

EXTENT AND ECONOMIC VALUE OF MANTA RAY WATCHING IN MALDIVES

R. CHARLES ANDERSON,* M. SHIHAM ADAM,†
ANNE-MARIE KITCHEN-WHEELER,‡ and GUY STEVENS§

*Malé, Republic of Maldives

†Marine Research Centre, Malé, Republic of Maldives

‡School of Biology, University of Newcastle, UK

§Four Seasons Resort, Landaa Giraavaru, Republic of Maldives

Manta rays, *Manta alfredi*, are a major attraction for tourist divers and snorkelers in the Republic of Maldives (central Indian Ocean). The aims of this study were to assess the extent and economic value of manta ray watching in the Maldives, by surveys of tourist numbers at manta diving sites, and from interviews with experienced divers. Ninety-one manta dive sites were identified, where tourists made an estimated 143,000 dives and over 14,000 snorkels annually during 2006–2008. This was estimated to be worth about US\$8.1 million per year in direct revenue. The growth of manta ray watching has provided support for both research and conservation in the Maldives. However, there are indications that at the most popular manta dive sites the large numbers of visiting divers and snorkelers may be having a negative impact on manta numbers. There is a need for improved tourist education, and perhaps for regulation of diver numbers at some sites.

Key words: Manta ray; Maldives; Wildlife tourism; Economic value

Introduction

The Republic of Maldives is a small island nation in the tropical Indian Ocean, southwest of India (Fig. 1). The country is composed entirely of coral atolls, of which there are 26, and on which there are some 1,200 small sandy islands. The population numbers about 300,000, roughly one third of whom live on the capital island of Malé, while the remainder are scattered over some 200

inhabited islands. The Maldivian economy is based almost entirely on fisheries and tourism.

Maldivian tourism is, naturally, much influenced by the country's geography. This lends itself to the development of exclusive island resorts, of which there were 94 operating at the end of 2008 (Ministry of Tourism, Arts, and Culture, 2009). In addition, there is a smaller, but thriving "safari boat" sector, with over 140 registered live-aboard vessels currently in operation (Ministry

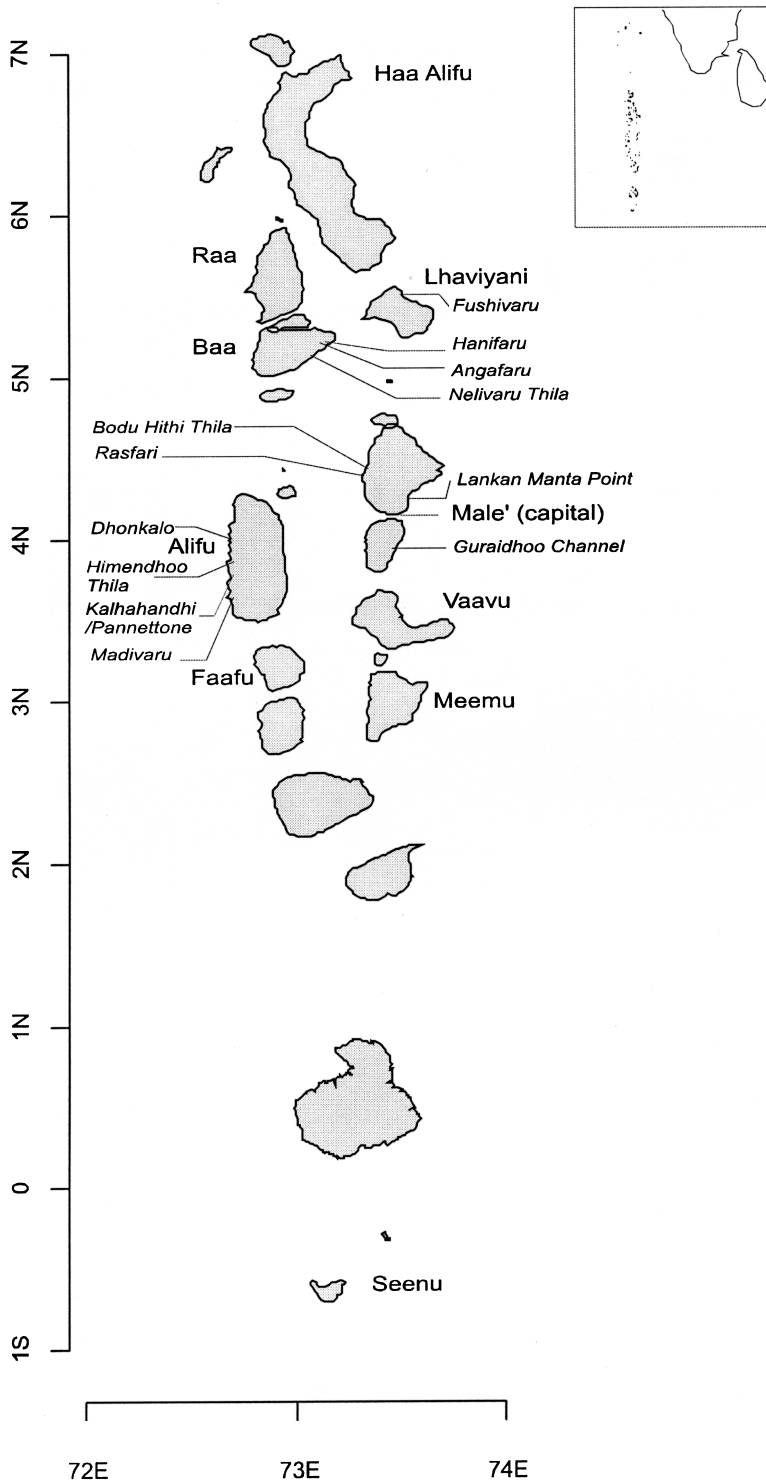


Figure 1. Location map, including positions of major manta diving sites.

of Tourism, Arts, and Culture, 2009). The majority of tourists (75% of arrivals in recent years) come from Europe, with the UK, Italy, and Germany being the largest markets (Ministry of Tourism, Arts, and Culture, 2009). Asia is the next largest regional market, contributing an average of 19% of visitors in recent years (Ministry of Tourism, Arts, and Culture, 2009). Tourism started in 1972 and attracted 683,000 visitors in 2008 (Fig. 2). While the tourist industry grew steadily throughout most of that period, the tsunami of December 26, 2004 had a major impact on tourist arrivals in 2005 and 2006.

