WANTED DEAD OR ALIVE?
The relative value of reef sharks as a fishery and an ecotourism asset in Palau

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DISCLAIMER

Photo cover: The grey reef shark (*Carcharhinus amblyrhynchos*) is the most abundant species sighted during shark dives in Palau. Photo by: Carlos Villoch contributed by Micronesian Shark Foundation.

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Executive Summary

- Arguments for conservation of sharks based on their role in the maintenance of healthy marine ecosystems have failed to halt a worldwide decline in populations of these top-order predators.
- This decline is driven by the economic value of sharks as a fishery and the growing market for shark fin products.
- An alternative approach for conservation stresses the economic value of sharks as a focus of dive tourism. In this context, sharks may have a greater value as a non-harvested resource than as a fishery.
- Our study quantified the economic benefits of the shark-diving industry to the community and Government of Palau.
- A series of questionnaires were used to survey the demographics, income and expenditure of divers visiting Palau, the markets, income and expenditures of dive tour operators and the income and interactions with shark fishers.
- The results of these questionnaires and recent statistics of tourism and revenues published by the Government of Palau were used to calculate the contribution of shark diving.
- The shark-diving industry attracts 8,600 divers each year or approximately 21% of the divers visiting Palau.
- The value of sharks to the Palauan economy was estimated to be US$18 million per year, accounting for approximately 8% of the gross domestic product of Palau.
- An individual reef shark in Palau was estimated to have an annual value of US$179,000 and a life-time value of US$1.9 million to the tourism industry.
- The annual income in salaries paid by the shark-diving industry to the local community was estimated to be US$1.2 million.
- The annual tax income to the Government of Palau generated by shark diving was estimated to be US$1.5 million or 14% of the business tax revenue.
- A fishery targeting the same 100 sharks that are interacting with the tourism industry in Palau would obtain a maximum of US$10,800, or 0.00006% of the life-time value of these animals as a non-consumptive resource.

- The tax revenues collected from shark diving were roughly 24 times higher than those from the fishing industry.
- The creation of the shark sanctuary could play an important role on the selection of Palau as a diving destination by tourists.

Background

Over the last 20 years, ecotourism to view and interact with marine megafauna has become increasingly popular (Higham and Lück 2008). Examples of this type of tourism include turtle and whale watching, snorkelling with seals and shark diving (Jacobson and Robles 1992; Anderson and Ahmed 1993; Orams 2002; Kirkwood *et al.* 2003; Dearden *et al.* 2008; Dicken and Hosking 2009). The occurrence of many aggregations of megafauna along the coasts of regional areas remote from centres of population means that such tourism also provides significant flow-on effects and diversification to local economies where few alternative sources of income exist (Milne 1990; Garrod and Wilson 2004). Importantly, the development of a well-managed ecotourism industry based on megafauna provides the opportunity for local people to utilise natural resources in a sustainable manner over the long-term (Mau 2008).

The economic value of tourism based on marine megafauna is enormous. In 2008, a study of whale watching estimated that this form of tourism was available in 119 countries, involved approximately 13 million participants and generated an income to operators and supporting businesses (hotels, restaurants and souvenirs) of over US$2.1 billion (O'Connor *et al.* 2009). This industry is estimated to have the potential to generate annual revenues of over US$2.5 billion (Cisneros-Montemayor *et al.* 2010). The development of whale watching has been paralleled by growth in tourism based on other types of marine megafauna. In particular, tourism to observe sharks and rays has become increasingly common. At the forefront of this relatively new market are industries that focus on whale sharks (*Rhincodon typus*) with estimates calculated in 2004 suggesting that these generated more than US$47.5 million worldwide, providing important revenues to developing countries such as Ecuador, Thailand and Mozambique (Graham 2004).

Diving with other species of sharks has followed a similar trend of growing popularity. In 2005, it was estimated that approximately 500,000 divers were engaged in shark-diving activities worldwide (Topelko and Dearden 2005). An increasing range of opportunities for this type of tourism are available, including cage diving, shark feeding and drift diving with reef and oceanic sharks. Shark-diving tourism can be found in more than 40 countries (Carwardine and Watterson 2002), with new destinations and target species being established rapidly, due to the increasing recognition of the economic potential of this activity (Dicken and Hosking 2009; De la Cruz Modino *et al.* 2010).

While there are no estimates of the total revenue of the shark-diving industry worldwide, this form of tourism has been shown to be of great economic value in many locations. In the province of Gansbaai, South Africa, cage diving with great white sharks (*Carcharodon carcharias*) generated US$4.1 million and hosted almost 30,000 divers in 2003 (Hara *et al.* 2003). On the east coast of South Africa, diving with tiger sharks (*Galeocerdo cuvier*) was estimated to generate US$1.8 million in 2007 , an important contribution to the economic viability of the local communities around

Umkomass (Dicken and Hosking 2009). In the Canary Islands, the revenues generated by shark and ray-diving activities were estimated to be responsible for the creation of 429 jobs, providing an in-flow to the local economy of US$22.8 million annually (De la Cruz Modino *et al.* 2010). The value of individual grey reef sharks (*Carcharhinus amblyrhynchos*) viewed by the dive industry in the Maldives was estimated to be up to US$35,000 annually in 1993, a figure approximately 100 times greater than the profits that could be obtained if the same shark was caught and sold for consumption (Anderson and Ahmed 1993).

Due to the presence of coral reefs and warm coastal waters that naturally attract divers, shark tourism forms an important and valuable element of tourism in many developing countries throughout the tropical Indo-Pacific and Caribbean. However, the growing demand for shark products, principally for shark fin soup, threatens the future of these valuable industries. Due to their conservative life-history traits of slow growth, low rates of reproduction and late ages at maturity, shark populations cannot withstand high rates of harvest and when depleted often take many years to recover (Field *et al.* 2009). For this reason, fishing for sharks both as a target species and as by-catch has severely reduced shark populations in many parts of the world's oceans (Baum *et al.* 2003; Myers 2003; Myers *et al.* 2007; Field *et al.* 2009), including tropical reef systems (Robbins *et al.* 2006; Ward-Paige *et al.* 2010). This phenomenon is likely to continue unless governments and local people can be convinced that ecotourism provides an attractive alternative for the use of shark resources.

In the islands of the Indo-Pacific, the major obstacles to altering the perception of sharks are both historical and cultural. Fishing has provided the economic basis of island societies for millennia and is still a central part of cultural and economic life in many regions. Fishing rights and grounds are often managed through complex traditional systems by social units such as clans or villages (Johannes 1981; Brunnschweiler 2009) and in many cases small-scale shark fishing is an important part of local culture. This stands in marked contrast to the industrial-scale fisheries that supply the demand for shark fin. However, this cultural heritage may predispose local people and governments towards the primary view of sharks as a fishery resource.

Palau is exceptional among Indo-Pacific nations in its recognition of the importance of sharks as a resource for tourism for the nation's economy. The coral reefs of Palau still host large populations of top-order predators and this factor distinguishes the Palauan diving experience from that available in many other places throughout the tropics where sharks have been severely reduced in numbers or eradicated by fishing (Baum *et al.* 2003; Myers 2003; Myers *et al.* 2007). Diving with reef sharks and manta rays are among the main attractions for tourists to the country (Anon. 2001b). To protect this resource, the national government declared the waters around Palau a shark sanctuary in 2009, where shark fishing is prohibited. This initiative places Palau among a small group of nations that have a nationwide ban on commercial shark fishing.

