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**The economic value of shark-diving tourism in Australia**

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**Abstract**

Shark-diving is part of a rapidly growing industry focused on marine wildlife tourism. Our study aimed to provide an estimate of the economic value of shark-diving tourism across Australia by comprehensively surveying the whale shark (*Rhincodon typus*), white shark (*Carcharodon carcharias*), grey nurse shark (Carcharias taurus), and reef shark (mostly *Carcharhinus amblyrhynchos* and *Triaenodon obesus*) diving industries using a standardised approach. A socio-economic survey targeted tourist divers between March 2013 and June 2014 and collected information on expenditures related to diving, accommodation, transport, living costs, and other related activities during divers’ trips. A total of 711 tourist surveys were completed across the four industries, with the total annual direct expenditure by shark divers in Australia estimated conservatively at $25.5 M. Additional expenditure provided by the white-shark and whale-shark-diving industries totalled $8.1 M and $12.5 M for the Port Lincoln and Ningaloo Reef regions respectively. International tourists diving with white sharks also expended another $0.9 M in airfares and other activities while in Australia. These additional revenues show that the economic value of this type of tourism do not flow solely to the industry, but are also spread across the region where it is hosted. This highlights the need to ensure a sustainable dive-tourism industry through adequate management of both shark-diver interactions and biological management of the species on which it is based. Our study also provides standardised estimates which allow for future comparison of the scale of other wildlife tourism industries (not limited to sharks) within or among countries.

**Keywords:** economic evaluation;grey nurse sharks;reef sharks;whale sharks; white sharks; wildlife tourism

**Running head:** Value of Australia’s shark-tourism industry

**Introduction**

Tourism is arguably the world’s largest industry (Wearing and Neil 2009). Wildlife tourism is a relatively recent development and is one of the fastest growing sectors of the tourism industry (Scheyvens 1999, Wearing and Neil 2009). It has resulted from changes in fundamental societal values that have increased motivations to experience and preserve natural environments (Diamantis 2004), together with growth of real incomes that have increased the affordability of tourism for many people. Although wildlife tourism can sometimes be a threat to the species it targets and the ecosystems they inhabit (Duffus and Dearden 1990, Shackley 1996) and has the potential to produce a range of negative effects (for reviews see: Green and Higginbottom 2001, Orams 2002, Green and Giese 2004, Burgin and Hardiman 2015), it can also have many benefits. For tourists, these include a sense of well-being and better psychological health (Curtin 2009, Ballantyne, Packer et al. 2011), education, and improved conservation awareness (Wilson and Tisdell 2003, Zeppel 2008, Apps, Dimmock et al. 2017) and for society as a whole, economic benefits to the regions supporting the industry (Wells 1997, Dwyer, Forsyth et al. 2010). The latter is particularly relevant in developing countries where wildlife tourism can be a significant source of income and is increasingly seen as an alternative to the extractive and destructive uses of these resources by hunting and fishing (Higginbottom and Tribe 2004, Huveneers and Robbins 2014). Shark diving in Palau, for example, has been estimated to be the third highest contributor to the gross tax revenue in the country, and responsible for the disbursement of US$1.2 million in salaries to the local community (Vianna, Meekan et al. 2012). Increasing economic benefits was one the key motivation for the establishment of a shark sanctuary in Palau, an outcome of benefit to the target species. The presence of the tourism industry may support the enforcement of management regulations and the conservation of shark populations in other regions or countries with dive sites (Vianna, Meekan et al. 2016).

Approximately 590,000 divers per year engage in shark-diving activities worldwide (Cisneros-Montemayor, Barnes-Mauthe et al. 2013). Gallagher and Hammerschlag (2011) identified 376 established shark-tourism operations in 83 locations, spanning 29 different countries, and Huveneers and Robbins (2014) found that shark tourism provides the opportunity to dive with 51 different species of shark and ray. Economic valuations of shark-diving tourism are relatively recent, with 50% published between 2009 and 2014 (Huveneers and Robbins 2014), and rare compared to more mature industries such as whale-watching (O’Connor, Campbell et al. 2009). Valuations are also geographically biased, as most studies (65%) focused on small island nations or developing countries (Huveneers and Robbins 2014), possibly due to the greater importance of tourism to these economies. Only one study by Cisneros-Montemayor, Barnes-Mauthe et al. (2013) has attempted to make an estimate of the global value of the industry and this has been criticised for a reliance on unrealistic assumptions (Brunnschweiler and Ward-Paige 2014). Other studies have attracted criticism for expressing their results in term of life-time valuations for individual sharks (Catlin, Hughes et al. 2013), although Vianna, Meekan et al. (2013) show that this criticism is largely unfounded. Overall, there is a lack of studies at large spatial scales that synthesise the results of evaluations that are transparent in their goals and methods. This remains an impediment to a better understanding of the impact of this type of tourism on economies and to the assessment of arguments for the growth of these industries and conservation of the species they target.

In Australia, there are four major tourism industries that focus on shark diving: snorkelling with whale sharks off Ningaloo Reef (Western Australia), cage-diving with white sharks off Port Lincoln (South Australia), diving with grey nurse sharks off the coast of New South Wales, and diving with reef sharks at Osprey Reef (Queensland). Of these, three (whale, white, and reef sharks) have been subject of economic valuation studies (Catlin, Jones et al. 2010, Stoeckl, Birtles et al. 2010, Bradford and Robbins 2013). Evaluations of both the whale and reef shark industries occurred at a time when patronage by tourists was very different than it is at present. For whale sharks, valuations were made over a decade ago (Catlin and Jones 2010), prior to a large global expansion of the industry (Gallagher and Hammerschlag 2011). The number of operators in the reef shark industry at Osprey Reef has recently declined from five to two, resulting in a 60–70% reduction in the number of tourists participating in these dives. For white sharks, the earlier evaluation used a rapid assessment technique that relied on assumptions about expenditure rather than surveys of actual spending (Bradford and Robbins 2013). It also only accounted for a portion of outlays (travel, accommodation, and tour costs) and did not include other related expenditures by tourists.