The coral reefs of the Maldives are a major attraction for tourists, and diving and snorkeling have always been a key component of Maldivian tourism. While the relative importance of diving has declined in recent years, particularly as more up-market resorts have been developed over the past decade, an estimated 15% of tourists still visit Maldives primarily for diving (Ministry of Tourism and Civil Aviation, 2007). Other tourists also make some dives and many go snorkeling. At the same time the beautiful island and coastal scenery continues to be a major draw. Indeed, there is recognition that the success of Maldivian tourism depends ultimately on the marine environment. As a result, there is awareness of the importance of

environmental issues and the need for sustainability within the tourism industry (Ministry of Tourism and Civil Aviation, 2007). More generally, the new *Constitution of the Republic of Maldives*, ratified in August 2008, enshrines the fundamental importance of environmental protection (Ministry of Legal Reform, Information and Arts, 2008, Article 22). The *Maldives' National Biodiversity Strategy and Action Plan* (Ministry of Home Affairs, Housing, and Environment, 2002) emphasizes the importance of economic forces for biodiversity conservation and specifically calls for economic valuation of ecologically and socially important components of biodiversity.

Manta rays, *Manta alfredi* (formerly *Manta birostris*, see Marshall, Compagno, & Bennett, 2009), are a conspicuous and charismatic component of tropical marine biodiversity. In many parts of the world, but not Maldives, manta rays are caught by a variety of fishing gears, but especially gillnets, in which they are easily entangled (Homma, Mauyama, Itoh, Ishihara, & Uchida, 1999; Noto-bartolo-di-Sciara, 1995; White, Giles, Dharmadi, & Potter, 2006). This and their biological characteristics (including slow growth and small numbers of young) mean that manta ray populations, like those of other chondrichthyan fishes (sharks and rays), can be easily overfished, and once over-

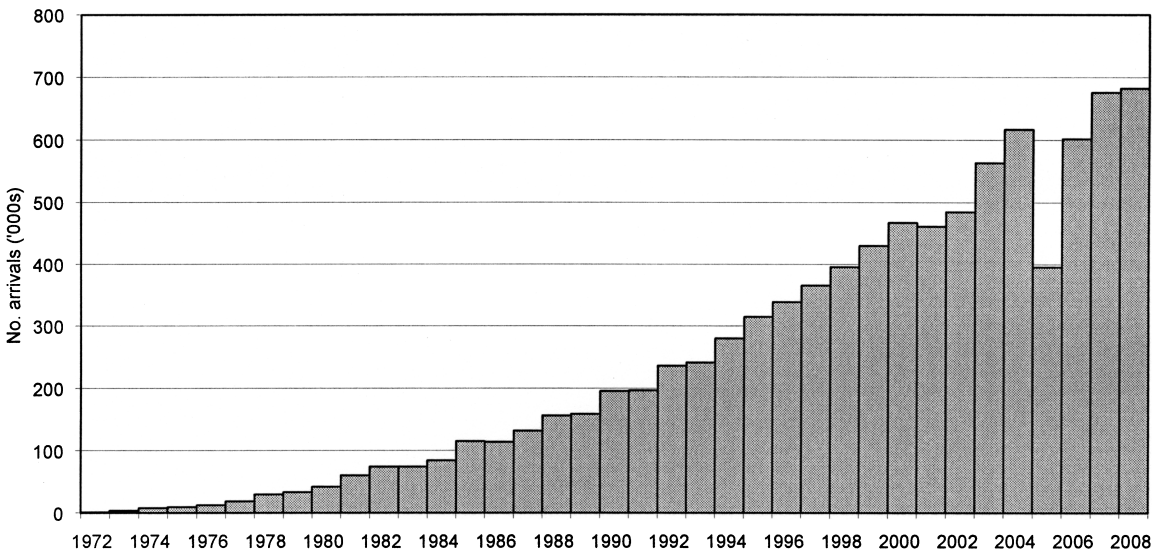


Figure 2. Annual tourist arrivals in the Maldives, 1972–2008 (Ministry of Tourism data, compiled from annual reports).

fished may take decades to recover (Camhi, Fowler, Musick, Brautigam, & Fordham, 1998; Camhi et al., 2009; Dulvy et al., 2008). While manta rays are not thought to be globally endangered (International Union for Conservation of Nature [IUCN] Red List global status Near Threatened), some populations (e.g., around Madagascar, Sri Lanka, India, Indonesia, Philippines, and parts of Mexico) have been heavily fished and may be vulnerable to local extinction (Camhi et al., 2009; Dulvy et al., 2008; IUCN, 2007; Ishihara, 2005; Marshall et al., 2006). Ironically, manta rays are often not even highly prized as food fish (although their gill rakers have recently started to attract high prices for use in Chinese medicine and cuisine). Their meat is often sold at low prices, used as shark bait, or discarded.

In contrast to many fishermen, divers prize manta rays. Divers delight in seeing mantas in their natural environment, and will pay good money to do so. In some areas manta rays occur in regular concentrations, and have become tourist attractions (e.g., off Mozambique, parts of Indonesia, Australia, Philippines, Yap in Micronesia, southern Japan, Hawaii, and Mexico). Because some of these concentrations occur in seas adjacent to relatively poor tropical countries, manta ray tourism may potentially make a major contribution to local economies (Homma et al., 1999), as does shark diving tourism (Anderson & Ahmed, 1993; Norman & Catlin, 2007; Topelko & Dearden, 2005). Furthermore, the economic value of ray and shark tourism may in some cases contribute towards marine research and conservation (Anderson, 2002; Anderson & Waheed, 2001; Burgess, 2005; Newman, Medcraft, & Colman, 2002; Topelko & Dearden, 2005).