The recognition of the contribution of reef sharks to the economy represents an important achievement by the government and people of Palau. However, the scale of this contribution is still unknown, since there has never been a quantitative assessment of the value of sharks to tourism and the local and national economy. This project addresses this issue with our principal objective being to quantify the economic value of sharks as a tourism resource to the economy of Palau. This was done using a series of standard questionnaires distributed widely among divers and tourist operators in Palau. These were followed by interviews and other questionnaires with a wider range of stakeholders, including fishers and local people.

Study Area

The Republic of Palau is a complex of approximately 300 islands, spread over an Economic Exclusive Zone (EEZ) that covers 629,000 km^2 of the north Pacific (7°N Lat and 134°E Long). Palau has a population of approximately 20,000 with roughly two-thirds of the inhabitants living on the island of Koror (Figure 1). In 2008, the Gross Domestic Product (GDP) of Palau was estimated as US$218.4 million (Anon. 2010). Subsistence agriculture and fishing are important economic activities however, the local economy of Palau relies primarily on tourism, which attracts approximately 80,000 overseas visitors per year (Anon. 2001b) (Table 1), generates more than US$1.5 million in taxes from hotels and restaurants annually and is one of the main sectors of employment in the country (www.palaugov.net/stats).

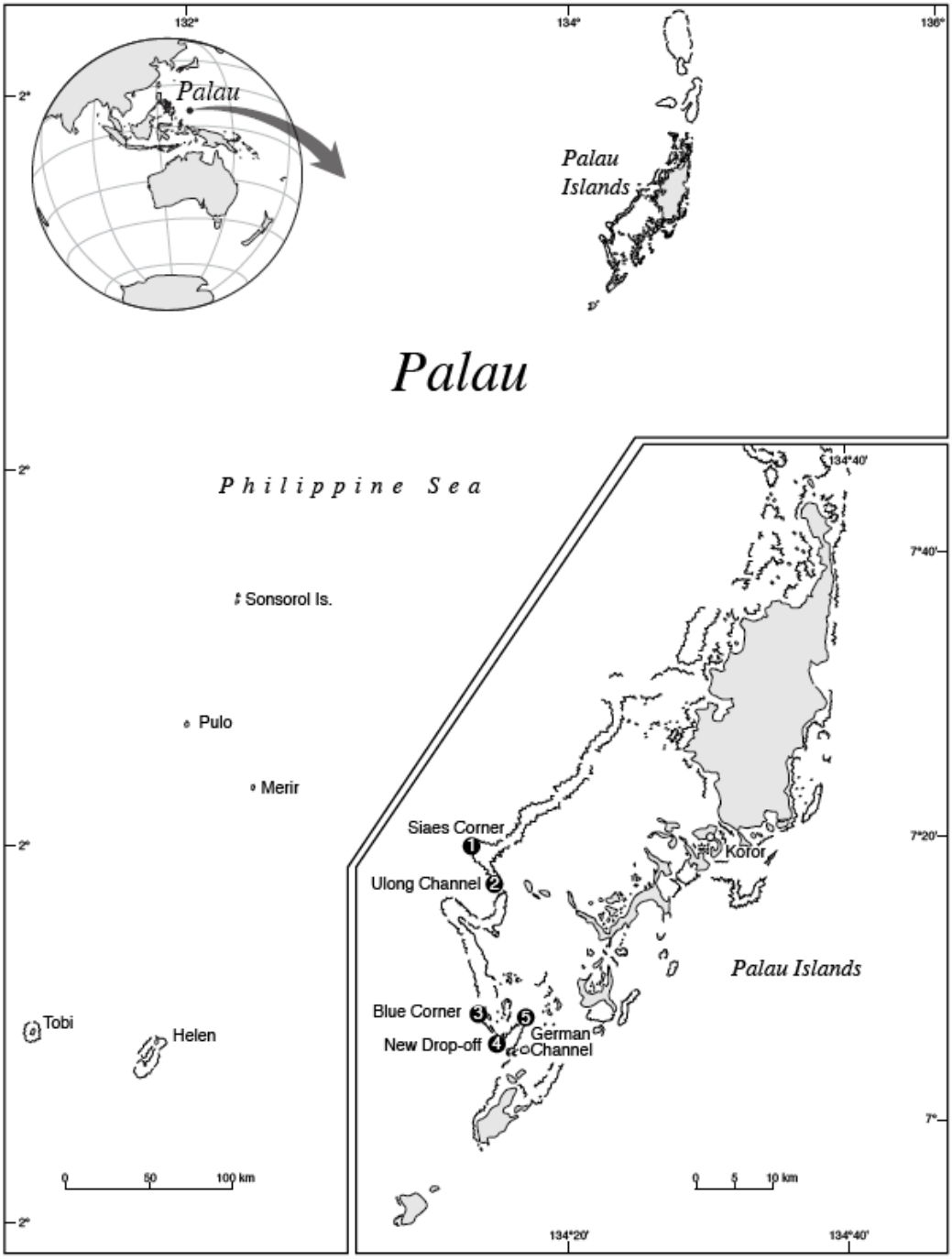


Figure 1: Map of Palau. Insert shows main archipelago with most popular shark-diving sites: 1) Siaes Corner; 2) Ulong Channel; 3) Blue Corner; 4) New Drop-off; 5) German Channel.

Table 1: Numbers of tourists and divers arriving in Palau by nationality from 2007 to 2009. Modified from www.visit-palau.com/publication/index.cfm.

Country of Origin	2007	2008	2009	Average	Divers
Aust/NZ	733	711	700	715	715
Germany	476	621	629	575	575
Guam	1,848	2,258	3,374	2,493	1,247
Hong Kong	465	344	334	381	286
Italy	328	344	327	333	333
Japan	29,198	30,018	26,688	28,635	26,058
Korea	14,342	14,186	13,009	13,846	692
Micronesia	964	1,041	1,055	1,020	0
Philippines	1,719	949	998	1,222	0
China	464	439	534	479	0
Taiwan	29,005	19,981	16,278	21,755	4,786
Russia	302	637	295	411	411
Switzerland	140	187	225	184	184
UK	389	335	373	366	366
USA Mainland	5,956	5,235	5,193	5,461	3,823
Other Europe	882	1,027	1,074	994	994
Others	964	946	801	904	506
TOTAL	88,175	79,259	71,887	79,774	40,976

Source: Extracted from Palau Visitor Authority statistics (www.visit-palau.com/publication/index.cfm), Anon. (2004) and Palau Visitor Authority, personal communication.

The marine environment is the main draw-card for tourists to Palau, particularly for diving and snorkelling (Anon. 2004). Palau is recognized as a world-class diving location and the abundance of large pelagic fish, most notably sharks, has established the country as a popular shark-diving destination. Most of the popular dive sites are located within the state waters of Koror or Peleliu. Each state requires tourists to purchase a diving permit costing US$25.00 and US$20.00 respectively. While Peleliu diving permits grant access to the dive sites for a period of 14 days, the Rock Islands use permit, issued by Koror State, grants tourists general access to some areas of the Rock Islands including beaches, kayaking and snorkelling sites. This permit also grants access to the dive sites and is valid for a period of ten days. Alternatively, tourists may purchase a Jellyfish Lake permit (US$35.00), that grants access to the same sites as the Rock Islands use permit and also includes access to Jellyfish Lake, arguably the most popular non-diving destination in Palau (only snorkelling is permitted).