Our study aimed to provide a reliable estimate of the value of shark-diving tourism across Australia using a standardised and comprehensive survey of the whale, white, grey nurse, and reef shark diving industries. This involved scripted interviews and questionnaires with clients and operators of tourism businesses. These methods have been used previously to survey the economic value of shark diving in Palau (Vianna, Meekan et al. 2012), Fiji (Vianna, Meeuwig et al. 2011) and Malaysia (Vianna and Meekan 2012), and provide estimates that allow realistic comparisons within or among countries.

**Methods**

Measuring economic value

In this study, economic value refers to the revenues generated within each of the four Australian shark-diving industries and by associated sectors that support these industries. We recognise that revenue does not provide a measure of net economic benefits from the industry. For that, we would need to estimate both the supply and the demand curve for shark-diving to calculate producer surplus and consumer surplus (Just, Hueth et al. 2004), and the costs of establishing and enforcing policies or regulations that underpin the industries. There is a lack of market data that would be needed for statistical estimation of supply and demand curves. Nevertheless, revenue provides a useful indicator of the economic importance of the industry, and is consistent with common economic metrics such as Gross Domestic Product (Vianna, Meekan et al. 2012). It would have been possible to provide an estimate of economic benefits to the tourism operators (their producer surplus) by collecting industry cost data and following similar estimation/extrapolation procedures.

Sampling

We used a socio-economic survey based on self-administered, anonymous questionnaires targeting tourists who were divers. These were structured to collect data on the general motivations for a diver’s participation in shark diving and the influence of shark diving on the decision by the diver to travel to a particular locality. The questionnaire also collected information on expenditures related directly to tourism, including diving, accommodation, transport, living costs while travelling, and other peripheral expenditures such as purchases of souvenirs or other tourist activities during the same trip. Questionnaires were distributed to tourists in each of the four Australian regions with significant shark-diving industries between March 2013 and June 2014. We took a conservative approach by only including the expenditures we could unequivocally attribute to the industry in our calculations and our estimates can thus be considered as minimum values. The total economic value of shark diving was calculated as the mean expenditure of shark divers multiplied by the number of shark divers using that service per year as per Vianna, Meeuwig et al. (2011) and Vianna, Meekan et al. (2012). The number of tourists involved in shark diving was provided either by the tourist operators directly or by the government agencies responsible for the industry. Amounts are reported in Australian dollars throughout the study unless stated otherwise.

We used a standard questionnaire to sample the four industries. Demographic

questions (age, sex, nationality, education, diving experience, and annual income) were included to describe the profile of participants. For each industry, the questionnaire was slightly adapted to account for the differences between regions, operations, scale, and activities available. For example, the white-shark cage-diving industry only has three operators and all are based in Port Lincoln, whereas the grey nurse shark industry is composed of independent shops or clubs scattered throughout the southern Queensland and New South Wales coast. Questionnaire modifications and differences in analysis are described below.

Western Australia - whale sharks

The shark-diving industry at Ningaloo Reef, Western Australia, involves in-water swimming and snorkelling with whale sharks (*Rhincodon typus*) during a season from around March to July (Wilson, Taylor et al. 2001). The whale-shark industry has been in operation since 1989, with the number of operators growing rapidly during the first 15 years, leading to a limit of 15 operator licenses being imposed in 1995. Over the past decade, 11–12 companies have remained active in the region. During a whale-shark tour, spotter planes locate sharks swimming at the surface off the reef front and direct tour vessels to within no less than 30 m of the animal. Snorkelers are disembarked ahead of the direction of travel of the animal and must keep a distance of 3–4 m from the shark. Any contact with the shark is strictly prohibited. Operators are allowed a maximum of 23 passengers on board, but with no more than 20 snorkelers in total, only 10 of whom may be in the water with the shark at one time. Interactions by snorkelers with a shark may only occur for a maximum of 60 minutes.

Of the 11 tour companies in operation at the time of the sampling (from May and June 2014), four responded to the invitation to participate in the study and allowed the questionnaire to be distributed to tourists boarding their vessels. Three of these companies were based in Exmouth near the northern tip of Ningaloo Reef and one in Coral Bay towards the southern end of the reef (Fig. 1). Since all operators are subject to the same set of management regulations and conduct tours in nearly identical formats, these operators were considered to be representative of the industry. Tourists were briefed about the study in the morning before leaving for the snorkelling trip. Survey forms were distributed during the briefing and collected from the operator at the end of the day. Using the approach of Vianna et al. (2012), divers were classified into two categories based on whether the respondent indicated that shark diving was the principal reason for travel to that particular locality. ‘Dedicated shark divers’ were defined as those tourists who visited specifically to dive with sharks and would not have chosen the area as a tourist destination if no shark dive was available. ‘Casual shark divers’ were tourists for whom shark diving was not the primary reason for visiting the region. The expenses of each group included in the economic value of the industry varied depending on the diver category. For dedicated shark divers, all costs were included (other activities while on the trip, souvenirs, travel costs) for the entire time they spent at Ningaloo Reef, as these participants would have not gone to this destination if the shark-diving opportunity was not available. Travel costs did not include international airfares as the questionnaire did not ask international participants if they would still have chosen Australia as a holiday destination if whale-shark-diving had not been possible. As a result, our estimates of expenditure attributable to shark diving were conservative. For casual shark divers, we only included the costs that were specifically incurred for shark diving. This included the tour, accommodation, and living costs of the day prior and after the day of diving. The number of participants in whale shark snorkelling tours in 2014 was obtained from the WA Department of Parks and Wildlife. A total of 103 tourists completed the survey.