In the Maldives, manta rays are relatively common and are a major attraction for tourist divers. Manta ray dive sites feature prominently in Maldivian diving guidebooks (Amsler, 1994; Godfrey, 1996; Harwood & Bryning, 1998), and the Maldives are increasingly described as the “islands of the mantas” (or similar) in advertisements aimed at tourist divers. Waheed (1998) estimated (from a survey of tourists’ willingness to pay) that the *potential* value of manta ray watching in the Maldives was about US\$7.8 million in 1997. That contingent valuation undoubtedly overestimated

the actual value of manta ray diving at that time because the estimate of the extra amount that tourists were willing to pay to take part in one manta dive was applied to all dives. Nevertheless, it is clear that manta ray watching was worth a substantial amount at that time. Waheed (1998) also noted that tourists reported being willing to pay a higher surcharge to see manta rays than to see either sharks or turtles (US\$12.80 per dive, vs. US\$11.80 and US\$10.50, respectively).

The aim of this study is to document for the first time the actual extent and value of manta ray watching by tourist divers and snorkelers in the Maldives.

Method

Study Area

The Maldives archipelago runs north–south from about 7°N to 0.5°S, a total distance of over 800 km (Fig. 1). Until very recently, tourism was confined to the central tourism zone (southern Raa and Lhaviyani Atolls in the north to Dhaalu and Meemu Atolls in the south) plus Haa Alifu Atoll in the far north and Seenu Atoll in the far south. This constitutes approximately 55% of the total atoll area of the Maldives. New resorts opened in all the remaining atolls during 2009–2010, but this study was confined to the more restricted area open to tourism up to 2008.

The oceanography of the Maldives is strongly influenced by the seasonal monsoons. The northeast (NE or boreal winter) monsoon lasts from about December to March, during which time ocean currents are predominantly to the west. The southwest (SW or boreal summer) monsoon lasts from about May to October, during which time ocean currents are predominantly to the east. Within the Maldives, the distribution of mantas is known to be highly seasonal, with mantas typically being present at sites on the downstream sides of the atolls; that is, on the western sides of the atolls during the NE monsoon and on the eastern sides of the atolls during the SW monsoon (Anderson, Adam, & Goes, in press).

Data Sources

Information on the extent and economic value of manta ray watching was obtained from two

sources: (1) from interviews with experienced divers, and (2) from personal observations. Some information was obtained during 2003–2004, but the tsunami of December 2004 disrupted tourism in the Maldives, and all economic activities were impacted. As a result this study was interrupted; it was restarted in early 2006 and completed in June 2008. Information on manta seasonality collected prior to 2006 was retained, but all economic data were recollected.

To obtain information from divers, interviews were conducted with experienced resort dive center staff and safari boat dive guides ($n = 52$), who between them had knowledge of every atoll then open to tourism. Interviews were conducted with base leaders, or the next most experienced person available; interviewees had between 4 and 30 years of full-time diving experience in the Maldives, with most having between 8 and 15 years. Most interviews were conducted in person ($n = 38$), but some were conducted by phone ($n = 14$). Divers were asked to identify all manta dive sites that they used and the months during which mantas were present at those sites. Divers were also asked to give additional information for the one or two manta dive sites that they visited most frequently: cost per dive, frequency of visits (i.e., number of boats per week or month), average numbers of divers per boat, numbers of other diving and snorkeling boats seen at the site(s), and seasonal variations.

Our personal observations between January 2006 and June 2008 included 404 manta dives and 180 manta snorkels at 23 different sites. Numbers of boats were recorded and numbers of divers estimated during each visit; on most occasions visits were of 2–3 hours' duration, but 25 full day counts were made. At the time this article was drafted, the authors had a combined 39 years diving experience in the Maldives, during 27 of which mantas were a particular research interest.

Analysis

For this study we consider only specific dive sites where mantas are a particular attraction. For all such sites, total numbers of dive boats and divers visiting were estimated for the season during which mantas were present (usually 4–6 months;

periods at the beginning and end of the season when mantas are sometimes but not always present were not included). Estimated numbers of dives per season were multiplied by the estimated average cost per dive for that site to give seasonal diving revenue for each site. Dive prices mostly varied between US\$40 and US\$85, depending on dive package (a single dive costs more than one of a multidive package) and operator (dives on liveaboard safari boats are usually included within the holiday price and so are difficult to cost individually, but were estimated conservatively at US\$40; at the other extreme, one manta dive from a top resort as part of an exclusive day excursion could cost US\$750). Sometimes surcharges are applied if special full day excursions were required to visit distant manta sites. Prices used here include boat costs (because everyone must use a boat) but exclude gear hire (because many divers have their own). Average dive prices of US\$45 to US\$70 were applied to different sites, the lower values being for sites most frequented by liveaboard safari boats, while the higher values applied to sites used mainly by top-end resorts.

Snorkeler numbers and revenue were estimated only for those few sites where snorkeling with mantas is a major activity; at many other manta sites some snorkeling does take place, but it has not been quantified. Snorkeler numbers were estimated in a similar way to diver numbers. An average snorkel excursion cost of US\$20 was roughly estimated from information received from interviews and additional ($n = 9$) inquiries at resorts (range from free of charge to US\$50, mostly US\$15–25).

Results

Extent and Value of Manta Watching

A total of 91 specific manta ray dive sites were identified; these were distributed throughout the entire area where tourism was allowed (Fig.3). Snorkeling is a significant activity at 10 of these sites (where the mantas occur on reefs shallow enough to be clearly visible from the surface).

The extent and value of manta ray watching by divers is summarized in Table 1 and by snorkelers in Table 2. It is estimated that on average some 143,000 manta ray dives and at least 14,000 manta

