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Visitation and economic impact of whale shark tourism in a Maldivian marine protected area

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ABSTRACT

Whale sharks are a major attraction for tourist divers and snorkelers in South Ari Atoll, Maldives. Yet without information regarding the use and economic extent of the attraction, it is difficult to prioritize conservation or implement effective management plans. Using empirical recreational data and generalized mixed models, this study provides the first economic valuation—via direct spend—of whale shark tourism in Maldives. We estimate that direct expenditure on whale shark excursions in the South Ari Marine Protected Area for 2012–2013 at US$7.6 and $9.4 million, respectively. These expenditures are based on an estimate of 72 to 78 thousand tourists who are involved in whale shark excursions annually. This level of visitation and expenditure highlights the need to implement regulations and management which can safeguard the sustainability of the industry through ensuring guest satisfaction and whale shark conservation.

Keywords: Economic valuation, wildlife tourism, whale shark, Maldives, regression model

INTRODUCTION

In tropical locations around the world a new wildlife tourism industry has emerged in the last two decades that brings tourists in close proximity with whale sharks (*Rhincodon typus*). Due to the sharks' docile nature, patterns of seasonal aggregation (Sequeira et al., 2013), as well as accessibility, tourists are able to snorkel and scuba dive with unrestrained (or free-swimming) whale sharks. Whale sharks are listed as "Vulnerable" to extinction on the IUCN Red List of Threatened Species (IUCN, 2014); due to this, whale shark tourism has been hailed as an important income-generating alternative to consumptive or extractive uses of whale sharks such as shark finning or liver-oil processing (Norman and Catlin, 2007).

Tourism revenue can be considered a type of non-consumptive direct use value (Catlin et al., 2013; for a description of value types see Turner et al., 2003). The direct spend method has been previously used to estimate the economic impact of a natural location or a non-consumptive activity, including elasmobranch watching (Anderson et al., 2011; Clua et al., 2011). It is complementary to non-market valuations like those estimated by the contingent (e.g. willingness to pay) and travel cost methods. Direct spend provides a "minimal very conservative estimate of the economic value of natural areas" (Wood and Glasson, 2005). When data are available researchers use multipliers to also estimate the indirect effects in the economy (Catlin et al., 2010b). Direct spend, however, might also overestimate the value if it includes expenditures not exclusive of that resource. Therefore, tourism expenditure cannot be attributed to the natural resource if it is not the reason of the trip nor it influences the length of the stay. By estimating only the direct spend in whale shark excursions our valuation is closer to the substitution value, i.e. "the amount of expenditure that would be lost if whale shark tourism did not exist" (Catlin et al., 2010b).

The whale shark tourism industry first began at Ningaloo Reef in Western Australia in the late 1980's and early 1990's when operators began taking tourists mainly on diving excursions to swim with whale sharks during aggregation times from roughly May–June (Colman, 1997; Davis et al., 1997; Catlin and Jones, 2010). Whale shark tourism industries can now be found at numerous places worldwide—including

Table 1. Previous economic valuation of whale shark tourism (in US million dollars). Valuations reported in other currencies were converted to US$ using the average official rate for the year.

Location (season duration)	Year	Total expenditure	Expenditure on WS excursions	Method	Reference
Belize (6 wks)	2002	$3.7	-	Direct spend	Graham, 2003
Seychelles (14 wks)	2003	-	$1.2	Contingent	Cesar et al., 2004
	2007	$3.9 - 5.0	-	Direct spend	Newman et al[1]
Ningaloo (9 wks)	1994	$4.7	$1.0	Direct spend	Davis et al., 1997
	2004	$13.3	-	Unknown	Norman, 2005
	2006	$4.5	$2.3	Direct spend	Catlin et al., 2010b
	2006	$1.8 - 3.5	-	Substitution value	Catlin et al., 2010b

[1] Unpublished, cited in Rowat and Engelhardt, 2007

Mexico, Philippines, Belize, Mozambique, Seychelles, Maldives and Honduras. The burgeoning industry has made a strong economic case for conservation in that the sharks are worth more alive for tourism purposes than dead (Cisneros-Montemayor et al., 2013). However, the economic value of whale shark tourism remains unclear apart from economic evaluations from Belize, the Seychelles and Ningaloo Reef (Table 1). Without this information it is difficult for localities with limited institutional powers—particularly in regards to environmental protection—to prioritize conservation of natural areas or implement effective management plans.

One popular location for whale shark tourism is the Republic of Maldives. Known for its abundance of sharks, rays, turtles, and cetaceans, the country is an iconic location for marine wildlife tourism. While local populations historically used marine resources such as whale sharks for extractive purposes, the exact closure date of the Maldives whale shark fishery is unclear. Sinan et al. (2011) suggest that large shark fisheries for liver-oil extraction ceased in the 1960's, while Anderson and Ahmed (1993) reports it still happened in small-scale in the early 1990's. In 1993 the first valuation of the reef shark diving tourism industry was made public, and concerns about its vulnerability from pelagic fisheries precipitated a chain of legislation that ended with a national whale shark hunting ban in 1995 (Notice No: FA-A1/29/95/39) and the subsequent declaration of three Marine Protected Areas in 2009—Hanifaru Bay, Agafaru, and the South Ari Atoll Marine Protected Area (South Ari MPA).

The South Ari MPA is well-known regionally due to the year-round presence of whale sharks. Unlike the Hanifaru Bay MPA—one area in the Baa Atoll Biosphere Reserve with a management plan in place—the South Ari MPA's protected status is preliminary in that there is neither a management plan nor regulation in place yet. Anecdotal data suggest that tens of thousands of tourists participate in whale shark excursions there each year, however, no statistics exists that detail the extent of the industry or the economic impact it has.