South Australia - white sharks

The white-shark cage-diving industry began in the late 1970s in waters off the Eyre Peninsula in South Australia. The industry is now restricted in operations to the Neptune Islands Marine Park located 60–70 km south of Port Lincoln (Fig. 1), with most cage-diving activities focussed at the North Neptune Island group. The locality is the only place where cage-diving with white sharks is permitted in Australia. After 2007 the industry expanded from two to three operators and the mean annual number of days when tours operated rose from 124 (2000–2006) to 265 (2008–2011) (Bruce and Bradford 2013). Since 2012, the number of operators has been capped at three with the number of operating days limited to a maximum of 10 per fortnight or 260 days per year. Two operators offer day trips whereas the third organises 2–4 day live-aboard boat trips. All three operators participated in the study. Tourists were briefed about the study goals at the start of each trip. Survey forms were distributed during the briefing and collected at the end of the trip between March and May 2014. Across this period a total of 229 tourists from all three operators completed the survey.

Similarly to whale-shark snorkelling trips, divers were classified into categories of dedicated shark divers and casual shark divers based on whether the respondent indicated that shark diving was the principal factor determining travel to the region. The expenses allocated to each diver category followed that of the whale shark study. In addition, if the respondent was an international tourist, they were asked whether white shark-cage diving was the main determinant for travel to Australia so that the economic value of the cage-diving industry to tourism beyond the region of Port Lincoln could be calculated, including international airfares, transfers, accommodation, and other activities while in Australia. This question was not included for the other three industries. The number of divers participating in the industry in 2014 was obtained from the three operators.

Queensland and New South Wales - Grey nurse sharks

The grey nurse shark (Carcharias taurus) is a popular attraction for scuba divers on the east coast of Australia (Pollard 1996, Smith, Scarr et al. 2010, Barker, Peddemors et al. 2011). Surveys of the distribution of grey nurse sharks on the east coast conducted by Otway, Burke et al. (2003) established that almost 90% of the population aggregated at 14 sites, nine of which are currently listed as critical habitat (NSW Department of Primary Industries and Fisheries 2007). This tendency to aggregate is advantageous for the dive industry, as these sites provide a focus for scuba divers to reliably observe these sharks (Environment Australia 2002, NSW Department of Primary Industries 2011). Due to the complexity of this industry, a range of sampling methods was employed to collect economic data. A literature and online website review was conducted and identified 56 operators with dive sites located near recognised aggregation sites for grey nurse sharks.Contact with these operators and content analysis of their website home page identified operators who offered diving tours that targeted grey nurse sharks. This resulted in a list of 17 operators from nine locations ranging from Point Lookout, North Stradbroke Island (South Queensland) to Ulladulla (New South Wales South Coast) (Fig. 1). Operators were invited to participate in the study and were emailed a survey that asked about the size of their operations (number of tourists specifically participating in dive tours to see grey nurse sharks) and diving prices for tourists. The final data set included 12 operator responses from eight locations. Sampling of individual divers was restricted to participants visiting Wolf Rock, Queensland because other operators did not respond to the invitation to distribute questionnaires to their customers. Surveys were collected by the operator at the completion of the trip between March 2013 and June 2014 during which 104 tourists completed the survey.

Diving prices for tourists were obtained from the operators. When operators provided a range of dive options that had different costs, for example from single shore dive to two boat dives with all gear supplied, we used the option with the minimum cost for calculations. Since living expenditures were likely to be broadly similar over the region and could not be accurately estimated by the operators, we used the estimates provided by divers at Wolf Rock from our survey to extrapolate estimates to the entire industry. We could not ascertain whether divers were only within the area to dive with grey nurse sharks because we only collected information from divers visiting Wolf Rock and that diver motivation might vary between locations. Therefore, we only included living expenditures for the day when the diving occurred in the valuation.

When the number of divers was provided by the operators, they were also asked to estimate the proportion of non-local vs. local divers to account for accommodation expenses, where a non-local diver was defined as someone who travelled far enough to the dive site to require accommodation while away from home. Only one operator did not provide this estimate and in this case it was assumed that the numbers provided by the other operator in the same location were representative. Several of the operators provide accommodation as part of their tour business at cheaper rates than standard accommodation. For these, we asked for the nightly costs of accommodation and assumed that all divers on their tours were using these cheaper rates and stayed for two nights. For the remaining operators, we used an internet search to estimate the average accommodation costs within the region. Accommodation costs were only included for non-local divers.

Queensland - Reef sharks

Targeted diving with reef sharks occurs at Osprey Reef, a remote submarine seamount in the Coral Sea, situated 125 km east of the Great Barrier Reef (Fig. 1). Other dives within the Great Barrier Reef Marine Park Area where reef sharks can be sighted do not specifically target these animals as an attraction or advertise their presence and were therefore not included in this analysis. Shark dives at Osprey Reef are restricted to North Horn, a site at the northern tip of the reef, where reef sharks are known to aggregate (Fitzpatrick, Abrantes et al. 2011, Barnett, Abrantes et al. 2012). Dives consist of either provisioning (food presented to and consumed by sharks) or attraction (food presented but inaccessible to sharks) of grey reef (*Carcharhinus amblyrhynchos*) and whitetip reef (*Triaenodon obesus*) sharks, with numbers varying from around 10 to 50 sharks in each dive (Fitzpatrick, Abrantes et al. 2011). In addition, silvertip sharks (*Carcharhinus albimarginatus*), scalloped hammerhead (*Sphyrna lewini*) and great hammerhead (*Sphyrna mokarran*)sharks can also be present during dives. Regular shark dives have been conducted at Osprey Reef since the 1980s, with up to five live-aboard operators each offering one to two shark dives per week. In 2013/14, after three operators stopped conducting trips to Osprey Reef for economic reasons, only two live-aboard boats were operating regular trips for a total of two shark dives per week or approximately 90–100 dives per year.