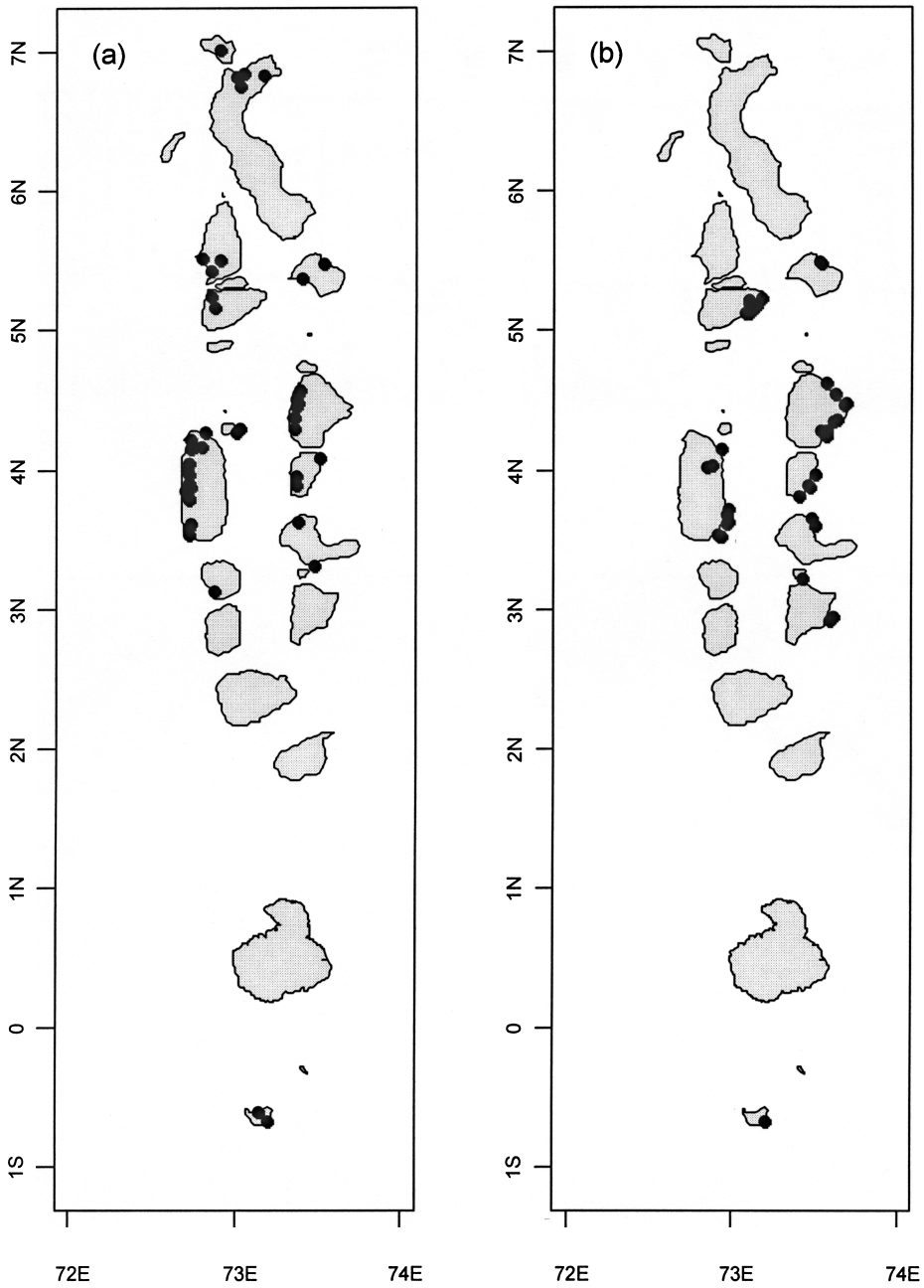


Figure 3. Seasonal distribution of manta rays as reported by divers (each dot represents one dive site, at which mantas are reported to be present in that season). (a) NE monsoon season. (b) SW monsoon season.

Table 1
Estimated Annual Extent and Value (US\$)
of Manta Ray Diving by Atoll

Atoll	No. Sites	No. Boats	No. Divers	Value
Haa Alifu	5	210	1,700	\$119,000
Raa	5	132	1,188	\$58,320
Baa	12	2,411	19,230	\$1,087,550
Lhaviyani	3	442	5,310	\$269,550
North Malé	18	3,423	36,231	\$1,798,700
South Malé	9	998	11,068	\$602,900
North Alifu	13	1,183	14,796	\$880,560
South Alifu	15	3,770	44,840	\$2,494,200
Vaavu	6	685	7,045	\$409,275
Meemu	2	90	810	\$40,500
Faafu	1	32	256	\$14,080
Seenu	2	60	480	\$26,400
Total	91	13,436	142,954	\$7,801,035

ray snorkels were made per year during 2006–2008. This was worth an estimated US\$8.1 million per year in direct diving and snorkeling revenue. Total revenue, including accommodation and food, has not been estimated, but must be much more. Major manta ray sites (those generating an estimated annual revenue in excess of US\$200,000) are listed in Table 3, and can be located in Figure 1.

Accuracy of Results

The estimates of the extent and value of manta watching presented here do demonstrate the scale of economic interest in this tourist activity. However, we recognize that these estimates may not be especially accurate. In particular, estimating diver and snorkeler numbers by multiplying up number of boats per month by average number of occupants per boat and then again by average cost per participant may tend to produce overestimates. With this in mind, we have been conservative in

Table 2
Estimated Annual Extent and Value (US\$)
of Manta Ray Snorkeling by Atoll

Atoll	No. Sites	No. Boats	No. Snorkelers	Value
Baa	2	200	2,000	\$40,000
North Malé	3	335	4,020	\$80,400
South Malé	2	310	3,560	\$71,200
South Alifu	3	420	4,440	\$88,800
Total	10	1,265	14,020	\$280,400

our approach. In estimating site averages we have ignored the highest reports of boat numbers, divers (and snorkelers) per boat, and cost per dive. And we have not included: diver numbers at the beginning and end of each season, when mantas may not always be present; all dive data from four recognized manta sites where mantas are present for only part of the season; and snorkel data from any but the most popular manta snorkeling sites.

As a rough check on the accuracy of our results, we note that 683,000 tourists visited the Maldives in 2008 (Ministry of Tourism, Arts, and Culture, 2009), that the average duration of stay was 8.8 days (Ministry of Tourism, Arts, and Culture, 2009), and that 15% of arrivals come primarily for diving (Ministry of Tourism and Civil Aviation, 2007). Assuming that these dedicated divers make an average of 15 dives each, and that other visitors make an average of 0.25 dives each, then a total of about 1.7 million dives were made in Maldives in 2008. With our estimated annual average of 143,000 manta dives, this implies that something of the order of 1 dive in 12 was a manta dive. Resort-based divers typically make about 12 dives per week, and about one manta dive per week during the season when mantas are present in the vicinity of their resort, plus occasion excursions to more distant manta sites during the other season, so roughly 1 dive in 20 might be a manta dive. Liveaboard divers typically make 18 dives per week, and about 2 manta dives per week, so roughly 1 dive in 9 would be a manta dive. Our average estimate of 1 manta dive in 12 is therefore within reasonable bounds.