Without informed and effective management, wildlife tourism can have negative effects on wildlife like disruption of activity, injuring, and habitat alteration, ultimately damaging the resource it is intended to protect (Green and Higginbottom, 2000); as stakeholders overuse the resource, the long-term benefit is jeopardized (Isaacs, 2000; Moore and Rodger, 2010). Site-specific information and statistics are not only important to prioritize conservation, but are also invaluable to develop appropriate management plans (Garrod, 2002). Davis et al. (1997) assert that effective management planning for whale shark tourism needs both biological and recreational data. When complementing the ecological concern, recreational data and economic valuations can also be crucial tools to transparently determine appropriate management strategies such as visitation fees, licensing systems or other restrictions, as well as gaining public support on the implementation of such measures (Ludwig, 2000; Catlin et al., 2012, 2013).

In this study, we improve current understanding of whale shark tourism by exploring the visitation patterns and economic effect of whale shark excursions in South Ari MPA in 2012 and 2013. To our knowledge this is the first study to model tourism metrics (expenditure, visitation and boat activity) in a MPA based on data collected with dedicated field surveys, rather than surveying a sample of the visitors. The results and recommendations we provide can be used to enhance the management of whale shark tourism at this location and encourage similar valuation studies in other wildlife attractions around the world.

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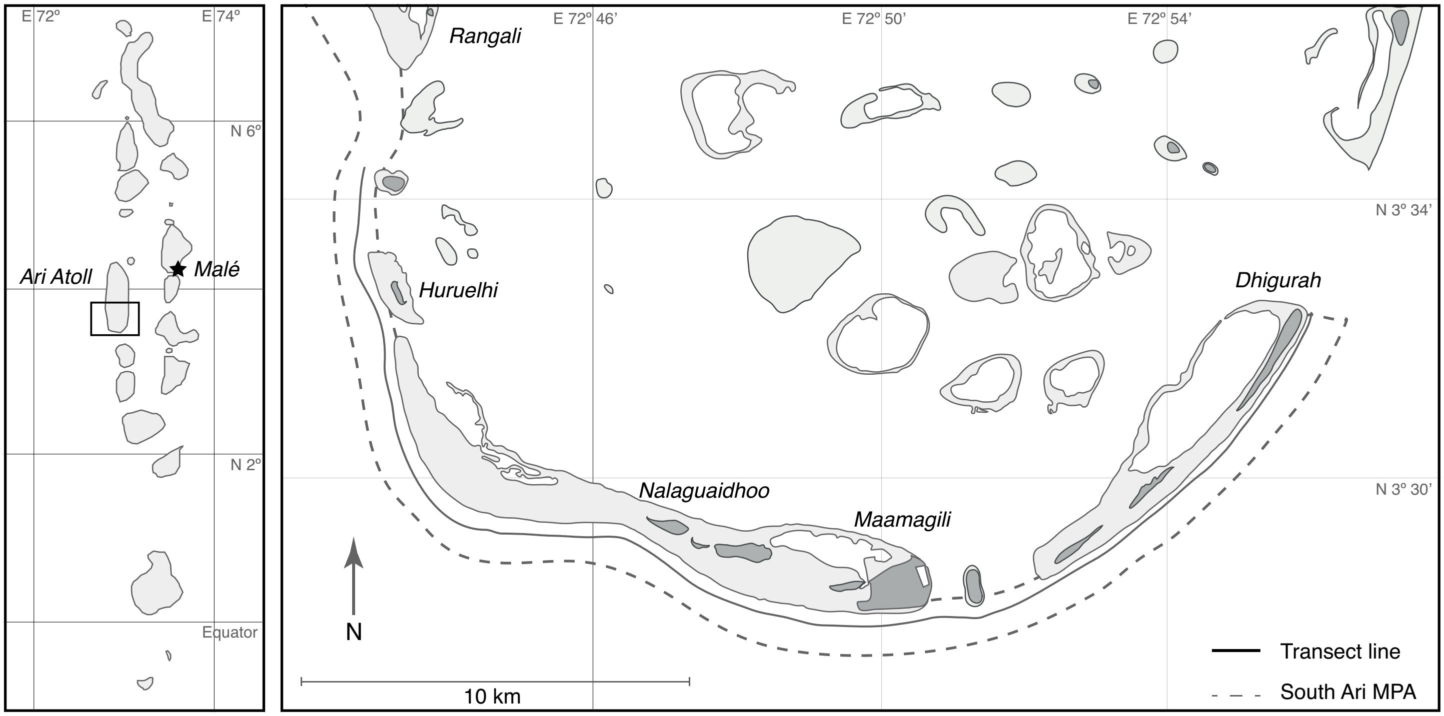

Figure 1. Map of South Ari Atoll showing the South Ari MPA and the survey transect.

METHODS

Study Location

Officially designated a protected area in 2009, the South Ari MPA is the largest Marine Protected Area in the Maldives with a total area of 42 km^2. The purpose of the MPA, according to the Maldives Environmental Protection Agency (2010), is to "protect and preserve a Maldivian aggregation of whale sharks, promote long-term conservation of the marine environment, and foster educational and scientific initiatives in the area."

The boundaries of the MPA extend along the seaward fringe of the South Ari Atoll from Rangali Island until Dhigurah Island, which encompasses 1 km of littoral zone measured from the reef crest (algal ridge) and includes the reef crest and 650 m to 900 m of open sea (Fig. 1). The MPA boundaries represent the geographical area most commonly frequented by tour operators to encounter whale sharks, which are typically found swimming close to the surface between 0 m to 20 m depth.

Whale shark tourism activity

Due to the geographical isolation of the Maldivian islands, tourists wishing to participate in a whale shark excursion in the South Ari MPA must go through a tour operator. Tour options are typically limited to dive centers, in-house operators at the resort the tourist is staying at, or with a liveaboard operator (locally called "diving safari"). Twenty-eight tourist resorts are located in the greater Ari Atoll, four of them on the MPA boundaries. Prices for whale shark excursions are varied and are exclusively determined by the individual operators. Guesthouses, situated in local islands as opposed to resort-exclusive islands, are a relatively new accommodation option. In this study we did not distinguish them from resorts or diving safaris due to their recent emersion and limited guest numbers.