Although trips to Osprey Reef are advertised as shark dives, live-aboard operations are multi-purpose trips focused on many activities during the same trip (e.g., reef and wall dives, and several dives involving megafauna including sharks). Divers may, therefore, have only partaken in shark dives as part of a broader range of the activities on offer. Since all the dives during a live-aboard trip are done as part of a package and may play an equally important role in the decision of a tourist to take the trip, we only reported expenditures for divers who indicated that they would not have undertaken the live-aboard trip if the reef shark dives were not available (dedicated shark divers). Questionnaires were handed to and collected from all divers by the boat staff at the end of each trip by the two operators conducting regular trips to the Coral Sea. Surveys were distributed between September and November 2013 during which 275 tourists completed the survey. The number of divers undertaking live-aboard trips was estimated for the two operators based on the number of trips carried out in 2014 and the reported occupancy rate (Stoeckl, Birtles et al. 2010).

In the discussion, comparison between estimates was undertaken in real terms using December 2014 consumer price index (CPI), which represented the end of the study period. Nominal values (not adjusted for inflation) are also presented to allow findings to be related to the results from the original studies.

**Results**

Survey and tourist profiles

We interviewed a total of 711 participants in shark-diving activities across Australia (Table 1). Most participants were males, as was the case in other studies involving divers (Edney 2012) and shark divers (Dicken and Hosking 2009, Du Preez, Dicken et al. 2012, Apps, Lloyd et al. 2014, Dicken 2014, Apps, Dimmock et al. 2015). However, there was a higher proportion of female participation in whale shark dives compared to other shark dives, which is also consistent with earlier studies of this type of tourism (Davis, Banks et al. 1997, Catlin, Jones et al. 2010). Divers participating in whale and white shark tours were slightly younger on average (21–30 years old) than those diving with grey nurse sharks (31–40 years old), whereas divers going to Osprey Reef were evenly distributed from 21 to >50 years old. Over 50% of participants of whale shark and reef shark tours were international tourists. Most tourists in whale shark snorkelling tours were European (55%) and only 29% were Australian. About half the white shark divers were domestic tourists with ~30% of North American origin, which is consistent with previous studies (Apps, Dimmock et al. 2016). The highest percentage of domestic tourists was found in the grey nurse shark-diving industry (59%). Most tourists undertaking a white-shark cage-diving tour had undertaken fewer than 5 dives whereas most participants in grey nurse shark and reef shark tours had 100–500 dives. The whale-shark industry had the highest number of participants (22,124), approximately as many as the white shark and grey nurse shark industries combined. The reef shark industry was much smaller, with only 1,848 participants (Table 1). Annual income of shark-diving tourists was similar for grey nurse shark and white shark tourists with ~45% making over US$80,000. Whale shark tourists earned slightly less with 19% having an annual income over US$80,000, whereas reef shark tourists had the highest annual income with 65% making US$80,000 or more.

Economic value

Direct comparisons of the different components of shark-tourism expenditure (e.g., shark diving, accommodation, transport) across industries should be made with caution because of the different model for tourism used by each of these industries. For example, accommodation was included in the cost of ‘shark diving’ for one of the white-shark operators and for the reef-shark diving as they have multi-day tours and use live-aboard vessels. Transport costs were also only collected from tourists participating in whale and white shark tours (and thus were presented separately). Overall, the expenditure per tourist varied among industries and the type of diver (dedicated versus casual shark diver) (Table 2). Within the category of casual shark diver, tourists spent the most on white-shark tours ($763) and the least on grey-nurse shark tours, even when including the accommodation costs of non-local divers ($358 and $196 for non-local and local divers respectively). Although transport costs were not included in the estimates for reef shark tours, participants going to Osprey Reef spent the most ($4,084) due to the costs of the live-aboard tour. Trips to Osprey Reef are also not solely targeted at reef sharks and divers partake in a range of activities, which can be associated with other experiential benefits and encourage greater expenditure than during day trips. Dedicated divers in the whale-shark industry spent the next highest amount ($1,939), followed by those in the white-shark industry ($1,720). The white-shark cage-diving industry attracted the most dedicated divers (83%) compared to the other industries, where the majority of participants were casual divers (Table 1). The difference between expenditures of dedicated and casual divers was $957 and $1,415 for the white shark and whale shark industries respectively.

Overall, a conservative estimate of the total annual direct expenditure of tourists participating in shark diving in Australia was $25.5M in 2014 (Table 3). Variation in the total annual expenditures of tourists for each industry reflected differences in expenditure per person and number of participants. Total direct expenditures were greatest in the whale shark industry at just over $11.5M per year. Tourists diving to see white sharks spent $7.8M in direct expenditures, a total slightly greater than the combined direct expenditure of tourists in the grey nurse and reef sharks industries (Table 3). Participants who were dedicated shark divers also contributed to the economy of the region beyond the direct costs of shark tourism through additional tours, transport, accommodation and food. We calculated the additional expenditure of dedicated divers to be $8.1M and $12.5M in the Port Lincoln and Ningaloo Reef regions respectively (Table 3). In addition, 3% of the tourists undertaking white-shark cage-diving trips specified that they would not have come to Australia if cage-diving was not available. This proportion was up to 5% for some operators. These tourists contributed another $0.9M to the Australian economy, in addition to the expenditures already incurred by cage-diving trips.