Secondary Data

The country of origin and numbers of tourists arriving in Palau were obtained from surveys by the Palau Visitors Authority (PVA) and were based on mandatory visitor questionnaires completed on entry to the country. These statistics were available online (www.visit-palau.com/publication/index.cfm) and a summary is presented in Table 1. The percentage of divers among the tourists of each nationality was provided by the PVA (personal communication) and other sources (Anon. 2004) (see Table 1). Estimates of the gross tax revenue of hotels,

restaurants and fishing industry were provided by the Office of Planning and Statistics (www.palaugov.net/stats). Other sources of data used by our study are shown in Tables 2 and 3.

Definitions

Shark diving: a SCUBA-diving activity during which observation of sharks is the major objective.

***Shark diver*:** a diver who visits Palau principally to dive with sharks.

Shark-diving industry: the services provided by the dive industry focussed on fulfilling the demands of shark divers.

Economic value: Total revenues (business revenues + tax revenues) generated by an industry.

Direct socio-economic benefit: Community and government income earned directly from jobs or taxes generated by the shark-diving industry.

Indirect socio-economic benefit: Community and government income earned directly from jobs or taxes generated by services supporting the shark-diving industry (e.g. hotels and restaurants).

Table 2: Description of formulas, values and sources of data used to calculate parameters and estimates of economic benefits related to the tourism and shark-diving industry in Palau.

Abbrev.	Parameters and estimates	Description	Values	Units	Source	Comments
D	Number of divers per year	Sum of number of divers of each nationality	40,976	No./Year	Table 1; Anon. (2004), Anon. (2001a), Anon. (2001b)	Based on the percentage of tourists of each nationality visiting Palau to dive
FI	Fisher Income	Average income from fishing x days fishing	23,800	USD/Year	Fisher questionnaire	Based on four days of fishing per week for 50 weeks
ND	Number of non-diving tourists per year	T - D	38,798	No./Year	Table 1; Anon. (2004), Anon. (2001a), Anon. (2001b)	
NSDP	National shark diving parameter	(SDP x D)/T	0.11	-	Pilot and tourist questionnaires; Table 1	
S	Number of sharks	Sum of average number of sharks sighted on each of the five most popular sites for shark diving	100	No.	Dive guide questionnaire	Calculated from the following sites: Blue Corner, German Channel, Siaes Corner, Ulong Channel and New Drop-Off
SDP	Shark diving parameter	Shark divers /D	0.21	-	Pilot and tourist questionnaires	A shark diver is defined as a diver who visits Palau principally to dive with sharks
T	Annual number of tourists	Average number of tourists visiting Palau from 2007 to 2009	79,774	No./Year	Table 1	
TAX	Tourist taxes	Rock Islands use permit + green tax + departure tax	60	USD/Trip	Table 1	Rock Island permit: $25.00, green tax: $15.00 and departure tax: $20.00
TFP	Tourist fish market parameter	Percentage of fish sold to tourists x TP	0.44	-	Market representative interview	Based on sales to hotels and restaurants
TP	Tourism parameter	T/(Local Population + T)	0.8	-	Table 1 and Anon. (2010)	Percentage of sales that can be attributed to tourists rather than local consumers
W	Wages parameter	Percentage of revenues of dive industry used to pay wages	0.18	-	Operator questionnaire	
BT	Business revenue tax	Four percent of business revenue	0.04	-		
AT	Accommodation tax	BT + (Room tax/2)	0.09	-		Since 80% of tourists interviewed during the survey shared accommodation with another person, we divided the 10% “Room tax” by two to calculate the tax paid by each tourist

Table 3: Description of formulas and sources of data used to calculate parameters and estimates of economic benefits related to the tourism and shark-diving industry in Palau in 2010.

Abbrev.	Variables	Formula	Units	Source	Comments
Economic value					
EVD	Economic value of divers	D x TDET	USD/Year		
EVIS	Economic value of individual shark	EVS/S	USD/Year		
EVND	Economic value of non-divers	ND x TNDE	USD/Year		
EVS	Economic value of sharks	EVD x SDP	USD/Year		
EVT	Economic value of tourism industry	EVD + EVND	USD/Year		
Business revenues					
BRD	Business revenues from divers	D x DETUSD/Year			
BRIS	Business revenues from individual sharks	BRS/S	USD/Year		
BRND	Business revenues from non-divers	ND x NDE	USD/Year		
BRS	Business revenues from sharks	BRD x SDP	USD/Year		
BRT	Business revenues from tourism industry	BRD + BRND	USD/Year		
Economic benefits from shark diving					
DCIDI	Direct community income from dive industry	D x DED x W	USD/Year		Expenditure of dive industry on salaries
DCISD	Direct community income from shark diving	DCIDI x SDP	USD/Year		Expenditure of the shark-diving industry on salaries
FISD	Indirect value of shark diving to fisher	FI x TFP x NSDP	USD/Year	Fisher questionnaire; Fish market interview	
Tax revenues from shark diving					
DTSD	Direct taxes from shark divers	SDP x D x TAX	USD/Year		
BRTSD	Business revenue tax from shark diving	SDP x D x BT x Diving + NSDP x T x AT x Accom + NSDP x T x BT x Other	USD/Year		The sum of tax revenue from shark divers from diving, accommodation and other expenses
TTRSD	Total tax revenues from shark diving	DTSD + BRTSD	USD/Year		
Expenditures					
DDE	Daily diver expenditure	DET/length of stay	USD/Day	Pilot and tourist questionnaires	
DED	Diver expenditure on dives	Sum of diving expenses/ respondents	USD/Trip	Pilot and tourist questionnaires	Average expenditure of a diver on dives per trip
DNDE	Daily non-diver expenditure	NDE/length of stay	USD/Day	Pilot and tourist questionnaires	Average expenditure of a non-diver
NDE	Non-diver expenditure per trip	Accommodation + other expenses + tours	USD/Trip	Estimated based on pilot and tourist questionnaires + TAX	Assumes that expenditures on accommodation and extras by a non-diver tourist are similar to a diver's expenditure on these items. Tours refers to the sum of one land-based ($100.00) and one marine day trip ($100.00)
TNDE	Total non-diver expenditure per trip	NDE + TAX			
DET	Diver expenditure per trip	Accommodation + diving + other expenses	USD/Trip	Pilot and tourist questionnaires + TAX	Average of the total expenditures in each item. "Other" expenses include souvenirs, land-based tours etc.
TDET	Total diver expenditure per trip	DET + TAX	USD/Trip		

Shark Diving

Shark diving in Palau relies on dive sites that host aggregations of sharks that are predictable both in their numbers and timing of appearance. Such sites tend to be on the outer reef slope near drop-offs and are usually associated with strong tidal currents**.** Aggregations can be found at a number of dive sites, mainly on the slope of the barrier reef, on the southwest side of the lagoon (Figure 1). Typically, shark diving occurs during incoming tides, when the sharks are swimming off the slope of the reef and divers can position themselves at the edge of the drop-off using hook and line attachments of the diver to the reef (Photo 1). This technique, known locally as hook diving, is used to keep the divers in place against the current flow with minimal effort and contact to the reef and to make divers' behaviour predictable to the sharks. The technique optimizes the shark-diving experience since it allows close encounters with sharks for extended periods of time.

Photo 1: Shark divers use hooks attached to the reef to stay in place against the current and view sharks at the dive site. Photo: Richard Brooks, contributed by Micronesian Shark Foundation.

According to the dive guides, the number of sharks sighted by divers is related to the dive site and tidal movements. The length of time of the experience varies and is usually terminated by the divers due to no-decompression time limits. Although several species of sharks can be found in Palau, the shark-dive industry relies mainly on interactions with two species, the whitetip (*Triaenodon obesus*), and the grey reef shark (*Carcharhinus amblyrhynchos*), with the latter drawing most of the attention of the divers due to its size, abundance and behaviour.