Data collection

From November 11, 2011, to December 31, 2012, the Maldives Whale Shark Research Programme (MWSRP) carried out 224 surveys along a 38 km linear transect section that coincides with the outer reef margin. Surveys lasted 4.9 $\pm$ 1.5 h (mean $\pm$ SD) and were mostly started in the morning. Each vessel in the MPA within 500 m of MWSRP's boat was documented by noting the vessel location, name, type and number of persons on-board. Surveys were part of MWSRP's monitoring program, which reduced

Table 2. Number of survey days by month.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2011											14	9
2012	4	19	0	0	8	3	0	0	0	8	21	20
2013	21	16	0	0	14	16	1	0	0	16	14	21

operation intensity during tourist low seasons (March-September; Table 2).

During the surveys we approximated the location of the vessels using the location of the survey boat recorded with a handheld GPS unit. To determine the number of people on-board, a minimum of two observers individually counted the total persons on-board with the aid of binoculars. One person was added to the count if the skipper was not visible. The counts were repeated until there was consensus between the observers. The type of boat was selected between the options presented in the Table 3. All vessels not engaged in whale shark tourism were removed from the scope of this study.

Although we were unable to survey the full extent of the MPA each day due to extraneous circumstances such as time, weather, or logistical constraints, we consider our surveys to be a representative approximation of a daily use census of the South Ari MPA as the same circumstances apply to tourists boats. This assumption does, however, imply that our expenditure and visitation figures might be underestimates of the actual values.

Data analysis

We used an array of statistical models to estimate tourism metrics for the South Ari MPA for 2012 and 2013. We modeled six variables: daily number of vessels associated to tour operators (resorts and liveaboards), daily number of visitors (from resorts, liveaboards and total number of guests), and daily direct economic expenditure on whale shark excursions.

The daily number of visitors was calculated by adding together the total number of persons observed on-board for each boat type. In order to control for the crew on-board, we subtracted two from the total number on-board each boat. Although occasionally there were more than two crewmembers per boat (especially on liveaboards), this imprecision is counteracted by the fact that in some cases we were not able to see and count all people on-board. To calculate daily direct expenditure we first multiplied the number of guests in a boat by the respective prices of a daily trip for each specific boat operator to determine the direct expenditure per boat. Subsequently all the expenditures per boat were summed. Because we surveyed the MPA only over a limited period of the day and because of the complications of counting the number of people on-board we consider our results to be conservative estimates of the actual tourism metrics.

Although it could change in the future due to the emergence of local community guesthouses and dive centers, for this analysis we included only resort and liveaboard associated vessels as currently they

Table 3. Boat types used in the study.

Type	Description
Resort associated vessels	
Excursion boat	40 - 60 ft diesel engine traditional boats (dhoni) and 40 -70 ft sailboats used for snorkeling excursions
Diving boat	40 - 60 ft diesel engine dhonis adapted for one-day diving excursions
Sport fishing boat	26 - 60 ft sport fishing boats and motor yachts whose primary purpose is recreational fishing by anglers
Liveaboard associated vessels	
Liveaboard	70 - 140 ft boats that offer 10 - 30 guests to stay one or more nights at sea
Liveaboard diving vessel	40 - 60 ft day boats for scuba diving and shore excursions from the main liveaboard
Tender	Outboard motor dinghies that support liveaboard operations
Other	Local fishing vessels, ferries and supply boats, PWC, military boats, dinghy sailboats, etc

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Table 4. Daily prices per person for each boat type (US$)

Boat type	Min.	Mean	SD	Max.
Liveaboard[1]	90	247	68	381
Resort diving boat	17	102	61	200
Resort excusion boat	17	97	60	250
Resort speed boat	50	162	153	667

[1] Liveaboards and associated vessels

are the only ones considered to generate substantial whale shark tourism-based economic income. The prices per daily excursion were sourced through online queries based on boat name, type, and operator (if known). This search yielded the price of daily trips for 168 of the 568 vessels that frequented the MPA (Table 4). For the vessels that we were unable to obtain the 2013 trip price, a price average was allocated according to vessel type. Whale shark excursions are liable for a Goods & Service Tax under Maldivian law (Maldives Inland Revenue Authority, 2014); although the associated taxes were not used in this study to determine the overall expenditure.

In the case of liveaboards, we estimated the daily price based on the total price of a trip per person in standard shared accommodation divided by the number of nights, without including taxes and service charge. We directly associated this expenditure with whale shark tourism in the South Ari Atoll MPA because the opportunity to encounter whale sharks is a primary reason for diving safaris to visit this area. Unlike the resort boats, we combined the boat types in the liveaboard category (liveaboard, diving vessel, tender) and assigned them a common price. We did this because it was usually possible to associate diving vessels and tenders to their respective liveaboards. Moreover, guests were often counted while on the support boats, not on the liveaboards.

In all six models we used the variables Season, Year and Day of the Week, mean daily Wind Speed (in order control for weather conditions), and the interactions between Day of the Week and Season, and Day of the Week and Year as explanatory variables. Roughly following Shareef and McAleer (2007) we considered that high tourist season occurs between October 1 and February 28 and low tourist season accounts for the rest of the year. Because there is no wind speed data measured from the MPA, we obtained daily means from the Blended Sea Surface Wind product from the National Climatic Data Center at the United States National Oceanic and Atmospheric Administration (Zhang et al., 2006).

To model expenditure, we fitted a linear model with generalized least squares (GLS) to the log transformed daily expenditure maximizing the log-likelihood. The GLS approach allowed us to account for heteroscedasticity, which improves the reliability of the coefficients calculated for the fixed effects (Goldstein, 1986). To select the most parsimonious model we used the Akaike information criterion (AIC), first determining the best weight and covariance structure, and then selecting the most appropriate fixed-effects set (Zuur et al., 2009).