**Discussion**

We estimated that direct expenditure by tourists in the shark-diving industry in Australia generated in excess of $25.5 M in 2014. For whale shark and white shark industries, regional expenditures could also be calculated and this more than doubled their direct values. In addition, we estimated that international tourists participating in white-shark cage-diving spent a further ~$1 M in Australia.

These are conservative valuations of the contribution of shark diving to the Australian economy. Comparisons with figures for Australian tourism generally and for similar industries (e.g. whale watching) are hampered by conflicting methods, definitions, and temporal scope. Overall in 2014, there were 4.2 M international visitors to Australia who undertook some form of nature-based tourism, representing 66% of all international tourists (Griffith Institute for Tourism 2014). Nationally, it has been estimated that expenditure by nature-based tourism amounts to a third of all tourism expenditure (e.g., visiting national parks, bushwalking, snorkelling, whale watching), with nature-based tourism contributing $30–40 billion to the Australian economy each year. Marine-based tourism was an important component, with dive-related spending estimated to be potentially worth as much as $2.2 billion a year (Beaver and Keily 2015).

Although these figures show the economic importance of wildlife tourism to Australia, the definition of this activity can be extremely broad and encompass a very wide range of expenditures (Tisdell 2012). For this reason, Beaver and Keily (2015) advised that their data for marine tourism should be used with caution and is likely to reflect an upper-bound, rather than a mean value. For rigour and comparability, we were careful to clearly identify expenditures that were related to the motivations of tourists engaged in the activity (dedicated vs. casual shark-divers). It is likely that a similar approach to all types of nature-based tourism would reduce the overall economic value attributed to this endeavour, which makes it very difficult to compare our estimate of the contribution of shark diving to other national valuations. Other, similar forms of marine tourism include the whale-watching industry, which was estimated to contribute ~$22 M (~$19 M nominal value) to the Australian economy in 2008 (O’Connor, Campbell et al. 2009). It is likely that the value of the whale-watching industry has increased in recent years.

Importantly, the whale-shark industry also contributed $12.5 M to the region of Ningaloo Reef, whereas white-shark diving contributed $8.1 M to the Port Lincoln area. Such values are similar to those calculated for equivalent marine-based industries a decade ago by Stoeckl, Smith et al. (2005), who found that visitors interacting with dolphins at Monkey Mia, Western Australia, contributed between $5.5 and $11.5 M ($4.2 and $8.8 M nominal value) per annum in direct expenditure to the local economy, while whale watching in Hervey Bay, Queensland, contributed between $8.5 to $15.0 M ($6.5 to $11.5 M nominal value) per annum to the local economy. Both our estimates and those of earlier studies represent significant contributions to the relatively small economies of these regional areas.

Western Australia - whale sharks

Overall, the whale shark industry accounted for the highest amount of expenditure of any type of shark-diving tourism in Australia. Our estimate of $11.5 M in direct expenditures was supplemented by an additional $12.5 M in related travel, accommodation and other activities in the region by tourists for whom the opportunity to snorkel with whale sharks was the primary motivation for their trip.

Whale-shark tourism occurs in the coastal environments of many tropical and warm-temperate countries and the industry has been the subject of at least seven valuation studies world-wide (Huveneers and Robbins 2014). Our estimates are greater than many of these valuations for other localities, although studies vary in methods and dates of estimates. In the Seychelles, the whale-shark-diving industry was estimated to be worth US$4.9 to US$6.1 M (US$4.0 to US$5.0 M nominal value) for a short season of 14 weeks each year, including costs of the tours, accommodation, and international flights (Rowat and Engelhardt 2007). Equivalent values have been calculated for the whale-shark-diving industry on the barrier reef of Belize, where the six-week season generates tourist expenditures of US$5.0 M (US$3.7 M nominal value) including US$1.8 M (US$1.3 M nominal value) in five stakeholder communities (Graham 2004). Contributions as high as a US$206 M (US$150 M nominal value) have been estimated for whale-shark tourism in Thailand. However, these are confounded by the pooling of shark divers with all tourists visiting the location (Phuket) to participate in diving activities (Bennett, Dearden et al. 2003).

At Ningaloo Reef, previous studies suggested that tourist expenditure in the whale-shark industry totalled $7.6 M ($6 M nominal value) in 2006 (Catlin, Jones et al. 2010). A number of studies have also used Davis et al.’s (1997) valuation of $9.9 M ($6.2 M nominal value) (from 2,000 participants) to extrapolate total expenditure in more recent years using updated participant numbers. These estimates ranged from $14.1 M ($10 M nominal value) (Newman, Colman et al. 2002) and $18.5 M ($12 M nominal value) (Fowler 2000, Wilson, Taylor et al. 2001) to as much as $22.6 M ($16 M nominal value) (Norman 2002). The three-fold increase in the value of the industry between Catlin et al.’s (2010) study ($7.6 M) and our work ($24 M) is mostly related to the number of tourists, which more than tripled from 6,677 in 2006 to 22,124 in 2014. The remaining difference is likely due to differences in the classification of casual and dedicated divers across the two studies (although the proportions of each were the same). In 2006, total expenditure of casual shark divers was $972 ($764 nominal value from $894 minus $130 for transport, given that these participants would have visited Ningaloo Reef regardless of the whale shark industry) (Catlin, Jones et al. 2010). This is comparable to our estimate of $524 per casual diver, since our estimate included only two nights of accommodation, whereas Catlin et al.’s (2010) study included an average of 4.8 nights. However, expenditure from dedicated divers increased significantly between 2006 and 2014. These divers were estimated to spend an average of $1,211 ($952 nominal value) per trip in 2006, whereas they spent $1,939 in 2014. This large difference was likely due to the costs of travel, which were estimated to be $165 ($130 nominal value) in 2006 and ~$860 in 2014. Both studies excluded international airfares and the discrepancy might be due to Catlin, Jones et al. (2010) study also excluding domestic airfares, which were included in the present study.

