yes	479 (98.4%)
Sea turtle	451 (94.2%)
Manta/Mobula/Ray*	213 (44.5%)
Dolphin	203 (42.4%)
Whale	121 (25.3%)
Other	13 (2.7%)
Shark (other than whale shark)	5 (1.0%)
Swam with other marine life during tour	
No	44 (9.1%)
Yes	437 (90.9%)
Sea turtle	406 (92.9%)
Manta/Mobula/Ray*	151 (34.6%)
Dolphin	120 (27.5%)
Whale	19 (4.3%)
Other	1 (0.2%)
Shark (other than whale shark)	2 (0.2%)

Note. *All ray species were grouped together as tourists may have difficulty identifying the type of ray they saw (e.g., identified as manta ray when they actually saw a devil ray).

Megaptera novaeangliae). Overall, respondents were very satisfied with their whale shark experience, with 64.1% stating it was "much better than expected" and only 0.8% saying it was "worse than expected" (mean = 4.5, SD = 0.81). None rated it "much worse than expected." Respondents were also very satisfied with the number of other marine wildlife seen during their whale shark experience in Nosy Be (mean = 4.2, SD = 1.21), although 11.9% of respondents noted they were "somewhat" or "very dissatisfied." The vast majority of respondents saw and/or swam with other marine wildlife during their whale shark tour, mainly sea turtles (Table 2).

The vast majority of respondents strongly agreed that they were more likely to choose a destination if whale sharks were protected (88.9%, mean = 4.4, SD = 1.03), while 86.9% strongly agreed that whale sharks should be protected (mean = 4.7, SD = 1.00).

Estimated Value of Whale Shark Tourism. The economic value of the whale shark tourism industry in Nosy Be was estimated using mean expenditures

Table 3
Total Numbers of Tourists and Mean (± SE) Expenditure per Person for Dedicated and Casual Whale Shark Divers in Nosy Be, Madagascar (All Values in US$) Based on 379 Surveys

		Mean Expenditure per Person (± SE)						
	No. of Tourists	Whale Shark Tour	Lodging	Meals/Drinks	Other Activities	Souvenirs	Transport	Total Mean Expenditure
Dedicated whale shark diver	1,600	\$126 ± 23	\$186 ± 23	\$44 ± 4	\$109 ± 19	\$13 ± 2	\$69 ± 11	\$547 ± 54
Casual whale shark diver	6,400	\$92 ± 4	–	–	–	–	–	\$92 ± 4

Note. Number of tourists in each category was calculated based on the estimated number of tourists participating in the whale shark tour in 2018 (n = 8,000) and the proportion of "dedicated" and "casual" whale shark divers participating in whale shark tourism in Nosy Be based on the tourist survey (i.e., 20.5% "dedicated" whale shark diver, 79.5% "casual" whale shark diver). A "dedicated" whale shark diver was defined as someone who stated that whale sharks were an "extremely important" reason in their decision to visit Nosy Be and that the main reason for visiting Nosy Be was "mainly" or "only" to see whale sharks. SE = standard error.

per person for both "dedicated" and "casual" whale shark divers (Table 3). The estimated value of the whale shark tourism industry in Nosy Be was US$1.5 million for the 3-month 2019 season. "Dedicated" whale shark divers spent 55% more money overall (US$901,274) and six times the amount individually (mean expenditures per person: US$547) compared to "casual" whale shark divers (mean expenditures per person: US$92; overall estimated expenditures: US$581,239).