Diving Industry

In 2010, there were 18 licensed dive tour operators who offered dive trips to popular shark-diving sites in Palau. Typically, dives involved day trips aboard small speed boats that had an average carrying capacity of 12 people. The average flat-rate charge for the dive trip during our study was US$125.00 for two SCUBA tanks (i.e. two dives), with an optional extra dive costing on average US$50.00. Live-aboard boats were also available but consisted of only four boats with total capacity of 64 divers, thus represented a small portion of the market (approximately 8%).

The tourism industry in Palau principally caters to Asian, American and European tourists (Table 1) and for this reason, dive operators often employ overseas workers to suit the needs of their particular clientele base. Operators also benefit from local knowledge and the work force includes many locals. Consequently, the staff of dive tourism operations typically consists of a mix of overseas and Palauan workers.

Methods

Survey

The socio-economic survey was based on five different questionnaires that collected information from people directly interested in, or affected by, the shark-diving industry in Palau. These stakeholders included tourists, dive operators, dive guides and local fishers (Table 4). This onsite survey was conducted in March (pilot) and May/June 2010 and provided a total of 297 completed questionnaires. Of this total, 246 respondents were divers (shark and non-shark divers), ten were dive operators, 20 were dive guides working within the industry and 21 were local fishers.

A pilot study trialled the survey questionnaire and its delivery to the divers as well as providing a general profile of the tourists engaged in diving activities, including both shark and non-shark divers. This pilot was structured as a face-to-face interview conducted by a single interviewer with a target sample size of 30 dive tourists. Divers visiting Palau typically spend several days engaged in dive activities and interviews were done after at least a few days of diving so that tourists had sufficient experience and knowledge of the location and their expenditures (Table 4).

Table 4: Structure, content and sample size of the five questionnaires and interviews conducted for data collection of the economic value of sharks in Palau in 2010.

Respondent	η	Date	Structure	Information collected
Tourist (pilot)	30	March 2010	Face-to-face questionnaire	Demographic characteristics, motivations to visit Palau, satisfaction and expenditures on diving, shark diving, accommodation, other activities and living costs while in Palau, knowledge of the shark sanctuary and influence on decision to visit Palau
Tourist (main)	216	May /June 2010	Self-administered questionnaire	Demographic characteristics, motivations to visit Palau, satisfaction and expenditures on diving, shark diving, accommodation, other activities and living costs while in Palau, knowledge of the shark sanctuary and influence on decision to visit Palau
Dive operator	10	May / June 2010	Face-to-face questionnaire	Number of tourists taking dive trips, tourist preferences, main dive attractions and activities, expenditures, expectations regarding the industry and effects of the creation of the shark sanctuary.
Dive guide	20	May / June 2010	Face-to-face questionnaire	Popular sites for shark diving, number of divers visiting these sites, average number of sharks per dive in each site, most common species of shark sighted during dives.
Fisher	21	May / June 2010	Face-to-face questionnaire	Fishing frequency, fishing techniques, income from fishing, level of interaction with sharks, perception of sharks and conservation
Fish Market	1	July 2010	Interview	Number of suppliers, fishing frequency, buyers, market volume and market prices

The pilot study provided the basis for the design of a self-administered questionnaire, structured to obtain information about the demographic characteristics of the divers visiting Palau, their motivations, satisfaction and expenditures. The self-administered questionnaire included questions about expenditure on accommodation, other activities (e.g. land tours) and living costs while in Palau. It also assessed the diver's knowledge of the shark sanctuary and its influence on their decision to visit Palau (Table 4). Self-administered questionnaires and a printed explanation of the purpose of the research were available in both English and Japanese. Many of these questionnaires were supplied to divers at the airport just prior to their departure from Palau. The self-administered questionnaire was answered by 216 dive tourists in May and June 2010. Since this questionnaire required minimal changes from the questionnaire used during the pilot study, the information collected by both the pilot and the main questionnaire were pooled, yielding a sample size of 246 tourists (Table 4).

The dive operator questionnaire obtained information about the characteristics of the operator's business, including number of tourists taking dive trips and their preferences, main dive attractions and activities, expenditures and expectations regarding the dive industry and effects of the creation of the shark sanctuary (Table 4). This questionnaire was answered by ten dive operators during face-to-face interviews, however, one incomplete form was discarded from the analysis.

Twenty dive guides of eight nationalities working for nine dive operators were also interviewed. The dive guide questionnaire was presented to subjects during a face-to-face interview that focused on obtaining information about the most popular dive sites for shark diving in Palau. It also aimed to provide an estimate of the number of divers visiting these sites throughout the year, average number of sharks in each site per dive and most common species of shark sighted during dives (Table 4).

Since conservation regulations are likely to affect fishing activities, fishers were also surveyed in face-to-face interviews using a standard questionnaire. This provided information about their fishing activities, techniques, level of interaction with sharks, perception of shark conservation and income from fishing. The interviews were conducted in the main fish market in Koror. The owner of the fish market was also interviewed regarding the fishers' activities, market and market prices (Table 4).

Economic variables and data analysis

Based on the survey data, a range of variables were estimated to quantify the value of sharks as a tourist resource to the economy of Palau, and the benefits from the shark-diving industry to the local community. A detailed list of variables, formulas and parameters used in these calculations and the data sources are presented in Tables 2 and 3.

Parameters

The average total number of tourists visiting Palau on an annual basis was calculated as the average number of tourist arrivals from 2007 to 2009 (Table 1). Two parameters were used to quantify the revenues of different sectors of the economy generated by the presence of shark divers (Table 2). The shark diving parameter and national shark diving parameter were the percentage of shark divers among the total number of divers surveyed (from the tourist questionnaire) and the proportion of shark divers among the total number of tourists that visited Palau (from government statistics) respectively (Tables 1 and 2). The number of sharks used in the calculations of the economic value of an individual shark was an estimate of the total number of sharks (grey and whitetip reef sharks) regularly seen by dive guides at the five most popular shark diving sites in Palau (Blue Corner, Ulong Channel, Siaes Corner, New Drop-off and German Channel), (Figure 1, Table 2). The number of sharks was calculated by summing the average number of sharks regularly sighted in each one of these dive sites (data from the dive guide questionnaire), and assumed that sharks sighted at different dive sites were different individuals. Although this assumption was necessary for the calculations, it is likely that individuals can transit between dive sites. Thus, the economic value of an individual shark was an estimation of the average value of a shark (not a marginal value), based on reported numbers (Table 2).

Using the data from the operator questionnaires, we estimated the percentage of revenues of the dive industry used to pay wages in Palau. We then estimated the percentage of the expenditures on shark diving by tourists that could be attributed to the payment of these wages. The resulting parameter was assumed to represent the economic contribution of shark diving to the local community in Palau (Table 2).

All tourists in Palau (divers and non-divers) visiting sites in the Rock Islands are required to pay at least three taxes, including a Rock Islands use permit, departure and green taxes (see below). For the purposes of our study these values were summed and treated as a single value (tourist taxes) in calculations (Table 2). It is important to note that the green tax (US$15.00) was implemented in November 2009. Consequently, our estimate of tourist taxes from shark divers is based only on a one year period.