Catlin, Jones et al. (2010) observed a large decline in expenditure per participant between 1995 ($4,023; $2,370 nominal value) and 2006 ($1,137; $894 nominal value) and suggested that this was an indication that the industry had entered a consolidation phase. As part of this process, tourists participating in whale-shark tours were argued to have changed from higher-spending “specialists” to more frugal “generalists” (Dearden, Bennett et al. 2006, Catlin and Jones 2010). However, one of the characteristics of the consolidation phase is a reduction in the growth rate of tourist numbers (Butler 2006) and this has not occurred at Ningaloo, where numbers of tourists have increased consistently since 1997 (Colman 1997) and have more than tripled between 2006 and 2014. Tourist type might have, regardless, changed from high-spending to low-spending, as suggested by the annual income of whale-shark tourists being the lowest compared to the other Australia shark-diving industries.

South Australia - white sharks

We estimated that cage-diving with white sharks contributed $7.8 M in direct costs to the economy in 2013–14. This is lower than a previous study that estimated total expenditure at $9.9 M ($9 M nominal value) in 2011, a calculation that included the cage-diving tour, two nights of accommodation, meals, and airfare (including international airfare) (Bradford and Robbins 2013). Airfares and transfers, however, should not automatically be included in cost estimates because tourists might have visited Australia and the Port Lincoln region regardless of the cage-diving industry. Removal of this expenditure gives an annual estimate of $5.3 M ($4.8 M nominal value) for 2011. Based on the number of participants in Bradford and Robbins (2013) study (5,241), this suggests an average expenditure per tourist of $1,013 ($921 nominal value). When applied to participation rates in 2014 (10,236 tourists), this gives a total expenditure of $10.4 M, which is greater than our estimate of direct expenditure of $7.8 M.

Comparison between estimates made by the present study and the revised estimate of Bradford and Robbins (2013) reveals a difference of $2.6 M in direct expenditures by shark divers in 2014. This discrepancy likely reflects differences in the method of assessing outlays. Although the rapid assessment technique employed by Bradford and Robbins (2013) offers ease of use, it does not refine all direct expenditure or allow allocation of outlays to direct, regional, or national scales, based on the likelihood of the tourist having visited the region or country had the opportunity for shark tourism not existed. With this data, we were able to estimate the contribution to the regional economy from payment by tourists for transport, adjunct tours, and extended stays within the region at just over $8 M. The use of participant surveys also allowed us to quantify the proportion of international tourists for whom the presence of the cage-diving tourism industry was the principal motivation for their trip to Australia (3%). These international tourists spent an additional ~$1 M in airfares and other activities while in Australia.

Tourism industries offering cage-diving with white sharks are also present in South Africa, Mexico, and California, USA. Of these, only the economics of the shark-diving industry operating out of Gansbaai, in South Africa has been valued, with local business turnovers estimated at $3.7 M ($2.7 M nominal value) in 2003 (Hara, Maharaj et al. 2003). Although the number of tourists on which this estimate was based (30,000) was nearly three times greater than that of South Australia (~10,000), shark divers in South Africa spent only $128 ($93 nominal value) per day compared to $763 in South Australia, a difference that was due to the much cheaper cost of tours in South Africa ($103 [$75 nominal value] vs. ~$550). Ultimately, this probably reflects the accessibility of the inshore coastal site in South Africa compared to the offshore islands where diving takes place for the South Australian industry. An offshore island location imposes a higher cost base for access due to longer boat transit times and restricts competition among operators.

Queensland and New South Wales - grey nurse sharks

We estimated the economic value of shark diving targeting grey nurse sharks to be $4.2 M in 2014. This industry has a large spatial extent (thousands of kilometres of coast), spanning two Australian states and included 17 operators that advertised diving with grey nurse sharks. Given the logistics involved in surveying the entire industry, we focused detailed participant surveys on operators working at Wolf Rock and used these figures to extrapolate for the industry as a whole. Although we recognise the limitations of a single geographic focus for participant questionnaires, our operator surveys included the majority of those offering tours and were spread along much of the coastline where sharks aggregate. These showed that most tours followed similar formats and involved both local and non-local divers. Therefore, we assumed that the responses to questionnaires by divers at Wolf Rock were representative of the entire industry.

Grey-nurse shark diving had the greatest number and proportion of Australian divers, with a third of divers living nearby to dive sites. This is lower than previous studies, which have tended to report an even higher proportion of domestic participants (80–95%) (Smith, Scarr et al. 2010, Apps, Lloyd et al. 2014, Apps, Dimmock et al. 2015). Although the number of participant divers was comparable to the white-shark industry, the lack of travel and accommodation costs for these local divers reduced expenditures. Regardless of the amount, income generated by the industry was distributed across a wide area creating various employment opportunities and demonstrating the importance of this industry to multiple regional economies such as South West Rocks, NSW.