Operator Interviews

When tour operators (n = 12) were asked what they perceived to be the main management issues for whale shark tourism at this site, the key themes that emerged were poor operator training/management (n = 7), overcrowding (n = 4), and negative impacts on the sharks (n = 1) (Table 4). One respondent noted no problems with whale shark tourism, while another said "I don't know." When the operators were asked how they would improve respect for whale sharks on the water, the focus was on better regulating the whale shark interactions (n = 7; Table 4). Suggestions included limiting the number of people and/or boats per shark (n = 3), limiting the number of in-water interactions per boat (n = 1), maintaining training and adherence to the voluntary code of conduct (n = 3), implementing a coercive system to punish those harassing the sharks or implementing a law that would control such activities (n = 2), and controlling fishing activities around the sharks (n = 1). Three respondents had no suggestions, while another "[left] it to the professionals to find solutions: the diving centers already have their own code . . . 'common sense.'"

Overwhelmingly, the tour operators supported protecting whale sharks in Madagascar (n = 11) and highlighted the potential to improve the regulation of whale shark tourism activities, as well as to ban the capture and killing of whale sharks, whether accidental or not (Table 5). One respondent was concerned that protecting whale sharks via legislation may help the informal operators to the detriment of recognized operators.

Table 4
Thematic Analysis of Tour Operator Perceptions of Whale Shark Tourism Management Issues and Needs in Nosy Be, Madagascar, Based on a Dedicated Survey of Tour Operators (n = 12)

Themes/Categories	Respondent Sample Quotes
Overcrowding	
Too many people	"Poor management due to the increase in tourist numbers"
Too many boats	"Too many boats around the sharks"
Need for improved management	
Poor operator training	"Lack of respect of the code of conduct, lack of knowledge of the animal on the part of operators"
	"The tourists and the guides, whether formal or not, who do not respect the approach protocol"
Lack of respect for wildlife	"There are too many people who do not know how to respect the ocean and its rules, as well as the whale sharks"
Impacts on sharks	
Altering shark behavior	"Irresponsible behavior linked to mass tourism makes the sharks more nervous"
Better regulate the interactions	
Coercive/legal sanctions	"Put in place a coercive system for the nonrespect of the animal and the clients, put in place a similar law to the one already in place for in-water interactions with whales"
	"Fine those who do not respect the code of conduct"
Limit number of in-water interactions per boat	"It's not easy because it's normal that we all want our clients to take part, but maybe if there is only one shark, they could ban in-water interactions but I think that's impossible. Or just one in-water interaction per boat. Limiting the number of in-water interactions, I don't know if the clients will agree to that."
Limit the number of people/boats	"Limit the number of boats and people per whale shark"
Use code of conduct	"The work done with the [voluntary] code of conduct is a good solution"

Table 5
Thematic Analysis of Tour Operator Perceptions of the Importance of Protecting Whale Sharks at the National Level in Madagascar (n = 12)

Theme/Category	Respondent Sample Quotes
Legal	
Create laws regulating whale shark tourism and fisheries	"Obviously [we should protect whale sharks], it would allow the legislating of whale shark tourism activities, as well as fisheries (accidental or not), especially with respect to potential [foreign] fishing agreements[s]"
	"Absolutely, [whale shark tourism] is the future of the island, but it needs to be managed properly"
Safety concerns	"We have to regulate [whale shark tourism] before there's an accident that will cost Madagascar dearly, for our reputation."
Unexpected consequences	"'To protect' sometimes means 'to prohibit.' Prohibiting sometimes favors the informal tour operators to the detriment of companies that have a reputation, are well-known and can be the target of lawsuits."

Discussion

Economic Importance of Whale Shark Tourism to Nosy Be

The 3-month whale shark season in Nosy Be was worth an estimated US$1.5 million in 2019, highlighting the economic benefit that the presence of this species provides to Nosy Be. Our approach also reflects the amount of money that would be lost to Nosy Be if whale sharks were not present, as it takes into account not only the total expenditure of visitors, but also identifies the percentage of these tourists who traveled to Nosy Be specifically to swim with sharks (Catlin et al., 2010). These "dedicated" whale shark divers spent considerably more (US$901,273) in a single whale shark season than did "casual" whale shark divers (US$581,239). The value of whale shark tourism to Indo-Pacific countries varies widely, from an estimated US$100,000 in Mafia Island, Tanzania (Ziegler & Dearden, 2021), to US$9.4 million in South Ari Atoll in the Maldives (Cagua et al., 2014), and US$19 million at Ningaloo Reef in Western Australia (Huveneers et al., 2017). However, it is important to note that the approach used to assess these values differed across sites. For example, the value for Mafia Island was based on the number of tourists for the 2018 season, multiplied by the mean cost for the whale shark tour, without including other local expenditures of these tourists while on the island (Ziegler & Dearden, 2021). The corresponding value from this study was approximately US$520,000, based on an estimated 8,000 whale shark tourists and average tour cost of US$65.