Business revenue and economic value

We took a conservative approach to all calculations. For example, although it is common practice by divers to purchase a Rock Islands use permit and a Peleliu dive permit, the latter tax was not included in our calculations due to the lack of information on the number of divers purchasing both permits. Similarly, airfares to and from Palau were not included in the calculations since there is little or no in-flow from these expenditures to the local economy in Palau.

Our study estimated the financial revenue of the shark-diving industry and the magnitude of key components of that revenue. We recognise that revenue does not equate to net economic

benefits from the industry. For the latter, estimates of both the supply curve and the demand curve for shark-diving services would be required in order to calculate producer and consumer surpluses (Just et al., 2004). This was not attempted due to a lack of market data required for any statistical analysis of supply or demand. 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. The approach we take allows us to focus on economic benefits that are retained within Palau, whereas much of the producer and consumer surplus generated by the industry would be captured by foreign businesses and consumers.

Annual business revenue from sharks (*BRS*) in the shark-diving industry and associated businesses was estimated as

$$BRS = DET \times D \times SDP \quad (1)$$

where *DET* was average expenditure per dive tourist per trip without tourist taxes (assumed to be the same for shark divers and other divers), *D* was the number of dive tourists per year (from official statistics) and *SDP* was the proportion of all divers who were shark divers (estimated from the surveys). We also estimated the annual business revenue from tourism as a whole (Table 3). Business revenue was calculated both for the industry and on a per shark basis.

We calculated estimates of the economic contribution of divers and on a broader scale, the entire tourism industry to Palau in order to place the economic value of sharks within the context of the economy of the country. The value of sharks as a non-consumptive resource was calculated as the expenditure of divers multiplied by the shark diving parameter (the percentage of shark divers of the total number of divers surveyed) (Table 3).

For the calculation of the economic value of the typical non-diving tourist, we included the following expenses: accommodation, living (food and drink), other costs (souvenirs, etc) a land-based tour (estimated as US$100.00) and one marine-based day trip (estimated as US$100.00) during their holiday (Table 3). Considering the variety of tourist activities in Palau and assuming that tourists would be expected to visit more than two popular destinations during their time in the country, it is likely that this approach provides a relatively conservative estimate of the economic value of non-diver tourists.

Socio-economic benefits from shark diving

The annual economic contribution of the shark-diving industry to the economy of Palau has two main components: community income and taxes collected by the government. Direct community income is a component of the business revenue from shark diving (BRS) and is dispersed through the Palauan economy by payment of wages and salaries to employees of dive business. Direct community income from shark diving (*DCISD*) was calculated as follows:

$$DCISD = D \times SDP \times DED \times W \quad (2)$$

where *DED* was diver expenditure on dives (from questionnaires) and *W* was the proportion of dive industry income that was allocated to paying wages and salaries (from operator questionnaire) (Tables 2 and 3).

The taxes collected by the government that were gained from shark-diving tourism were estimated in two ways. Firstly, the direct tax income from shark diving was calculated as the combination of tourist taxes paid by shark divers (Rock Islands use permit, green tax etc, see above) (Table 3). Additionally, the Palauan government imposes a revenue tax of 4 per cent on most of the expenditures made by shark divers (and all other tourists), including accommodation, restaurants, land tours and souvenirs etc. This component of tax revenue was included within BRS. Tax revenue from the shark-diving industry (*TTRSD*) was calculated as follows:

$$TTRSD = TAX \times D \times SDP + SDP \times D \times BT \times Diving\ expenses + NSDP \times T \times AT \times Accommodation\ expenses + NSDP \times T \times BT \times Other\ expenses \quad (3)$$

where *BT* was the business revenue tax (4%, see Table 2) , *NSDP* was the national shark-diving parameter (the proportion of shark divers out of all tourists) and *AT* was the accommodation tax (9%, see Table 2).

The combination of these two sources of income gave an estimate of the tax revenue provided to the government by shark divers (Table 3).

A third and smaller economic contribution of the shark-diving industry was also calculated. This was the indirect economic value of the shark-diving industry to fishers, which was estimated as the profits a fisher obtained from selling his fish to the shark divers via a chain of commerce (i.e. fish market, hotels and restaurants). This represented a source of income that would not be available if the shark divers were not visiting Palau and therefore, represented a source of income directly related to the preservation of sharks interacting with the diving industry and was calculated as follows:

$$FISD = FI \times TFP \times D \times SDP/T \quad (4)$$

where FI was average annual fisher income (from fisher questionnaire), TFP was the tourism fish-market parameter (the proportion of fish sold to tourists, based on an interview with a fish-market representative to determine fish sales to hotels and restaurants, multiplied by TP, the proportion of hotels and restaurants revenue attributable to tourists), and T was the annual number of tourists visiting Palau (from official statistics, PVA 2010), (Tables 2 and 3). This calculation assumed that Palauan locals could represent up to 20% of the market of hotels and restaurants (Table 3).

Results

Demographics and profile of respondents

Respondents to our survey originated from four principal regions (Figure 2). Europeans constituted the largest group and accounted for 36% of the total. Of this group, 9% of all tourists were from Germany and 6% from Britain. Slightly fewer divers of East Asian origin were interviewed (33% of respondents). Of these 23% originated from Japan. Divers from Hong Kong comprised 6% of the total respondents, while divers from the Americas accounted for 21% of respondents, nearly all of whom (20%) originated from the USA. Australian divers accounted for 7% of respondents, and were the only country represented from Oceania (Figure 2).

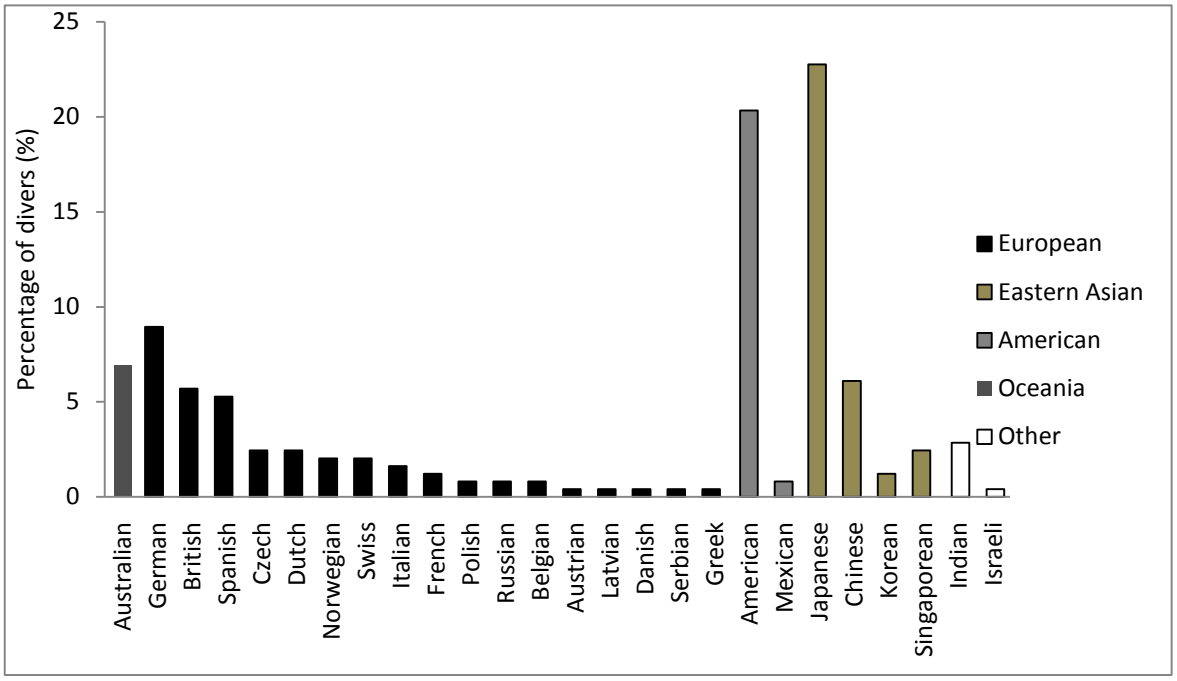


Figure 2: Frequency distribution of divers by nationality in the sample of tourists (n=246) surveyed in Palau in 2010.