As a second check on our results, we note that a more detailed study of one manta dive site (Hanifaru in Baa Atoll) in 2009 estimated total seasonal revenue of about US\$330,000 (Stevens, unpublished data). Because diver and snorkeler visits to this particular site are known to be increasing, our estimate of US\$241,000 per year for the period 2006–2008 appears reasonable.

Discussion

Extent of Manta Watching

A total of 91 dive sites were identified where manta ray watching is a significant attraction for divers and snorkelers. Manta diving sites occur

Table 3
Major Manta Ray Diving and Snorkeling Sites (Value in US\$)

	Atoll	Site	Main Season	Annual Value
1	South Alifu	Madivaru	NE	\$1,164,800
2	North Malé	Lankan Manta Point	SW	\$766,500
3	South Malé	Guraidhoo Channel	SW	\$609,300
4	North Malé	Bodu Hithi Thila	NE	\$588,600
5	South Alifu	Kalhahandi/Panettone	NE	\$547,200
6	North Alifu	Dhonkalo	NE	\$468,000
7	South Alifu	Himendhoo Thila	NE	\$432,000
8	Baa	Hanifaru	SW	\$241,000
9	Baa	Angafaru	SW	\$240,000
10	Lhaviyani	Fushifaru	SW (&NE)	\$229,950
11	Baa	Nelivaru Thila	SW	\$227,500

throughout the area open to tourism up to 2008. That comprised some 55% of the total atoll area, so it is to be expected that many more manta diving sites will be developed in the coming years as tourism spreads to every atoll in the country. It was estimated that during 2006–2008 an average of some 143,000 manta ray dives and at least 14,000 manta ray snorkels were made annually. We are not aware of any other published estimates of numbers of manta ray dives for any other country that would allow comparison. But clearly these are not insignificant figures.

In other areas where manta ray diving is carried out, the number of separate manta dive sites is relatively small. In addition, in other areas where mantas have been studied, the local populations have generally been estimated to be of the order of 50–350 individuals (Marshall et al., 2006). In contrast, the Maldives is home to thousands of manta rays (authors' personal observations and unpublished data). It seems clear that Maldives supports a particularly large population of manta rays, and this in turn supports a particularly large manta watching industry.

Value of Manta Watching

We estimate that diving and snorkeling with manta rays was worth about US\$8.1 million per year in direct revenue during 2006–2008.

Because there is little or no market for manta rays in the Maldives, it is not possible to estimate their local fisheries value. However, manta rays

are caught and sold elsewhere in south Asia, normally at low prices. In western Pakistan in 2002, manta rays were sold for up to Pakistani Rupees 1500 (about US\$22) depending on size (Ali, Arshad, & Akhtar, 2002). In Sri Lanka, mantas are taken as by-catch in gillnets, and occasionally harpooned; catches are believed to have declined over the past decade (Leslie Joseph, personal comments, July 2008). In Sri Lanka in July 2008, manta meat was selling for about Rs 135 per kg (about US\$1.25) wholesale, and Rs 240–320 per kg (US\$2.25–3.00) retail (Leslie Joseph and Asha de Vos, personal comments, July 2008). Even at the highest Sri Lankan retail prices, a 100-kg manta would be worth just US\$300; fishermen would likely receive less than half this amount. A rapidly developing market for manta gill rakers for use in Chinese medicine and cuisine may inflate market prices, but it is still the case that prices paid to fishermen are relatively low.

From photo-identification analysis it is known that several hundred manta rays regularly frequent Lankan Manta Point in North Malé Atoll, but that roughly 75% of sightings are from a core group of about 120 individuals (A.-M. Kitchen-Wheeler and G. Stevens, unpublished data). Because it is the regular occurrence of mantas that makes this dive site so attractive, it could be argued that these 120 individuals are responsible for 75% of revenue. Because this site generates over US\$760,000 per year (Table 3), this suggests that each one of these mantas is worth something over US\$4,700 per year in terms of diving revenue generated. But

manta rays live for many years (Homma et al., 1999). One individual female has been individually identified as part of a photo-identification project many times at Lankan Manta Point over 20 years, between 1989 and 2009 (G. Stevens, unpublished data). Thus, the life time value of individual mantas in Maldives may be 20 or more times their annual worth, perhaps something of the order of US\$100,000 at current prices. In contrast, a dead manta is likely to be worth much less than US\$500 elsewhere in south Asia.

Such comparisons make the point that mantas can be worth very much more alive than dead, but they are simplistic. For example, they take no account of displacement effects: if tourists spend their money on diving with mantas, they may have less money to spend on other activities or purchases. They also fail to consider the distribution of revenue. Thus, revenues from fish catches accrue not only to fishermen but also to many others involved in the fishing industry (Chen & Phipps, 2002). Furthermore, diving revenue does not multiply in the way that fish sales do (from fisherman to wholesaler to retailer), and much of it leaks away from local communities (although the diving industry does employ many Maldivians).

With this type of situation in mind, Rodriguez-Dowdell, Enriquez-Andrade, and Cardenas-Torres (2007) have argued, in the case of whale shark watching in Mexico, for the concession of property rights to local operators in order to maximize benefits to local communities. Such an approach is unlikely to find much support in the Maldives, where marine resources are traditionally seen as open access. Nevertheless, the equitable distribution of benefits from diving, and indeed tourism in general, remains an issue of concern in the Maldives (Ministry of Tourism and Civil Aviation, 2007).

Manta Ray Protection

Despite these concerns, the wide (but previously unquantified) recognition of the value of manta rays to Maldivian diving tourism has contributed to their protection.

Even without any formal economic investigations, it was recognized in the mid-1990s that manta rays were a valuable resource for tourism

(R. C. Anderson, personal observations). As a direct result, the export of all rays was banned from June 24, 1995. Subsequently, the export of ray skins was specifically banned from January 1, 1996 (in response to an attempt by a local company to start ray skin exports). Other protection has come in the form of, mostly small, marine protected areas, of which there are currently 32 in the Maldives. Five of these were designated specifically because of the seasonal presence of mantas (Table 4). However, a more effective form of protection for manta rays in the Maldives is indirect: most types of net fishing (including pelagic gill-netting, trawling, and purse seining) have long been banned, to protect the interests of the traditional pole and line tuna fishermen.