In the past, the majority of research on shark-diving tourism that targets grey nurse sharks in Australia has focused on potential negative impacts on the species from diving (Smith, Scarr et al. 2010, Barker, Peddemors et al. 2011, Barker, Peddemors et al. 2011, Smith, Scarpaci et al. 2016) and diver beliefs in relation to grey nurse shark diving regulations (Apps, Lloyd et al. 2014, Apps, Dimmock et al. 2015), largely due to the IUCN Red List status of the species as Critically Endangered on the east coast of Australia (Pollard, Gordon et al. 2003). Our data provides the first economic evaluation for the industry in Australia, although Dicken (2014) included this species (referred to as ragged-tooth sharks) as part of an economic evaluation of diving at Sodwana Bay, South Africa between July 2011 and July 2012. Dicken’s (2014) study focused on both direct (travel, park entry, diving, accommodation, food, souvenirs etc.) and indirect (fishing and quad biking tours, etc.) expenditures by tourists. Divers were asked to nominate the percentage of dives that they attributed to each of the attractions of the Bay, which included reef environments, grey nurse sharks, and whale sharks. These values were then used to calculate a total contribution of US$128,456 (US$120,262 nominal value) (excluding travel, as in the present study) to the local economy. Given the estimated number of divers (15,780) and the proportion of dives that focused on grey nurse sharks (1.9%), this gave an estimate of expenditure of ~US428/diver (US$401/diver nominal value), roughly twice that of divers in Australia ($196 and $358/diver for local and non-local divers, respectively). However, these comparisons must be treated with caution, as they are likely to be confounded by differences in sampling methods between studies.

Queensland - reef sharks

We estimated that shark diving at Osprey Reef in the Coral Sea generated direct revenues of $1.9 million annually. Given that three of the five live-aboard vessels working in the area recently ceased operations prior to our study, the estimated value in 2014 is likely to represent a fraction of the economic value of shark diving at Osprey Reef in the past. We estimated the economic value of the diving industry operated by the two remaining vessels at Osprey to be approximately $7.6 million (including dedicated and casual divers). This represents between 50% and 66% of the revenues generated five years earlier, when this industry generated between $13 and $17.3 M ($11.5 and $15.3 M nominal value) (Stoeckl, Birtles et al. 2010), a reflection of the loss of vessel capacity. We estimated the total number of divers to be ~1,800 in 2014, a sizeable reduction compared to the 4,890–6,542 estimated to participate by Stoeckl, Birtles et al. (2010).

Dedicated shark divers represented 25% of all divers participating in the live aboard operations in far North Queensland. Shark diving occurs within trips that include a combination of reef dives at the Great Barrier Reef and oceanic dives at Osprey Reef, where sharks and other large pelagic fish are the main attractions. Sharks and rays have been listed as the main animals divers want to see during these trips with tourists willing to pay nearly twice as much to see these animals than they would to dive with other marine life (Farr, Stoeckl et al. 2014). Sharks are also listed as one of the principal attractions that tourists visiting the northern part of the Great Barrier Reef are hoping to see during day-trip operations to the reef (Stoeckl, Birtles et al. 2010). For this reason, promotion for live-aboard dive trips to Osprey Reef highlights diving with sharks and this is likely to be a key motivation for tourists to join these vessels. However, in our survey, it was not possible to account for the economic value of shark diving generated by casual shark divers since the multi-purpose nature of the trips prevented us from defining the loss of revenues if no sharks were sighted. Consequently, we have probably underestimated the value of reef-shark diving at Osprey Reef.

Reef-shark diving had the smallest number of participants (1,848) compared to other shark-diving industries in Australia, which ranged from 10,000–22,000 tourists. This is probably a consequence of the expense and need for relatively long-distance travel to access to the shark-diving site. Individual expenditures of dedicated shark divers for live-aboard tours were the highest of all industries in Australia ($4,084 compared to ~$100–600), mostly due to the cost of the live-aboard trip (~$3,000). Besides the high trip cost, the mean expenditure on food, accommodation, and other expenses during the trip was $1,142, which was also higher than in other shark-diving destinations (~$600 to $700). This is likely related to clients of the live-aboard being wealthier, as indicated by their annual income being the highest compared to participants of other Australian shark-diving industries.

Conclusion

Our study provides standardised estimates of the value of the shark-diving tourism industry in Australia that allow for comparison of the scale of different industries within and among countries. The questionnaire and analysis were slightly adapted to account for the differences between regions, operations, and activities with over 700 surveys collected from the four main shark-diving industries in Australia across four States. These provided a conservative estimate of the total annual direct expenditure of tourists partaking in shark diving at $25.5 M. Moreover, our study identified regional expenditure that would not have occurred if the whale shark and white-shark-diving industry did not exist ($8.1 M and $12.5 M for the Port Lincoln and Ningaloo Reef region respectively). In the case of diving targeting grey nurse sharks, small regional towns provide the access points for aggregations of these sharks offshore, and these towns benefit from income stream from shark-diving participants. These additional revenues show that benefits not only flow to operators of shark-diving industries, but that the regions supporting these industries can also gain substantial economic benefits, even in countries with developed economies that are not typically considered to have a dependence on tourism for revenue. Our results highlight the need to ensure a sustainable industry through adequate management of target species and the tourism industries they support.