An important caveat of this study is that we did not assess how much of this value is retained within the local community. Many (~90%) of the marine tourism operators and hotels in Nosy Be are foreign owned. A follow up to this study could usefully identify the percentage of the community that works in or benefits from whale shark tourism, whether directly or indirectly. As over 70% of Malagasy people live below the poverty line, and over half the population relies on natural resource extraction as a primary livelihood (Le Manach et al., 2012), alleviating poverty should be a primary focus of marine wildlife tourism activities in Madagascar (Harris, 2011; Jones et al., 2019). Beyond the obvious economic benefits of working in tourism, the industry can also contribute to positive conservation outcomes by generating community support for the protection of focal species and the wider marine environment (Ziegler et al., 2020, 2021). In Oslob, Philippines, the revenue generated from whale shark tourism activities is split between the whale shark operators, the *barangay* (village), and the municipality in which the activity occurs (J. Ziegler, unpublished data). A similar approach, in which a certain percent of ticket sales is reserved for community development projects, could be applied to Nosy Be. Future research should include a value chain analysis of the whale shark tourism industry in Nosy Be in order to address potential issues of access and economic leakages, as well

as surveying local perceptions of whale sharks and tourism activities.

Guest Perceptions of Whale Shark Tourism

Tourists were very satisfied with their whale shark tour experience overall, although our results suggest a potential problem with misleading advertising setting unrealistic expectations (Ziegler et al., 2012). Despite the fact that most respondents reported seeing (98.4%) and/or swimming with (90.9%) other marine wildlife during their whale shark tour, 11.9% of respondents were dissatisfied with the number of other marine wildlife species seen during the tour. Respondents stated they particularly wanted to see whale sharks, manta rays, and humpback whales. Part of the problem may be that tourists were unaware they were there during the off-season for humpbacks (core season July–September). Although there is no specific season to view manta rays, they are relatively rare to see in Nosy Be waters (i.e., sighted 3–4 times per season, S. Diamant, unpublished data). Advertising for these tours may be at fault if operators are promising a variety of marine wildlife during these tours, but only whale sharks are typically observed (Ziegler et al., 2012). Tour operators in Nosy Be provide pretour briefings highlighting the marine diversity in the region, including the various dolphin species, manta rays, humpback whales, and Omura's whale (*Balaenoptera omurai*) even if they are out of season or relatively rare to see at the site. Therefore, a solution may be to clarify during such briefings the seasonality of the species and likelihood of viewing a given species during that day's tour.