To model the number of guests and boats for resorts and liveaboards—count data—we compared a generalized linear model (GLM) with a poisson and one with a negative binomial error structure; the negative binomial distribution performed consistently better for all models (likelihood ratio test, $p < 0.001$). Although we detected a significant—albeit small—autocorrelation on the residuals of all models, we did not account for it. Instead, because of our priority on prediction precision (as opposed to coefficient estimation), we employed a multi-model inference approach that accounts for model inference uncertainty by averaging a set of candidate models (Buckland et al., 1997). Predictions were done with the AIC weighted average models that accounted for at least 95% of the evidence.

We used the models to predict the six response variables from January 1, 2012, to December 31, 2013, including those days when surveys were not conducted (due to limited sampling we did not predict any value for 2011). Because of the importance of quantifying the accuracy of our estimates, we computed means and confidence intervals of the annual number of visitors by bootstrapping the models with 1000 replications (Young et al., 2003). Due to the more complex parameterization of the expenditure model, we calculated the corresponding standard errors using the Jackknife method leaving one sample out at a time (Efron and Tibshirani, 1986).

All analyses were performed used R 3.0.2 with the packages 'nlme', 'glmulti', 'MASS', and 'bootstrap' (Calcagno and de Mazancourt, 2010; Canty and Ripley, 2013; Pinheiro et al., 2013; R Core Team, 2013;

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Table 5. Yearly total expenditure and guests in the MPA. Confidence intervals (CI) and standard errors (SE) were calculated by jacknifing the expenditure model and by bootstrapping the guest models.

Year	Expenditure (US$ million)			Liveaboard guests (thousands)		Resort guests (thousands)		Total guests (thousands)	
	Total	SE	Bias	Total [95% CI]	Bias	Total [95% CI]	Bias	Total [95% CI]	Bias
2012	7.62	2.69	-0.70	26.27 [20.23, 37.06]	-2.09	45.07 [33.94, 55.57]	5.76	72.37 [57.76, 85.43]	0.52
2013	9.36	1.99	0.60	23.89 [18.43, 29.61]	-0.26	56.03 [46.35, 84.72]	2.78	77.93 [65.55, 129.4]	-1.92

Venables and Ripley, 2002).

RESULTS

We estimated that mean direct expenditure on whale shark excursions was US$7.6 and $9.4 million in 2012 and 2013, respectively, with a mean total of 72 and 78 thousand visitors per year for the same period (Table 5).

Daily direct expenditure on whale shark excursions was calculated based on the most parsimonious model (Eqn. 1; Supplemental Information Table S1). This model included Day of the Week (w), Season (s), Year (y) and Wind Speed (u), but not their interactions. It also takes into account the temporal autocorrelation of the residuals with an autoregressive structure of first order ($\Phi_1 = 0.123$), at the same time that each level on the predictor variables is allowed to have a different variance (Table S1, S2).

$$log(E+1) \sim 1+w+s+y+u \qquad var(\varepsilon_{iwsy}) = \sigma_s^2 \times \sigma_w^2 \times \sigma_y^2 \qquad \varepsilon_t = \phi_1 \varepsilon_{t-1} + \eta_t \tag{1}$$

The daily number of guests and boats (both for liveaboards and resorts) were calculated from a weighted average of models that accounted for 95% of the evidence weight (Table S3). Predictions for the number of resort guests were based on all independent variables but not their interactions, whereas all other count models also included the interaction between Season and Day of the Week (Table S4a).

The effect of season was the largest in all models. While both liveaboard boats and resort boats visit the South Ari MPA in a given day more during high than low season, the difference between high and low season is three times larger for liveaboards than for resort vessels (Fig. 2d). There was a 60% decrease on the total number of guests, which was reflected on a 35% decrease on resort boats numbers and an 88% decrease on liveaboard boat numbers, causing a 64% decrease in daily economic expenditure (estimates based on model coefficients; Table S2 and S4, Fig. 2b).

Boat activity varied throughout the week—Wednesday being busiest day and Friday the least (Fig. 2c). The vessel types encountered in the MPA also varied per weekday with liveaboard-associated boats being present much more from Monday to Tuesday than from Friday to Sunday. However, the presence of resort-associated boats was relatively constant during the week except on Wednesdays when there was a larger amount of boats conducting whale shark excursions. In general, weekly patterns of vessel activity are similarly associated with visitors per day and expenditure per day (Fig. 2a). The estimated number of people engaging in whale shark tourism from resorts is not significantly different across the week, however, there are three times more guests from liveaboards on a Wednesday compared to Friday.

As expected, wind had a negative effect on the expenditure, for example a wind speed of one standard deviation above the average can cause a 13% decrease on daily the revenue. This negative effect is consistent in all models of number of guests and boats (SM Table 2, SM Table 4).

Approximately 75% of the boats visiting the MPA for whale shark tourism are encountered on a 5 km stretch between Nalaguraidhoo Island (Sun Island Resort & Spa) and Maamigili Island (Fig. 3).

DISCUSSION

We estimate direct expenditure on whale shark excursions at US$7.6 ± 2.7 million (mean ± SE) in 2012 and $9.4 ± 2.0 million in 2013 based on an estimate of 72 to 78 thousand tourists who are involved in whale shark excursions annually.