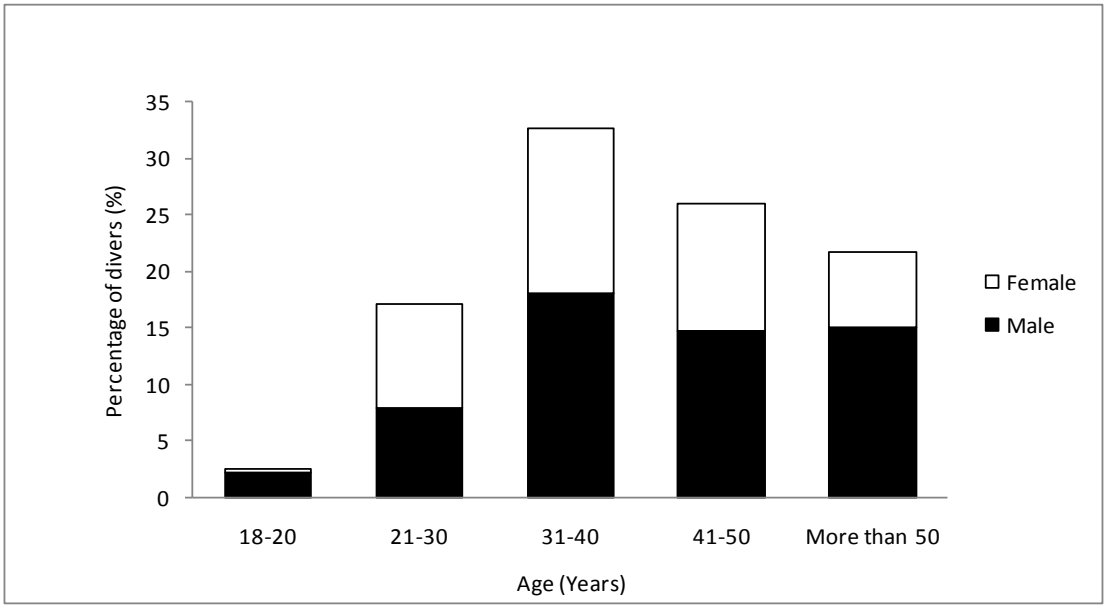


Figure 3: Frequency distribution of divers by gender and age classes in the sample of tourists (n=240) surveyed in Palau in 2010.

Over half (58%) of the survey respondents were male. Most divers (59%) were between 31 and 50 years of age, with 22% older than 50 years (Figure 3). Generally, divers had a reasonable level of experience (more than 50 dives) and 57% had more than 100 logged dives. Inexperienced divers (< 50 dives) accounted for 26% of respondents.

Over two-thirds of divers (69%) had annual incomes in excess to US$50,000. In this group, divers with annual incomes between US$50,000 and US$79,999 represented 31% of the total sample (Figure 4). On average, respondents spent 5.6 days (95% CI= 5.5-5.7) diving during their trip to Palau, with an average total trip duration of 8.1 days (95% CI=7.9-8.3) (Table 5), although trip duration varied with nationality (Figures 5 and 6).

Seventy-five percent of the divers said they were "interested" or "very interested" in shark ecotourism (Table 6). Shark diving was indicated as the main or specific reason to visit Palau and was a principal attraction that determined the choice of holiday destination for 21% of the respondents.

Approximately 72% of divers were unaware of creation of the shark sanctuary prior to their trip (Table 6). Of the 29% of divers that were aware of the sanctuary prior to their arrival, 42% reported that this was an important factor on their decision to choose Palau as a holiday destination (Table 6).

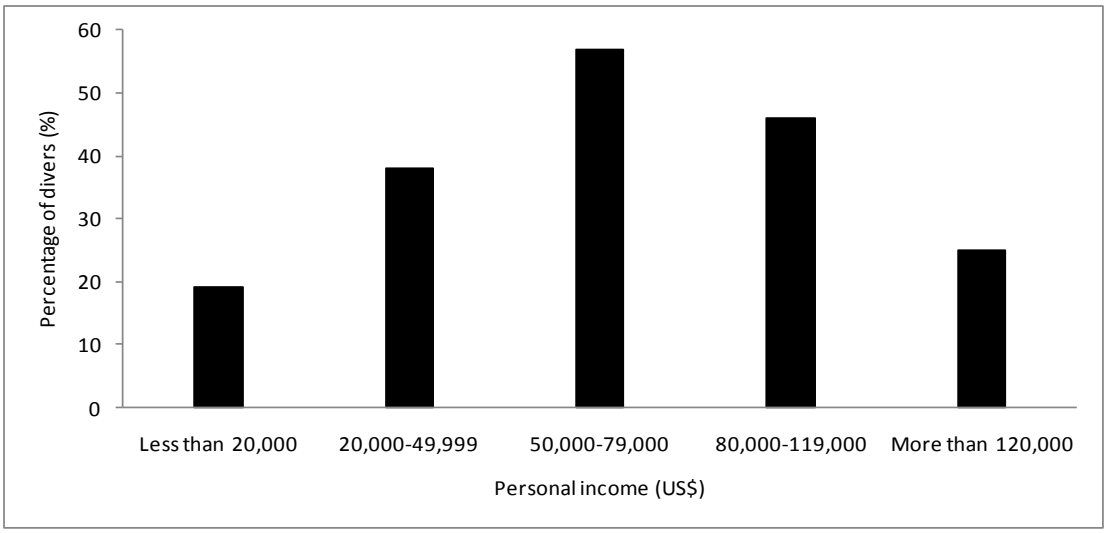


Figure 4: Frequency distribution of divers by annual income (US dollars) in the sample of tourists (n=185) surveyed in Palau in 2010.