Management of Whale Shark Tourism

The tour operator survey highlighted management issues at the site including overcrowding, lack of regulations/training, and safety issues both for the sharks and tourists. Overcrowding is a concern at many whale shark tourism sites globally due to the growing interest in swimming with these sharks (Ziegler & Dearden, 2021). The best-managed sites have addressed these issues through upper limits on the number of operators licensed to offer whale shark tours, as well as the numbers of people and boats allowed to interact with a whale shark at one time (Ziegler & Dearden, 2021). Therefore, it is important to gain government support for the sustainable management of this industry. Currently, a local NGO (Madagascar Whale Shark Project) runs regular training workshops for local guides and tour operators to ensure familiarity with the voluntary code of conduct for in-water whale shark interactions. These efforts have led to improvements, but remain limited in reach and are not legally enforceable. A request to add the whale shark code of conduct to an existing law regulating interactions with marine megafauna was filed by local NGO Cetamada to the Ministry of Tourism, the Ministry of Environment and the Ministry of Fisheries in June 2019 and is ongoing and predicted to take effect before September 2021 (A. Saloma, personal communication, September 16, 2021). However, even legally enforceable regulations regarding swimming with marine wildlife are not followed at the site, as 28.5% ($n = 139$) of respondents in our study reported swimming with whales and/or dolphins, which is illegal in Madagascar (Arrêté Interministériel No. 2083/2000). These marine mammal regulations can be hard to follow because the tour operator cannot predict which animals will appear when their tourists are already in the water. For example, manta rays and Omura's whales sometimes feed in the same area at the same time. Therefore, the operator may let their tourists interact with the manta rays, which is legal, when an Omura's whale then shows up to feed. However, there are cases where operators will allow tourists to swim with dolphins to ensure high customer satisfaction. Further, safety is an important concern as tourists may be injured by feeding whales (e.g., Barra et al., 2020). Other initiatives supported by the Ministry of Tourism have included multiday training workshops for guides/operators (e.g., a joint initiative with Cetamada, Madagascar Whale Shark Project and the Ministry of Tourism was run in November 2019).

Whale Shark Conservation in Madagascar

Both tourists and operators supported the legal protection of whale sharks at a national level. Most tourists stated that they would be more likely to choose a destination at which whale sharks were

protected, while tour operators saw legal protection as a means to improve regulation of the whale shark tourism industry. This study emphasizes the economic rationale for protecting whale sharks to safeguard the emerging marine tourism industry. Ensuring that tourism activities are effectively managed (e.g., by addressing crowding issues and mitigating negative impacts on the sharks) is essential in order to continue to attract the specialized "dedicated" whale shark diver segment, which is specifically drawn to Nosy Be by the presence of whale sharks—which means there is global competition among whale shark sites for visits from this group. It is also better, in conservation terms, to have fewer tourists paying more money per person to minimize the impact of tourism activities on the target species and environment (Dearden et al., 2006).

There are two existing marine protected areas (MPAs) in the region, Ankarea and Ankivonjy MPAs (see Fig. 1), in which activities are zoned to allow for multiple uses, including no-take areas. Thus, whale sharks and other marine species are protected within these areas, although the no-take zones are small relative to the area used by the whale sharks. However, these two MPAs are in the process of being expanded to include a corridor between them (Arrêté Régional No. 3/2020-MID/REG/DIANA). This corridor overlaps to a certain extent with the high-use area of whale sharks in this section of coastline, as identified by satellite telemetry and field surveys (Diamant et al., 2018, in press). However, only part of the corridor is likely to be fully no-take, and a large proportion of the identified high-use whale shark habitat lies outside the current and planned protected areas. Species-level protection is also a necessity for whale sharks in Madagascar, particularly as they disperse around the country after the Nosy Be "whale shark season" ends around December each year (Diamant et al., 2018). Occasional accidental catches of whale sharks have been documented in the area (C. Scarffe, personal communication, February 15, 2021). Typically, the sharks are released unharmed, but on rare occasions the sharks have been killed to save the fishing nets. There have also been rare cases where whale sharks have been targeted for their fins locally, which are then exported to China (e.g., on neighboring island Nosy Faly in 2018; S. Diamant, unpublished data).

Impact of COVID-19 Pandemic on Whale Shark Tourism in Nosy Be

The COVID-19 pandemic has had a major impact on tourism in Madagascar, with national borders closed from March 19, 2020, through to the present (September 2021) with a brief opening in early October 2020. According to the Economic and Development Board of Madagascar, only about half of businesses in the tourism sector remained open during the shutdown, and 97% of tourism businesses reported a decline in their turnovers (Mukabana, 2020). Whale shark tourism in Nosy Be was largely suspended for the 2020 season, with only a few hundred tourists (vs. the normal 8,000 tourists during the full 3-month season) doing the tour during the 2 weeks Madagascar opened its borders in October 2020 (T. Guillemain, personal communication, February 22, 2021), resulting in the loss of an estimated US$1.5 million based on our 2019 data. There is currently talk of opening the national border to international tourists in October 2021, but no decision has been made to date (September 2021).