Both estimates were generated from the development of linear regression models as opposed to previous elasmobranch valuations estimates where expenditure surveys are administered to stakeholders

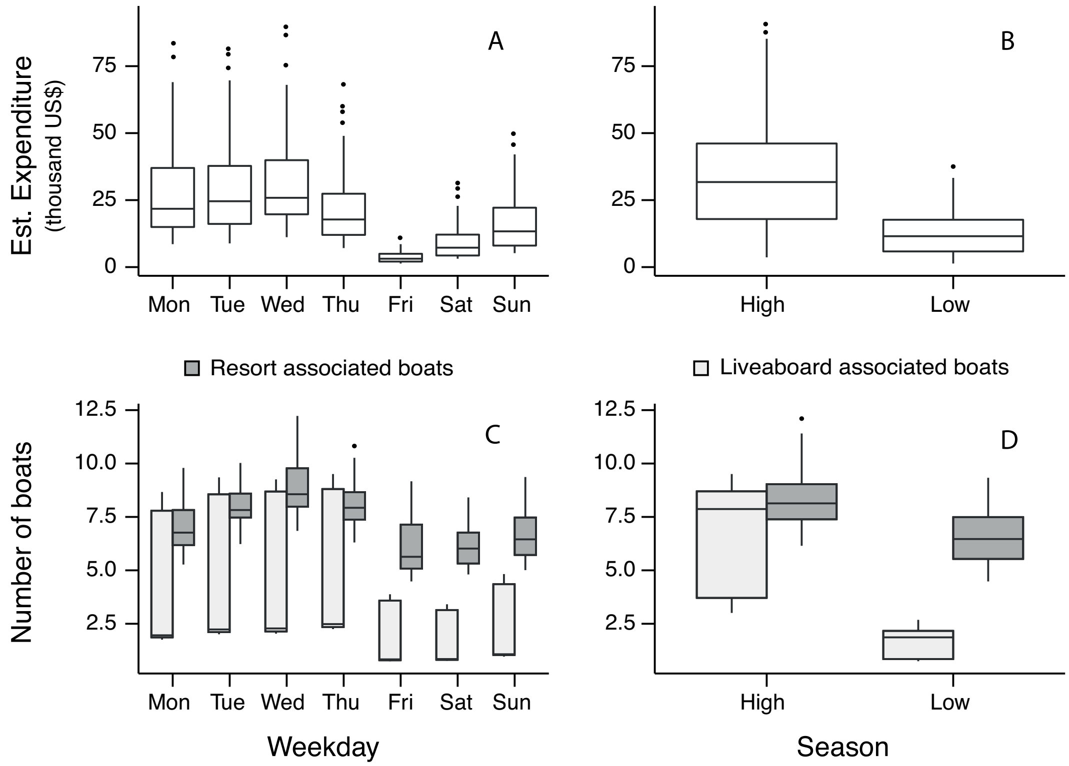

Figure 2. Boxplots of the values predicted by the models.

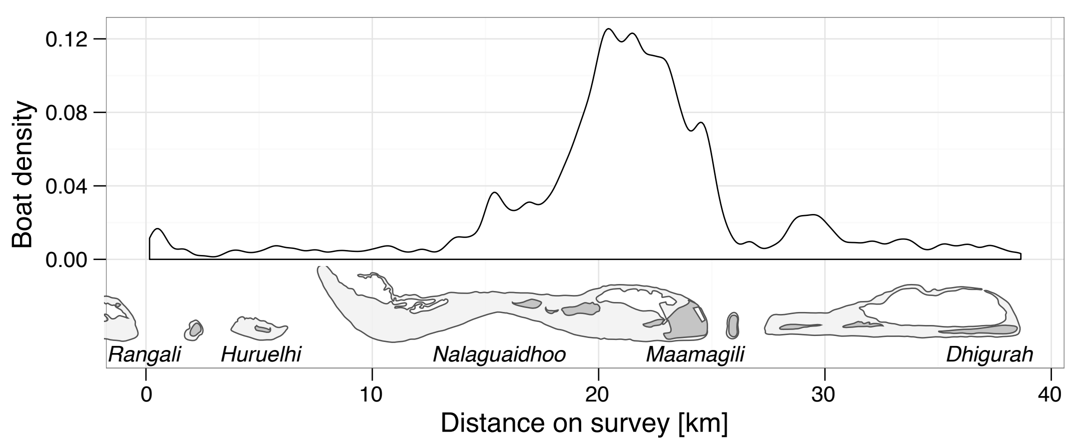

Figure 3. Density of observed touristic boats in the South Ari MPA.

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and mean expenditure figures are multiplied by previously known guest numbers (Catlin et al., 2010b; Anderson et al., 2011; Clua et al., 2011) . By taking into account temporal autocorrelation and using techniques that allowed us to estimate uncertainty, we believe that our estimates can be statistically superior to valuations that select a sample of guests and average individual expenses, often without providing confidence intervals or any other measure of variability. Our method presents a novel, unified approach to calculate expenditure and visitation metrics in the absence of official tourist data, while at the same time it captures temporal variability that other methods are insensitive to.

For instance, despite the less frequent sampling during low season (which is reflected in a higher standard deviation for this stratum; Table S2), we detected, as expected, a clear significant difference on guest numbers and income generated by whale shark trips between seasons. This difference is stronger for liveaboards, which showed an 88% reduction in boat activity compared to a 35% reduction of resort boats. We also detected temporal variability on a weekly basis—Wednesdays bringing the most revenue and Fridays the least. Similarly, liveaboards visit the MPA significantly more from Monday to Thursday, probably due to weekly-based operations—Saturdays being the most common collection day of tourists in the capital city Malé (approx. 100 km away from South Ari MPA), while resorts show a nearly constant operation across the week.

Our estimate of $9.4 million for whale shark tourism in 2013 alone suggests that the value of shark tourism has experienced a marked increase over the last 20 years in Maldives. Anderson and Ahmed (1993) estimated that direct expenditure on shark diving tourism in Maldives was US$2.3 million per year ($3.7 million in 2013, using U.S. Consumer Price Index). Our findings reinforce the observation that shark—especially whale shark—tourism has continued to expand over the last few years.