At the time when the export bans were introduced, in 1995–1996, it would have been possible to introduce a total ban on ray catching. That was not done in recognition of the traditional rights of fishermen (R. C. Anderson, personal observations). Manta rays were traditionally caught in small numbers in the Maldives, mainly by harpoon. The largest single cause of fishing mortality was probably the small but regular catch of manta rays by harpoon for use as bait in a specialized fishery for tiger sharks, *Galeocerdo cuvier* (Anderson & Ahmed, 1993). Large tiger sharks were targeted for their enormous livers, which yielded large quantities of oil needed for treating wooden fishing boats. That fishery died out in the 1960s, when more efficient long-lining was introduced. Small numbers of manta rays (and stingrays) have continued to be taken for oil, bait, and skins.

Although local fishermen may still take some manta rays, the ban on exports has had the desired effect of forestalling the development of a major fishery. This provides an instructive comparison with reef sharks, which have also been a major attraction for tourist divers in the Maldives (Anderson, 2002; Anderson & Ahmed, 1993; Anderson & Waheed, 2001; Godfrey, 1996; Harwood & Bryning, 1998).

As with mantas, there is little demand for shark products within the Maldives. But there is a fishery for reef sharks, with the high international price of shark fins driving demand, and most shark catches being exported. In the early 1990s, valuation of shark watching by tourist divers in the

Table 4
Protected Dive Sites at Which Manta Rays Are a Significant Attraction

Atoll	Site	Area	Date Established
Baa	Hanifaru	303 Ha	June 6, 2009
Lhaviyani	Fushifaru Thila	4 Ha	October 1, 1995
North Malé	Rasfari	835 Ha	October 1, 1995
South Malé	Guraidhoo Channel	88 Ha	October 1, 1995
South Alifu	Madivaru (=Faruhuruvalhi)	60 Ha	October 21, 1999

Maldives (Anderson & Ahmed, 1993) demonstrated that reef sharks were worth very much more alive as tourist attractions than dead on a fishing boat. That finding directly influenced government decisions to initiate marine protected areas in 1995 and subsequently to ban all shark fishing in the central tourism zone in 1998. These management initiatives have not been particularly successful in conserving reef shark stocks (Anderson, 1998; Anderson & Waheed, 1999, 2001). However, they did probably slow the decline of reef shark numbers and provided the foundation for a complete ban on reef shark fishing from March 1, 2009, to be followed in 2010 by a complete ban on all shark fishing and shark product exports.

Despite an awareness of the value of shark diving to the national economy, and the introduction of conservation measures (including the declaration of marine protected areas and a ban of shark fishing in some atolls), reef shark numbers continued to decline and reef shark numbers are very much less now than they were in the 1980s and early 1990s (Anderson, 1998; Anderson & Waheed, 1999; personal observations). Without the precautionary ban on ray exports, which was introduced in direct recognition of the value of manta rays to tourism, it is likely that Maldivian manta rays would have suffered the same fate as the reef sharks.

In addition to contributing to their protection, the wide recognition of the value of manta rays to diving tourism also contributes to research on their biology. Many tourist divers visit Maldives in the specific expectation of seeing mantas. Two of this article's authors (A.-M. Kitchen-Wheeler & G. Stevens) are employed by tourism companies. Their employers recognize the attraction of mantas for divers and the value of offering well-informed

manta diving and snorkeling excursions. These companies (and others) use mantas in their marketing, and they have facilitated these authors' manta research. This research is improving understanding of manta ray biology, with consequently improved opportunities for divers and snorkelers to have successful encounters with mantas.

Negative Impacts

Wildlife tourism, both marine and terrestrial, can potentially bring benefits for both animals (in terms of better conservation measures) and local communities (e.g., in terms of improved employment opportunities). However, it is clear not only that these potential benefits are often not fully realized but also that wildlife tourism can itself have negative impacts (Cater & Cater, 2007; Garrod & Wilson, 2003; Higham & Lück, 2007; Newsome, Dowling, & Moore, 2005). Despite this, research on tourism impacts is often lacking or insufficient to inform policy decisions and management actions (Lück & Higham, 2007; Rodger & Calver, 2005). This is particularly the case for marine wildlife tourism. But where such detailed information is available, and demonstrates unsustainable practices, it can influence political decisions to manage tourist activities (Higham & Bejder, 2008).

In the case of manta rays in the Maldives, this study was not designed to address issues of tourism impacts. However, it is clear from our own observations, and from interviews with some experienced dive operators, that there are issues of concern. In contrast, several other dive operators appeared unaware or unconcerned about potential impacts of their activities on the manta rays. During interviews some divers pointedly referred to manta watching as a form of ecotourism, which was implied to be a "good thing." To the extent

that manta watching involves observing wild animals in their natural habitat, and has contributed to manta conservation, this may be true. However, most definitions of ecotourism also note that it should have no negative impact on the environment or the animals being observed, and that it should include some element of education (e.g., Cater & Cater, 2007; Garrod & Wilson, 2003; Higham & Lück, 2007; Newsome et al., 2005). In our experience, these last two requirements are often not met in the Maldives.

At the most popular manta dive sites it is quite common to have several dive boats visiting at the same time. On occasion there can be 10 or more boats present and over 100 divers and snorkelers in the water at once. This raises questions about diver and snorkeler safety, and about impacts on the mantas. During the NE monsoon season in 2007–2008, remarkably small numbers of manta rays were seen at many normally productive manta dive sites. The reasons for this are unknown. Nevertheless, we feel, and some experienced divers also suggested, that the large numbers of tourist divers and snorkelers visiting these sites could have caused the mantas to move elsewhere. An alternative hypothesis proposed by other divers was that an unknown change in oceanographic conditions caused the mantas to desert these sites. Because good numbers of mantas were seen at several little-visited sites, both within and without the main tourism area (personal observations), the former explanation seems more likely. (As a counterexample, some individual mantas seem to actively search out interaction with divers—for example, repeatedly “playing” in divers’ exhaust bubbles.) While anecdotal accounts such as this are intriguing, the lack of research on diver impacts on mantas does need to be rectified. If, as seems likely, excessive numbers of divers and snorkelers at some sites are affecting manta ray behavior and numbers, then the long-term impact of this disturbance needs to be assessed, and appropriate management strategies introduced.