Conclusion

Considering its growing international media exposure as a whale shark hotspot and its close proximity to an international airport, there is the potential that the demand for whale shark tourism in Nosy Be will grow considerably. The reliable sightings of whale sharks represent a unique financial opportunity for both northwest Madagascar and the country as a whole, bringing in US$1.5 million in tourism-related revenue during the 3-month season each year. Looking at the growth of other whale shark tourism sites globally, once a site is known as a whale shark hotspot and is easily accessible by an international airport, it tends to grow rapidly and quickly surpasses sustainable levels of tourism pressure for the sharks (e.g., Isla Mujeres in Mexico and Oslob in the Philippines; Ziegler & Dearden, 2021). Therefore, it is important to address management issues in Nosy Be now, before tourism pressure at this site surpasses sustainability, as it is far more difficult to scale back activities than manage them sustainably from the onset.

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Appendix A: Whale Shark Tourist Survey Instrument

Tonga Soa eto Nosy Be (Welcome to Nosy Be), we hope you are having a great stay in Nosy Be! We are whale shark scientists from the Madagascar Whale Shark Project, a collaborative project between Florida International University, the Marine Megafauna Foundation, and local NGO MADA Megafauna that focuses on whale shark and marine research and conservation.

Whale shark tourism has recently started to take off here, and we would like to hear from you and how your whale shark experience was. The information you provide will be crucial to show the local authorities and the government how important whale sharks are to their economy—and thus will help our conservation efforts here.

We greatly appreciate you taking the time to fill in this questionnaire based on your experience of this trip. You must be 18 years old to answer this survey, and your answers are completely anonymous. Please answer all questions by circling your answer, and when finished, hand the survey back to the person who gave it to you.

SECTION I: Your whale shark experience

Q1 How many days will you spend in Nosy Be during this trip? _____ days

Q2 What was the main reason for your visit to Nose Be? *Please select the option that best reflects how you feel.*

1. General diving/snorkeling activities
2. Mainly to see whale sharks
3. Specifically to see whale sharks
4. Mainly to see marine megafauna (not whale sharks)

5. Specifically to see marine megafauna (not whale sharks)
6. Dive/snorkeling activities and sight-seeing
7. Beach holiday
8. Other (please specify): _____

Q3 How important was seeing whale sharks in your decision to visit Nosy Be?
1. Not at all important
2. Slightly important
3. Important
4. Very important
5. Extremely important

Q4 Before going on this trip, were you aware that Nosy Be is an important area for whale sharks?
1. Yes
2. No

Q5 How would you rate your whale shark experience in Nosy Be?
1. Much better than I expected
2. Somewhat better than expected
3. Exactly what I expected
4. Somewhat worse than I expected
5. Much worse than I expected
6. Not applicable (I did not do a whale shark tour)

SECTION II Other marine megafauna

Q6a Did you see any marine megafauna other than whale sharks (e.g., whales, sharks, dolphins, mantas, turtles) during your current trip to Nosy Be?
1. Yes
2. No

Q6b If yes, which animals did you see? *Please circle all that apply.*
1. Whales
2. Dolphins
3. Manta rays
4. Sea turtles
5. Other species (please specify): _____

Q7a Did you swim with any animals other than whale sharks (e.g., whales, sharks, dolphins, mantas, sea turtles) during your current trip to Nosy Be?
1. Yes
2. No

Q7b If yes, which animals did you swim with? *Please circle all that apply.*
1. Whales
2. Dolphins
3. Manta rays
4. Sea turtles
5. Other shark or ray species (please specify): ____