Similarly, other chondrichthyan species, such as Manta rays (*Manta alfredi*), are a major natural attraction of Maldives. Anderson et al. (2011) estimated direct expenditure on manta ray diving and snorkeling excursions in Maldives to be US$8.1 million ($8.7 million in 2013 dollars). Their estimates came from 91 dive sites across the country with 157,000 visitors per year swimming with a population of mantas in the order of thousands. Contrastingly, our $7.6 to $9.4 million estimates come from just one site with 72 to 78 thousand visitors per year and a population of 60 to 100 juvenile whale sharks (Riley et al., 2010). This underscores the significance of the South Ari MPA and the relatively concentrated industry while also highlighting the importance to implement sound management to ensure the sustainability of industry.

Although less developed, the Maldives whale shark tourism industry shows some similarities with the developed whale shark industry at Ningaloo Reef, Australia. Catlin and Jones (2010) explain that the visitor profile has shifted from a specialist tourist interested in wildlife experiences to a generalist visitor with greater interest in the non-wildlife aspects. In Maldives, with the emphasis on high-end resorts, the relative importance of diving has declined in recent years (Anderson et al., 2011). As whale shark tourism becomes more popular, tour operators must put emphasis on a high-quality experience rather than in the encounter itself, especially in an industry where word of mouth is the most important mode of promotion (Catlin et al., 2010a).

To increase the amount of cases that meet and exceed guests' enjoyment and safety expectations and to minimize the impacts of the industry on the whale sharks, stakeholders should promptly attempt to adopt management strategies. In fact, educative and regulative policies can contribute to better guest experiences (Davis et al., 1997; den Haring, 2012; Techera and Klein, 2013). Operator licensing, which has been implemented in Ningaloo, has ensured minimal operation standards without it being perceived as an obstacle to business development. If licensing is flexible enough it can encourage continuous improvement of the operators (Catlin et al., 2012). An example to reduce crowding could be to focus resort operations on weekends since liveaboards visit the MPA more frequently from Monday to Thursday. Another example that comes from fisheries management, Individual Transferable Quotas, could limit the number of licensed boats in the MPA as a way to reduce crowding without dictating the actual number of people in the water with a shark at any time.

Alternatively, spotter planes can facilitate whale shark encounters by making searching more efficient and therefore dispersing operators among a greater number of sharks (Rowat and Engelhardt, 2007; Catlin and Jones, 2010). When the number of sharks available for encounters is limited, a code of conduct that encourages to "pass the shark" from one operator to another after a mutually agreed time might improve guest experience and reduce potential impacts on whale sharks.

Because of the importance of up-to-date information in effective management we suggest the South

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Ari MPA stakeholders to be directly involved in the collection of data on whale shark encounters and interactions. By supporting data collection using paper or electronic GPS based logbooks, the industry can obtain precise estimates, seasonal fluctuations as well as commercial feedback (Department of Parks and Wildlife, 2013). Stakeholder participation of this sort could be valuable to legitimize heightened management applications as well as assure timely stakeholder adoption of new regulations.

Bhat et al. (2014) found a large disparity between the economic value of atoll-based tourism in the Maldives and the amount of money that goes into environmental conservation. Collecting guest fees is now a well-established way to fund management strategies in protected areas (Dharmaratne et al., 2000; Thur, 2010). It has been shown that as long as it is transparent, tourists are willing to contribute to the sustainable management of the whale shark experience (Davis and Tisdell, 1998). Arthur (2011), in a willingness to pay survey, showed that tourists visiting the Maldives would be willing to pay an US$106 $\pm$ 15 per trip (mean $\pm$ SD) to see sharks in their natural environment on top of the dive price and would donate US$56 $\pm$ 6 towards a shark conservation fund. Exploring the guest willingness to pay is clearly an alternative that should be evaluated by stakeholders, managers and policymakers in the South Ari MPA if they are interested in improving or maintaining the quality of the ecosystem and the tourist experience (Davis and Tisdell, 1996; Rudd and Tupper, 2002).

Because of the scientific ambiguity and the many assumptions needed to value individual animals, we have refrained from ascribing a tourist value to the whale sharks in Maldives (Catlin et al., 2013). Our results, however, show that the Maldivian whale shark tourism industry is financially significant as it approaches 3% of the global shark ecotourism expenditure (Cisneros-Montemayor et al., 2013). Additionally, the results are indicative of the industry's local importance as a tourism driver that can generate revenue for local operators as well as the government. Based upon the expenditure rates for 2012 and 2013, the government would have collected approximately $457,200 and $748,800 (6% tax rate in 2012, and 8% in 2013), respectively, as a direct result of the whale shark tourism industry. This underscores the urgent need to manage this area to sustain the resident population of whale sharks by regulating use, so as not to exceed carrying capacity and limits of acceptable change (Davis and Tisdell, 1995).

Ecotourism projects are more likely to be successful when the target is a charismatic species and the management involves the local community (Krüger, 2005; Gallagher and Hammerschlag, 2011). Operators are in the best position to lead multidisciplinary and participatory processes to maximize tourist satisfaction while achieving protection goals and ensuring the long-term sustainability of whale shark encounters in the South Ari MPA (Bentz et al., 2013). However, considerable discussion and deliberation will need to happen to determine the best approach that all stakeholders—including local communities, industry, and government—are willing to adopt to ensure a functioning management system. This pursuit should be viewed as an iterative process with emphasis placed on evaluation and iteration based upon empirical findings.

CONCLUSION

Based on empirical recreational data, we found that whale shark tourism in the South Ari MPA has been increasing in popularity and represents a significant wildlife tourism industry for the country, which follows the increasing popularity of the global shark tourism industry. Our findings are significant in that they bolster previous studies on Maldivian wildlife tourism that highlight the importance of the industry and urge for effective management. We hope that this paper can contribute towards the establishment of an effective management system in the South Ari MPA and serve as a guide for other wildlife species and areas throughout the world.

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ADDITIONAL INFORMATION AND DECLARATIONS

Competing interests

James Hancock and Richard Rees are employees of the Maldives Whale Shark Research Programme. Fernando Cagua is member of the MWSRP scientific advisory board.