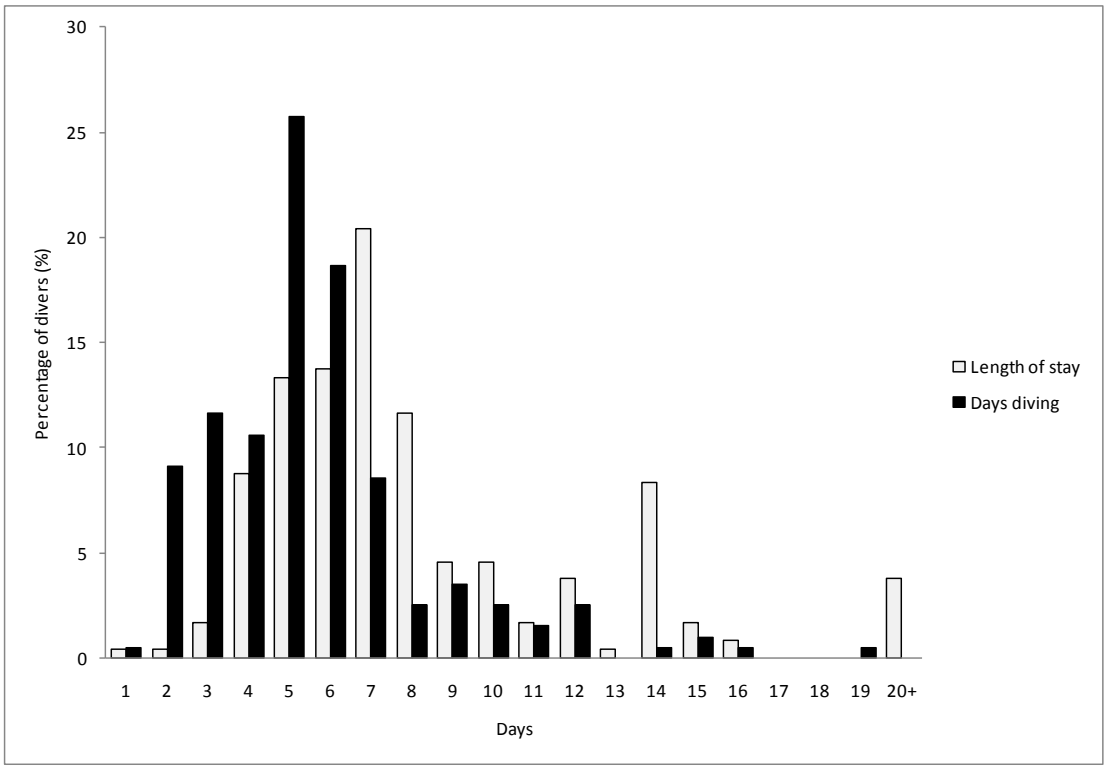


Figure 5: Frequency distribution of average length of stay (n=240) and average number of days diving in the sample of tourists (n=198) surveyed in Palau in 2010.

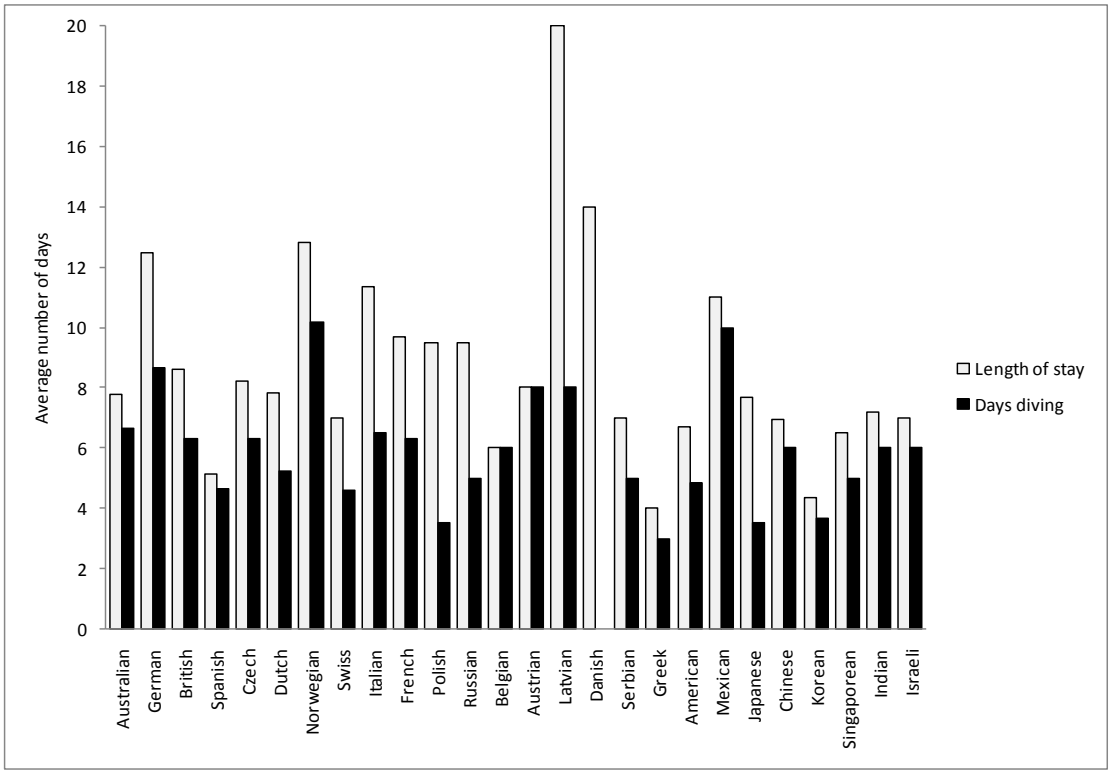


Figure 6: Frequency distribution of average length of stay (n=240) and average number of days diving by divers of different nationalities in the sample of tourists (n=198) surveyed in Palau in 2010.

Table 5: Comparison of results of four questionnaire-based studies of length of stay, number of days, diving and average expenditures per trip of tourists in Palau.

	Our Study (2010)	Comprehensive exit survey analysis report (Anon. 2001)	Dive tourism in Palau: Resource use, value and management (Anon. 2001)	Palau tourism economic valuation survey (Anon. 2004)
Tourist profile	Divers	General tourist	Divers	General tourist
Year	2010	2001	2001	2004
Average length of stay	8.1	7.1	6.9	5.1
Average tourist expenditure per trip (US$)	2,081	1,025	-	1,784*
Average days diving	5.6	-	5.1	-

* Average price of package tours including airfare

Table 6: Summary of responses to questionnaire about knowledge and relevance of the shark sanctuary in the decision to visit Palau by divers in 2010.

	N	%
Main reason to visit Palau (*n=228*)		
General diving	134	59%
Mainly to dive with sharks	35	15%
Specifically to dive with sharks	13	6%
Dive activities and sight-seeing	30	13%
Snorkelling	8	4%
Other	8	4%
Knowledge about the sanctuary before the trip (*n=244*)		
Yes	70	29%
No	160	66%
Unsure	14	6%
Influence of sanctuary in decision to go to Palau (*n=70*)		
Did not influence	28	40%
Influenced a bit	13	19%
Moderate influence	9	13%
Major influence	14	20%
Primary reason	6	9%
Importance of sanctuary on intention to return to Palau (*n=210*)		
Not important	15	7%
Minor importance	31	15%
Moderate importance	40	19%
Important	57	27%
Very important	67	32%
Interest in shark diving (*n=230*)		
Negative	0	0%
Not interested	7	3%
A little interested	33	14%
Interested	80	35%
Very interested	93	40%
Do not know/ not sure	17	7%

Economic value of tourism

Of the 80,000 tourists who visit Palau every year, approximately 51% are divers (Table 1), (Anon. 2004). The economic value of these divers to Palau is US$85.3 million per year (95% confidence interval (CI) US$78.8-94.7 million), which represents about 59% of the total value of tourism (Table 5). Based on these figures and our estimate of the economic value of the non-diver tourists of US$59.5 million (95% CI=US$54.7-64.3 million) (Table 7), the economic value of the tourism industry to Palau was estimated to be US$144.8 million (95% CI=US$133.8-154.5 million) annually (Tables 7 and 8).

The business revenue generated by these divers (BRD) for Palau was US$82.8 million per year (95% CI= US$76.4-89.3 million), representing about 59% of the total revenue from tourism

(Table 4). We estimated that the business revenue from non-diver tourists (BRND) was US$57.2 million (95% CI=US$52.4-62.0 million) (Table 4), so that the total business revenue of the tourism industry to Palau (BRT) was estimated to be US$140.0 million (95% CI=US$129.0-151.0 million) annually (Table 4).

Table 7: Expenditure of divers (US dollars) in Palau in 2010. CI (95%): 95% confidence interval.