Q8 Which marine megafauna species (including whale sharks) did you particularly want to see? Please rank the three species you most wanted to see, with 1 being the most important to you.
1. _____
2. _____
3. _____

Q9 How satisfied were you with the number of marine megafauna species seen during your current trip to Nosy Be?
1. Very unsatisfied
2. Somewhat unsatisfied
3. Neutral
4. Somewhat satisfied
5. Very satisfied

SECTION III Expenditures

In the following section, we ask you to estimate the financial value of each aspect of your trip both in Nosy Be and in Madagascar. These questions will allow us to quantify the value of marine tourism in Nosy Be and the wider region. Please write zero if you did not spend (or do not plan to spend) anything in a particular category.

Q10 Please specify the number of people included in your group (i.e., values provided are for how many people): _____ people

Q11 Please specify the currency used:
1. USD
2. Euro
3. Ariary
4. CAD
5. AUD
6. Other (please specify): _____

Q12 The following question focus on your expenditures for both Nosy Be and Madagascar. If you took a domestic flight to get here, please include it in the Madagascar section. **Do not include international flights.**

	Nosy Be	Madagascar
A. Whale shark tour (ticket, equipment rental, etc.)		
B. Marine megafauna tour (ticket, equipment rental, etc.)		
C. Other tours and activities		
D. Accommodation		
E. Meals, food, drinks		
F. Souvenirs and other retail purchases		
G. Transport (ferry, taxi, domestic flight, etc.)		

SECTION IV Marine wildlife conservation

Q13 Please state your level of agreement with the following statements.

		Strongly disagree	Disagree	Neither	Agree	Strongly agree
A	I am more likely to select a holiday destination where whale sharks are actively protected (e.g., laws and/or regulations enforced)	1	2	3	4	5
B	It is important to protect whale sharks	1	2	3	4	5

SECTION V About you

Q14 What is your gender
1. Male
2. Female
3. Other
4. Prefer not to say

Q15 What is the highest level of education you have completed?
1. Grade/primary school
2. High school
3. Trade or apprenticeship
4. College/university
5. Advanced degree
6. Other (specify?): _____

Q16 How old are you?
1. 18–25
2. 26–35
3. 36–45
4. 46–55
5. 56–65
6. >65

Q17 What is your nationality (e.g., British, French, etc.)? _____

Q18 What is your average annual individual income (before tax)?
1. < 2,000 Euro
2. 2,001–20,000 Euro
3. 20,001–50,000 Euro
4. 50,001–80,000 Euro
5. >80,000 Euro

Q19 Are there any other aspects of the marine megafauna watching experience in Nosy Be that you would like to bring to our attention?

Thank you!

Appendix B: Tour Operator Surveys

Q1 What is the name of your company?
Q2 What is your tour company's specialty?
1. Diving
2. Cruises
3. Marine wildlife tours
4. Wildlife tours on land
5. Whale shark tours
6. General tours in Madagascar

Q3 In which year did you start working as a tour operator in Nosy Be?
Q4 In which year did you start offering whale shark tours in Nosy Be?
Q5 Has the number of whale sharks increased or decreased since your arrival?
Q6 Has the dates of the whale shark season changed since your arrival?
Q7 During your tour activities, do you see whale sharks out of season, when and where?
Q8 Has the size of whale sharks increased or decreased since your arrival?
Q9 What proportion of your clients come to Nosy Be to see whale sharks?
Q10 Has this proportion increased or decreased since you started offering whale shark tours?
Q11 How many operators offer whale shark tours in Nosy Be?
Q12 Based on your expertise, what are the problems with whale shark tourism in Nosy Be?
Q13 Do you have any suggestions on how to improve the respect of whale sharks on the water?
Q14 Do you think it is important to protect whale sharks at the national level (knowing that the whale shark is not currently a protected species in Madagascar)?

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