Author contributions

Fernando Cagua and Neal Collins performed the experiments, analyzed the data, contributed materials/analysis tools, and wrote the paper, prepared figures and tables, reviewed drafts of the paper.

Jim Hancock and Richard Rees conceived and designed the experiments, performed the experiments, contributed materials/analysis tools, and reviewed drafts of the paper.

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SUPPLEMENTAL INFORMATION

Table S1. Models evaluated for the expenditure model using the Akaike information criterion (AIC).

Fixed effects	Variance, $var(\varepsilon)$	Correlation, ε_t	AIC
$w+s+y+u+w:y+w:s$	-	-	817.37
$w+s+y+u+w:y+w:s$	σ_y^2	-	807.63
$w+s+y+u+w:y+w:s$	σ_s^2	-	808.38
$w+s+y+u+w:y+w:s$	σ_w^2	-	757.01
$w+s+y+u+w:y+w:s$	$\sigma_s^2 \times \sigma_y^2$	-	764.91
$w+s+y+u+w:y+w:s$	$\sigma_w^2 \times \sigma_y^2$	-	748.90
$w+s+y+u+w:y+w:s$	$\sigma_s^2 \times \sigma_w^2$	-	748.78
$w+s+y+u+w:y+w:s$	$\sigma_s^2 \times \sigma_w^2 \times \sigma_y^2$	-	731.11
$w+s+y+u+w:y+w:s$	$\sigma_s^2 \times \sigma_w^2 \times \sigma_y^2$	$\phi_1\varepsilon_{t-1}+\eta_t$	729.53
$w+s+y+u+w:y+w:s$	$\sigma_s^2 \times \sigma_w^2 \times \sigma_y^2$	$\phi_1\varepsilon_{t-1}+\phi_2\varepsilon_{t-2}+\eta_t$	730.31
$w+s+y+u+w:y+w:s$	$\sigma_s^2 \times \sigma_w^2 \times \sigma_y^2$	$\phi_1\varepsilon_{t-1}+\theta_1\eta_{t-1}+\eta_t$	730.69
$w+s+y+u+w:y+w:s$	$\sigma_s^2 \times \sigma_w^2 \times \sigma_y^2$	$\phi_1\varepsilon_{t-1}+\phi_2\varepsilon_{t-2}+\theta_1\eta_{t-1}+\eta_t$	732.06
$w+s+y+u+w:y+w:s$	$\sigma_s^2 \times \sigma_w^2 \times \sigma_y^2$	$\phi_1\varepsilon_{t-1}+\theta_1\eta_{t-1}+\theta_2\eta_{t-2}+\eta_t$	732.55
$w+s+y+u+w:y+w:s$	$\sigma_s^2 \times \sigma_w^2 \times \sigma_y^2$	$\phi_1\varepsilon_{t-1}+\phi_2\varepsilon_{t-2}+\theta_1\eta_{t-1}+\theta_2\eta_{t-2}+\eta_t$	731.64
$w+s+y+u+w:y$	$\sigma_s^2 \times \sigma_w^2 \times \sigma_y^2$	$\phi_1\varepsilon_{t-1}+\eta_t$	726.37
$w+s+y+u+w:s$	$\sigma_s^2 \times \sigma_w^2 \times \sigma_y^2$	$\phi_1\varepsilon_{t-1}+\eta_t$	724.22
$w+s+y+u$	$\sigma_s^2 \times \sigma_w^2 \times \sigma_y^2$	$\phi_1\varepsilon_{t-1}+\eta_t$	**720.92**
$w+s+y$	$\sigma_s^2 \times \sigma_w^2 \times \sigma_y^2$	$\phi_1\varepsilon_{t-1}+\eta_t$	724.42
$w+s+u$	$\sigma_s^2 \times \sigma_w^2 \times \sigma_y^2$	$\phi_1\varepsilon_{t-1}+\eta_t$	728.27
$w+y+u$	$\sigma_s^2 \times \sigma_w^2 \times \sigma_y^2$	$\phi_1\varepsilon_{t-1}+\eta_t$	729.09
$s+y+u$	$\sigma_s^2 \times \sigma_w^2 \times \sigma_y^2$	$\phi_1\varepsilon_{t-1}+\eta_t$	733.02

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Table S2. Parameter estimates most parsimonious model of daily expenditure. Coeffcients and standard deviations (SD) per stratum

Effect	Cat.	SD per stratum	Coefficients		
			Est.	Error	p
Intercept	-	-	9.24	1.28	0.000
Weekday	Mon	1.437	1.95	1.25	0.118
	Tue	0.875	2.01	1.24	0.107
	Wed	1.190	2.11	1.24	0.092
	Thu	1.625	1.72	1.25	0.171
	Fri	4.195	- Baseline category -		
	Sat	1.113	0.85	1.25	0.500
	Sun	1.000	1.45	1.24	0.246
Season	Low	2.267	-1.02	0.29	0.001
	High	1.000	- Baseline category -		
Year	2011	1.000	- Baseline category -		
	2012	1.426	-0.06	0.26	0.811
	2013	0.731	0.53	0.22	0.018
Wind Speed	-	-	-0.43	0.18	0.018

Table S3. Akaike Information Criteria differences ($\Delta_i = AIC - AIC_{min}$) for the count models evaluated. Bold values indicate the models that accounted for 95% of the evidence weight and were used for predictions. Models were based on season (s), day of the week (w), year (y) and daily average wind speed ($u = log(speed + 1)$) as explanatory variables.