One factor contributing to the negative impacts of divers on manta rays at some sites may be a lack of tourist education. While all dive operators do brief clients before dives, these briefings are often inadequate. For example, even though most

divers are told not to touch mantas, some still do so. More generally, dive operators themselves do not always appear fully aware of the need to behave sensitively towards the mantas. Some dive operators do provide very well-informed briefings before manta dives (and in a few cases even offer specialty manta diving courses). However, in our experience the majority of dive operators in Maldives provide little information about mantas before their dives. Most divers and snorkelers do come away from their encounters with manta rays with feelings of contentment, exhilaration, and even awe, but with little or no additional knowledge to inform their experience. In other areas of marine wildlife watching, notably cetacean watching, onboard education and interpretation are seen as powerful tools to improve tourist understanding and satisfaction, to minimize disappointment if expectations are not met, and to promote conservation (e.g., Andersen & Miller, 2006; Zeppel & Mulion, 2008). This too is an area where manta watching in the Maldives could be improved.

Conclusions

In summary, an estimated US\$8.1 million was spent annually on diving and snorkeling excursions to see manta rays in the Maldives during 2006–2008. The high value of manta rays, and of other large marine animals, contributes not only to the development of marine tourism within the Maldives, but also to both research and conservation. Nevertheless, there are indications that at the most popular manta dive sites, the large numbers of visiting divers and snorkelers are having a negative impact on manta numbers. Tourist education needs to be improved, and regulation of diver numbers at some sites may be necessary.

Acknowledgments

We thank the many dive base leaders, dive instructors, and dive guides who provided information for this study. We also thank Leslie Joseph and Asha de Vos for information from Sri Lanka, and two anonymous referees for their pertinent comments on an earlier version of this article. R. Charles Anderson is especially grateful to the Lintilhac Conservation and Research Foundation, and to Crea Lintilhac and Jeffrey Griffin in particular,

for a grant towards the costs of this study. Anne-Marie Kitchen-Wheeler thanks Maldives Scuba Tours for their active support of her research. Guy Stevens thanks the Four Seasons Resorts Maldives and the Save Our Seas Foundation for their support of his work.

Biographical Notes

R. Charles Anderson, Ph.D., is a marine biologist and has been resident in the Maldives since 1983. With Maldivian colleague Hudha Ahmed he conducted the first survey of the value of shark watching by tourist divers in 1992. He has been a member of the IUCN Shark Specialist Group since 1993, and started research on Maldivian mantas in 1996.

M. Shiham Adam, Ph.D., studied in the UK and was post-doctoral fellow at the University of Hawaii at Manoa from 2000 to 2003, modeling ocean-scale movements of pelagic fishes. Since returning to Maldives in 2003, he has worked at the national Marine Research Centre. He is now Director General, managing both fisheries and coral reef research.

Anne-Marie Kitchen-Wheeler has worked in the diving tourism industry in Maldives since 2001. She is currently enrolled as a Ph.D. student at Newcastle University, UK, studying the behavioral ecology of mantas in the Maldives.

Guy Stevens is Senior Marine Biologist for Four Seasons Resorts in the Maldives and the founder of the Maldivian Manta Ray Project. This nonprofit organization aims to further the research on, conservation of, and education about manta rays. Guy is planning to start work on a Ph.D. shortly, using his Maldivian manta data.

Coordinating Editor: Anna Thompson

References

- Ali, Z., Arshad, M., & Akhtar, M. (2002). *Biological analysis of Mekran Coastal Wetlands Complex, Pakistan*. Unpublished report, WWF Pakistan.
- Amsler, K. (1994). *Maldives diving guide*. Italy: Whitestar.
- Andersen, M. S., & Miller, M. L. (2006). Onboard marine environmental education: Whale watching in the San Juan Islands, Washington. *Tourism in Marine Environments*, 2, 111–118.
- Anderson, R. C. (1998). Sharks mean business. *Scientific American Presents*, 9(3), 72–73.
- Anderson, R. C. (2002). Elasmobranchs as a recreational resource. In S. L. Fowler, T. M. Reed, & F. A. Dipper (Eds.), *Elasmobranch biodiversity, conservation and management: Proceedings of an international seminar and workshop, Sabah, Malaysia, July 1997* (pp. 46–51). Gland, Switzerland and Cambridge, UK: IUCN SSC Shark Specialist Group.
- Anderson, R. C., Adam, M. S., & Goes, J. I. (in press). From monsoons to mantas: Seasonal distribution of *Manta alfredi* in the Maldives. *Fisheries Oceanography*.
- Anderson, R. C., & Ahmed, H. (1993). *The shark fisheries in the Maldives*. Rome: FAO, and Malé: Ministry of Fisheries and Agriculture.
- Anderson, R. C., & Waheed, Z. (1999). Management of shark fisheries in the Maldives. In R. Shotton (Ed.), *Case studies of the management of Elasmobranch fisheries* (pp. 367–401). Rome: FAO.
- Anderson, R. C., & Waheed, A. (2001). The economics of shark and ray watching in the Maldives. *Shark News*, 13, 1–3.
- Burgess, G. H. (2005). Ecotourism. In S. L. Fowler, R. D. Cavanagh, M. Camhi, G. H. Burgess, G. M. Caillet, S. V. Fordham, C. A. Simpendorfer, & J. A. Musick (Eds.), *Sharks, rays and chimaeras: The status of chondrichthyan fishes* (pp. 32–34). Gland, Switzerland and Cambridge, UK: IUCN SSC Shark Specialist Group.
- Camhi, M., Fowler, S., Musick, J. A., Brautigam, A., & Fordham S. V. (1998). Sharks and their relatives: Ecology and conservation. *Occasional Paper of the IUCN Species Survival Commission*, 20, 1–39.
- Camhi, M. D., Valenti, S. V., Fordham, S. V., Fowler, S. L., & Gibson, C. (2009). *The conservation status of pelagic sharks and rays: Report of the IUCN Shark Specialist Group pelagic shark red list workshop*. Newbury, UK: IUCN SSC Shark Specialist Group.
- Cater, C., & Cater, E. (2007). *Marine ecotourism: Between the devil and the deep blue sea*. Wallingford, UK: CABI Publishing.
- Chen, V. Y., & Phipps, M. J. (2002). *Management and trade of whale sharks in Taiwan*. Taipei: TRAFFIC-East Asia.
- Dulvy, N. K., Baumb, J. K., Clarke, S., Compagno, L. J. V., Cortes, E., Domingo, A., Fordham, S., Fowler, S., Francis, M. P., Gibson, C., Martinez, J., Musick, J. A., Soldo, A., Stevens, J. D., & Valenti, S. (2008). You can swim but you can't hide: The global status and conservation of oceanic pelagic sharks and rays. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 18, 459–482.
- Garrod, B., & Wilson, J. C. (Eds.). (2003). *Marine ecotourism: Issues and experiences* (Aspects of Tourism, 7). Clevedon, UK: Channel View Publications.
- Godfrey, T. (1996). *Dive Maldives*. Melbourne: Atoll Editions.
- Harwood, S., & Bryning, R. (1998). *The dive sites of the Maldives*. London: New Holland.
- Higham, J. E. S., & Bejder, L. (2008). Managing wildlife-based tourism: Edging slowly toward sustainability? *Current Issues in Tourism*, 11, 75–83.