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| --- | --- | --- | --- | --- |
| **Table 1:** Summary of sampling dates and sizes, survey participants by gender, age, country of origin, income and experience for each type of shark tourism in Australia. Note that in some cases sample sizes of respondents varied among categories within an industry. | | | | |
|  | **Whale sharks** | **White sharks** | **Grey nurse sharks** | **Reef sharks** |
| *Survey period* | May–June 2014 | March–May 2014 | March 2013–June 2014 | September–November 2013 |
| *Number of surveys completed* | 103 | 229 | 104 | 275 |
| *Number of tourists in 2014* |  |  |  |  |
| Dedicated diver | 40% | 83% | a | 25% |
| Casual diver | 60% | 17% |  | 75% |
| Total | 22,124 | 10,236 | 13,978 | 1,848 |
| *Gender* |  |  |  |  |
| Male | 43% | 65% | 70% | 55% |
| Female | 57% | 35% | 30% | 45% |
| Sample size | 101 | 226 | 103 | 273 |
| *Age* |  |  |  |  |
| >21 | 14% | 3% | 1% | 2% |
| 21–30 | 46% | 44% | 26% | 22% |
| 31–40 | 16% | 20% | 41% | 28% |
| 41–50 | 10% | 19% | 17% | 21% |
| <50 | 15% | 14% | 15% | 26% |
| Sample size | 101 | 226 | 103 | 273 |
| *Tourist origin* |  |  |  |  |
| Africa | 0% | 0% | 0% | 0% |
| Asia | 4% | 1% | 2% | 4% |
| Australia | 29% | 54% | 59% | 22% |
| Europe | 55% | 33% | 26% | 29% |
| Middle East | 0% | 1% | 0% | 0% |
| North America | 7% | 9% | 5% | 39% |
| Oceania | 3% | 1% | 7% | 1% |
| South America | 2% | 0% | 1% | 3% |
| Sample size | 101 | 227 | 102 | 268 |
| *Annual income (USD)* |  |  |  |  |
| <20,000 | 24% | 13% | 4% | 8% |
| 20,000–49,999 | 34% | 20% | 18% | 11% |
| 50,000–79,999 | 24% | 29% | 33% | 16% |
| 80,000–119,999 | 12% | 17% | 26% | 27% |
| >120,000 | 7% | 21% | 19% | 38% |
| Sample size | 89 | 214 | 98 | 256 |
| *Dive experience* | b |  |  |  |
| <5 | - | 45% | 0% | 0% |
| 5–49 | - | 19% | 27% | 27% |
| 50–99 | - | 6% | 14% | 15% |
| 100–499 | - | 17% | 36% | 43% |
| >500 | - | 13% | 23% | 15% |
| Sample size | - | 223 | 103 | 272 |
| a Not recorded  b Only 25% of tourists were certified divers | | | | |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 2:** Total numbers of tourists and mean expenditures ± standard error per diver for dedicated and casual shark divers participating in whale, white, grey nurse and reef shark industries in Australia | | | | | | | |
| **Tourist category** | **No of tourists** | **Diving** | **Accomod-ation** | **Living** | **Other** | **Transport** | **Total mean expenditure** |
| *Whale sharks* |  |  |  |  |  |  |  |
| Dedicated diver | 8,850 | $370 ± 11 | $219 ± 57 | $131 ± 21 | $359 ± 85 | $860 ± 251 | $1,939 ± 246 |
| Casual diver | 13,274 | $347 ± 9 | $94 ± 16 | $83 ± 18 | a | a | $524 ± 30 |
| *White sharks* | | | | | | | |
| Dedicated diver | 8,485 | $585 ± 65b | $145 ± 10 | $152 ± 9 | $286 ± 10 | $552 ± 30 | $1,720 ± 51 |
| Casual diver | 1,751 | $530 ± 124b | $132 ± 18 | $101 ± 18 | a | a | $763 ± 129 |
| *Grey nurse shark* | | | | | | | |
| non-local diver | 9,283 | $120 ± 9 | $160 ± 27 | $76 ± 10 | c | c | $358 ± 30 |
| Local diver | 4,695 | $120 ± 9 | a | $76 ± 10 | a | a | $196 ± 10 |
| *Reef sharks* | | | | | | | |
| Dedicated diver | 462 | $2,942 ± 96 | d | d | $1,142 ± 94 | c | $4,084 ± 144 |
| a Not included as divers where not at that location solely for the purpose of diving, or because they were locals and did not require accommodation | | | | | | | |
| b For one of the operators, living and accommodation costs were included as part of the live-aboard tour  c Expenditure not estimated  d Living and accommodation costs were included as part of the live-aboard tour | | | | | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| **Table 3:** Total value of shark-diving tourism in Australia (with ± standard error). Direct refers to the specific costs of undertaking a shark tour (see Methods). Regional refers to other expenditures in the region by dedicated divers who would not have visited had shark diving not been available. National refers to expenditures by international divers who would not have visited Australia if shark-diving tourism had not been available | | | |
| **Targeted species** | **Direct** | **Regional** | **National** |
| Whale sharks | $11,592,976 ± 408,456 | $12,552,750 ± 888,820 | a |
| White sharks | $7,802,936 ± 520,742 | $8,120,145 ± $380,365 | $910,599 ± $192,642 |
| Grey nurse sharks | $4,234,548 ± 142,164 | a | a |
| Reef sharks | $1,886,714 ± 66,454 | a | a |
| Total | $25,571,174 |  |  |
| a Expenditure not estimated | | | |

Figure 1**C:\Users\huve0001\Documents\Publications & achievements\Scientific paper\Economic evaluation\Figure 1\map_shark diving.tif**

**Figure 1:** Main Australian shark-diving tourism locations. Number of tourists in 2014 is indicated for each location. The triangle shows the location of the whale shark industry; the star represents the white shark industry; the square represents the reef shark industry; and the circles shows the grey nurse shark dive sites where annual number of tourists is >300. For grey nurse sharks, the grey box shows the extent of diving locations.