Model Formula	Guest models			Boat models	
	Total	Liveaboard	Resort	Liveaboard	Resort
$s+w+u$	**0.00**	**2.17**	5.99	**0.20**	**3.61**
$s+w$	**0.06**	**2.23**	**5.03**	**0.00**	**4.12**
$s+y+w+u$	**0.22**	2.71	**5.90**	**3.37**	**0.00**
$s+y+w+u+s:w$	**1.31**	**0.43**	10.75	8.13	**2.01**
$s+y+w$	**2.02**	3.25	6.12	**2.60**	**1.07**
$s+w+u+s:w$	**2.35**	**0.59**	11.59	4.83	**5.36**
$s+w+s:w$	2.87	**0.00**	10.84	4.52	6.21
$s+y+w+s:w$	4.07	**0.58**	11.48	7.34	**3.59**
$s+y+u$	5.07	7.70	**0.00**	28.77	**1.48**
$s+y$	8.16	9.06	**0.80**	29.31	**3.53**
$s+u$	9.73	12.62	**2.25**	25.29	5.88
s	9.92	12.54	**1.40**	25.47	6.80
$w+u$	12.91	22.54	6.37	62.20	7.15
$s+y+w+u+s:w+y:w$	14.17	12.23	25.96	16.83	14.71
w	14.66	23.10	6.01	63.86	9.01
$y+w+u$	14.87	24.38	6.79	62.99	**3.27**
$s+y+w+u+y:w$	15.02	12.81	20.85	12.80	10.07
$s+y+w+y:w$	16.29	13.15	20.66	11.95	10.64
$s+y+w+s:w+y:w$	16.30	12.15	26.24	16.03	15.86
$y+w$	17.98	25.41	7.54	63.12	**5.20**
$y+u$	21.60	31.52	**1.41**	88.01	5.68
u	23.32	33.51	**3.00**	84.06	10.17
1	25.07	33.73	**2.83**	86.09	12.74
y	25.90	1.9e4	**2.81**	89.69	8.96
$y+w+u+y:w$	32.11	39.64	22.77	76.94	14.67
$y+w+y:w$	34.47	40.22	23.10	76.79	16.09

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Table S4. Parameter estimates for guest and boat number models that accounted fro 95% of the evidence weight (Table S3).

(a) Averaged coefficient estimates (Est.), unconditional variances (U.V) and relative importances (Imp.) of the independent variables.

Effect	Guest Models									Boat Models					
	Total			Liveaboard			Resort			Liveaboard			Resort		
	Est.	U.V.	Imp.	Est.	U.V.	Imp.	Est.	U.V.	Imp.	Est.	U.V.	Imp.	Est.	U.V.	Imp.
Intercept	5.41	0.13	1.00	3.91	0.33	1.00	5.37	0.10	1.00	1.44	0.12	1.00	2.47	0.10	1.00
Season															
High								- Baseline Category -							
Low	-0.91	0.33	1.00	-18.30	4.3e7	1.00	-0.19	0.03	0.69	-2.14	1.1e4	1.00	-0.43	0.15	0.91
Weekday															
Monday	0.49	0.07	1.00	1.14	0.23	1.00	0.01	0.00	0.05	0.78	0.09	1.00	0.08	0.04	0.80
Tuesday	0.57	0.08	1.00	1.12	0.24	1.00	0.01	0.00	0.05	0.88	0.09	1.00	0.14	0.05	0.80
Wednesday	0.67	0.07	1.00	1.12	0.24	1.00	0.02	0.00	0.05	0.89	0.09	1.00	0.33	0.06	0.80
Thursday	0.48	0.08	1.00	1.03	0.26	1.00	0.01	0.00	0.05	0.91	0.09	1.00	0.17	0.05	0.80
Friday								- Baseline Category -							
Saturday	-0.04	0.11	1.00	-0.11	0.38	1.00	0.00	0.00	0.05	-0.12	0.12	1.00	-0.08	0.05	0.80
Sunday	0.15	0.08	1.00	0.32	0.24	1.00	0.01	0.00	0.05	0.20	0.09	1.00	0.03	0.04	0.80
Wind Speed *	-0.15	0.03	0.63	-0.15	0.05	0.51	-0.14	0.03	0.55	-0.08	0.01	0.44	-0.14	0.02	0.67
Year															
2011								- Baseline Category -							
2012	0.05	0.01	0.41	0.26	0.12	0.43	-0.11	0.03	0.63	-0.02	0.00	0.19	-0.31	0.03	0.90
2013	0.12	0.03	0.41	0.26	0.12	0.43	0.07	0.03	0.63	-0.03	0.00	0.19	-0.15	0.02	0.90
Season:Weekday															
Low : *Monday*	0.27	0.21	0.25	16.59	4.3e7	0.78	.	.	.	0.72	1.1e4	0.04	0.17	0.11	0.17
Low : *Tuesday*	0.43	0.47	0.25	17.08	4.3e7	0.78	.	.	.	0.73	1.1e4	0.04	0.28	0.24	0.17
Low : *Wednesday*	0.32	0.28	0.25	17.11	4.3e7	0.78	.	.	.	0.73	1.1e4	0.04	0.15	0.09	0.17
Low : *Thursday*	0.45	0.53	0.25	17.72	4.3e7	0.78	.	.	.	0.76	1.1e4	0.04	0.24	0.19	0.17
Low : *Friday*								- Baseline Category -							
Low : *Saturday*	0.45	0.51	0.25	17.68	4.3e7	0.78	.	.	.	0.75	1.1e4	0.04	0.21	0.14	0.17
Low : *Sunday*	0.29	0.25	0.25	16.50	4.3e7	0.78	.	.	.	0.72	1.1e4	0.04	0.16	0.10	0.17

* Log transformed

(b) Negative-binomial dispersion parameters.

Model	Dispersion parameter (θ)		
	Min.	Mean	Max.
Total Guests	1.9070	1.9620	2.0440
Liveaboard Guests	0.6438	0.6715	0.6962
Resort Guests	1.3570	1.4010	1.4580
Boats Liveaboards	2.7310	2.7620	2.8140
Boats Resorts	3.8920	4.3730	4.9420

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