- Higham, J. E. S., & Lück, M. (2007). Ecotourism: Pondering the paradoxes. In J. E. S. Higham (Ed.), *Critical issues in ecotourism: Understanding a complex tourism phenomenon* (pp. 117–135). Oxford, UK: Elsevier Butterworth Heinemann.
- Homma, K., Mauyama, T., Itoh, T., Ishihara, H., & Uchida, S. (1999). Biology of the manta ray, *Manta birostris* Walbaum, in the Indo-Pacific. In B. Séret & J.-Y. Sire (Eds.), *Proceedings of the fifth Indo-Pacific fish conference, Noumea, 1997* (pp. 209–216). Paris: Société Française Ichtyologique.
- Ishihara, H. (2005). Manta ray *Manta birostris* (Donndorff, 1798). In S. L. Fowler, R. D. Cavanagh, M. Camhi, G. H. Burgess, G. M. Cailliet, S. V. Fordham, C. A. Simpendorfer, & J. A. Musick (Eds.), *Sharks, rays and chimaeras: The status of chondrichthyan fishes* (pp. 356–357). IUCN, Gland, Switzerland and Cambridge, UK: IUCN SSC Shark Specialist Group.
- International Union for Conservation of Nature. (2007). Review of migratory chondrichthyan fishes. Prepared by Shark Specialist Group of the IUCN Species Survival Commission on behalf of the CMS Secretariat. *CMS Technical Series, 15*, 1–68.
- Lück, M., & Higham, J. E. S. (2007). Marine wildlife and tourism management: Scientific approaches to sustainable management. In J. E. S. Higham & M. Lück (Eds.), *Marine wildlife and tourism management: Insights from the natural and social sciences* (pp. 380–388). Wallingford, UK: CABI.
- Marshall, A. D., Compagno, L. J. V., & Bennett, M. B. (2009). Redescription of the genus *Manta* with resurrection of *Manta alfredi* (Krefft, 1868) (Chondrichthyes; Myliobatoidei; Mobulidae). *Zootaxa, 2301*, 1–28.
- Marshall, A., Ishihara, H., Dudley, S. F. J., Clark, T. B., Jorgensen, S., Smith, W. D., & Bizzarro, J. J. (2006). *Manta birostris*. In *IUCN 2009. IUCN Red List of Threatened Species. Version 2009.2*. Retrieved from www.iucnredlist.org
- Ministry of Home Affairs, Housing and Environment. (2002). *National biodiversity strategy and action plan*. Malé: Author.
- Ministry of Legal Reform, Information and Arts. (2008). *Constitution of the Republic of Maldives 2008*. Functional translation by D. Hussein. Retrieved from www.presidencymaldives.gov.mv/publications/constitution.pdf
- Ministry of Tourism, Arts and Culture. (2009). *Tourism yearbook 2009*. Malé: Author.
- Ministry of Tourism and Civil Aviation. (2007). *Maldives third tourism master plan 2007–2011*. Malé: Author.
- Newman, H. E., Medcraft, A. J., & Colman, J. G. (2002). Whale shark tagging and ecotourism. In S. L. Fowler, T. M. Reed, & F. A. Dipper (Eds.), *Elasmobranch biodiversity, conservation and management: Proceedings of an international seminar and workshop, Sabah, Malaysia, July 1997* (pp. 230–235). Gland, Switzerland and Cambridge, UK: IUCN SSC Shark Specialist Group.
- Newsome, D., Dowling, R. K., & Moore, S. A. (2005). *Wildlife tourism. Aspects of tourism 24*. Clevedon, UK: Channel View Publications.
- Norman, B., & Catlin, J. (2007). *Economic importance of conserving whale sharks*. Australia: International Fund for Animal Welfare. Retrieved from www.whalesharkfest.com/pdf/economicimportance.pdf
- Notobartolo-di-Sciara, G. (1995). What future for manta rays? *Shark News, 5*, 1.
- Rodriguez-Dowdell, N., Enriquez-Andrade, R., & Cardenas-Torres, N. (2007). Property rights-based management: Whale shark ecotourism in Bahia de los Angeles, Mexico. *Fisheries Research, 84*, 114–118.
- Rodger, K., & Calver, M. (2005). Natural science and wildlife tourism. In D. Newsome, R. K. Dowling, & S. A. Moore, (Eds.), *Wildlife tourism* (Aspects of Tourism 24) (pp. 217–234). Clevedon, UK: Channel View Publications.
- Topelko, K. N., & Dearden, P. (2005). The shark watching industry and its potential contribution to shark conservation. *Journal of Ecotourism, 4*, 108–128.
- Waheed, A. (1998). *Economic value of marine ecotourism to the Maldives*. Unpublished B.Sc. thesis, Institute of Marine Sciences, University of Plymouth, UK.
- White, W. T., Giles, J., Dharmadi, & Potter, I. C. (2006). Data on the bycatch fishery and reproductive biology of mobulid rays (Myliobatiformes) in Indonesia. *Fisheries Research, 82*, 65–73.
- Zeppel, H., & Mulion, S. (2008). Conservation and education benefits of interpretation on marine wildlife tours. *Tourism in Marine Environments, 5*, 215–227.