Code	Average tourist expenditure per trip	Mean (US$)	CI(95%) (US$)
-	Accommodation	588	529-647
-	Diving	749	680-818
-	Other	684	589-780
-	Tours (1 land-based + 1 marine day trip)	200	-
DDE	Daily diver	285	263-307
DNDE	Daily non-diver	210	188-232
TDET	Total diver	2,081	1,924-2,239
TNDE	Total non-diver	1,534	1,410-1,657

Note: Estimated from 167 questionnaires.

Table 8: Socio-economic value (US dollars) of shark-diving industry and related sectors in Palau in 2010. CI (95%): 95% confidence interval.

Code	Variables	Mean (US$)	CI(95%) (US$)
Annual economic value			
EVD	All divers	85.3 million	78.8-94.7 million
EVS	Shark divers	18 million	16.6-19.3 million
EVND	Non-divers	59.5 million	54.7-64.3 million
EVT	Tourism industry	144.8 million	133.8-154.5 million
EVIS	Individual shark	179,000	165,445-192,515
Annual business revenues			
BRD	All divers	82.8 million	76.4-89.3 million
BRS	Shark divers	17.4 million	16.0-18.7 million
BRND	Non-divers	57.2 million	52.4-62.0 million
BRT	Tourism industry	140.0 million	129.0-151.0 million
BRIS	Individual shark	174,000	160,000-187,000
Economic benefits to the community from shark diving			
DCISD	Direct community income	1.2 million	1.1-1.3 million
FISD	Individual fisher income	1,180	915-1,440
Annual tax revenue from shark diving			
DTSD	Direct (TAX)	517,600	
BRTSD	Business revenue taxes	962,000	887,000-1.0 million
TTRSD	Total	1.5 million	1.4-1.6 million

Economic value of sharks

Approximately 8,600 shark divers visit Palau each year and observations by dive guides suggest that around 100 sharks interact with these divers in the five most popular shark diving sites. On this basis, the total value of sharks to the Palauan economy was estimated to be US$18 million per year (95% CI= US$16.6-19.3 million) (Table 8). The value of an individual shark to the economy at these dive sites was estimated to be US$179,000 per year (95% CI= US$165,000-US$192,000) (Table 8).

The total business revenue generated by shark diving (BRS) for the Palauan economy was estimated to be US$17.4 million per year (95% CI= US$16.0-18.7 million) (Table 4). The average contribution of each of the sharks (BRIS) was estimated to be US$174 000 per year (95% CI= US$160 000-US$187 000) (Table 4).

Socio-economic benefits of shark diving

The annual income generated by tourist taxes on shark divers was estimated to be US$517,600 (Table 8). In combination with the business tax revenues generated by the shark-diving industry and sectors that support infrastructure and services to shark divers (such as hotels, restaurants and souvenir shops) the total tax revenues from shark diving (TTRSD) collected by the government was estimated as US$1.5 million per year (95% CI=US$1.4-1.6 million)(Tables 3 and 8). The direct community income from shark diving was estimated to be slightly smaller than this value at US$1.2 million annually (95% CI=US$1.1-1.3 million) (Tables 3, 7 and 8). Fishers also benefitted marginally from the shark diving by supplying tourists with their catches via restaurants. This was estimated to provide an individual income of approximately US$1,180 annually (95% CI= US$915-1,440) (Table 8), or approximately 5% of a fisher's total annual income (Tables 2 and 3).

Discussion

The economic value of shark-diving tourism

The small island nations of the Indo-Pacific are characterized by a limited range of economic opportunities. However, their tropical locations, scenic beauty and diversity of marine life often make these places highly attractive holiday destinations for tourists. For this reason, tourism is a major source of revenue and increasingly occupies a central position in the economy of these countries (Milne 1992; Anderson *et al.* 1999; Anon. 2003; McElroy 2003). In the fiscal year of 2009/2010, the annual GDP of Palau was estimated to be US$218.4 million (Anon. 2010), with tourism representing the main source of income and accounting for 56% of this total (Anon. 2001b; Anon. 2010) . Our conservative estimate of the annual economic value of the diving industry was US$85 million, so that this sector accounted for a minimum of 39% of the GDP of

Palau. Given that the opportunity to view sharks is the principal reason for visiting Palau for 21% of divers, the shark-diving industry accounts for approximately 8% of the GDP of the country.

Economic value of individual sharks

A Palauan reef shark residing at one of the five most popular dive sites was estimated to have an average annual value of US$179,000 to the tourism industry and government. Grey and whitetip reef sharks are the main species interacting with divers in Palau. Assuming that there is limited variation in the number of sharks interacting with the tourism industry during a single generation and using a very conservative estimate of life span of 16 years for both species (Smith *et al.* 1998; Compango 1984), the lifetime economic value of each individual shark will be approximately US$1.9 million (present value at birth, assuming real discount rate of 5 percent). Given that approximately 100 sharks were interacting with the tourism industry at five major dive sites, the total present value of a generation of sharks interacting with the diving industry in Palauan waters is approximately US$200 million. These estimates of the annual value of an individual shark to the tourism industry in Palau are consistent with those made in other locations. In 1994, the annual value of each Caribbean reef shark (*Carcharhinus perezi*) interacting with the shark-diving industry of the Bahamas was estimated to be US$250,000 (Hall 1994), while in the Maldives, a single grey reef shark was estimated to generate annual revenues in 1993 of US$33,500 (Anderson and Ahmed 1993).

The significance of reef sharks in Palau and other tropical localities as a non-consumptive resource contrasts with their value as a fishery. The price of a set of shark fins (first dorsal, both pectorals and lower caudal) varies according to the species and market fluctuations and ranges from US$20 to US$90 (Clarke *et al.* 2007). While fins are valuable, the shark meat is considered to be of poor quality, with an average price per kilo ranging from US$2.00 to US$4.60 (Chen and Phipps 2002). A large grey reef shark, which is the biggest of the sharks regularly interacting with divers in Palau, weighs approximately 40kg (Wetherbee *et al.* 1997). Considering that the sharks interacting with the tourism industry tended to be adults (Meekan *et al.* unpublished data), the maximum total revenues that could be obtained from the targeting of these 100 animals by a fishery for the international market was approximately US$10,800. This represents 0.00006% of the life time value of the same sharks used as a non-consumptive resource in Palau (US$190 million).

Socio-economic benefits from shark diving

We estimated that approximately US$1.2 million was spent per year by the shark-diving industry on salaries to employees resident in Palau. These are a key benefit of the industry and because of the labour-intensive nature of diving, with relatively low guide-to-diver ratios (and therefore, more guides) and the need for roles involving maintenance, boat operation, catering and office work, the shark-diving industry maximizes dispersion of revenues and makes a major contribution

to the economy by generating jobs and income to the community and taxes to the government (Milne 1992; De la Cruz Modino *et al.* 2010).

Beyond the direct return of salaries to the community, the shark-diving industry indirectly provides benefits by increasing the buying power of the population. A proportion of salaries will be used to purchase additional goods and services, which in turn have a multiplier effect, generating more jobs and further dispersing the revenues from shark diving (Milne 1992). The great numbers of shark divers in Palau are also responsible for jobs and revenues generated in different sectors of the tourism industry such as hotels, restaurants and souvenir shops. These contributions were not quantified by our study and thus it is likely we have underestimated the economic benefit to Palau of the shark-diving industry.

Tourist taxes paid by shark divers in Palau generated an income of approximately US$1.5 million to the government. This accounts for approximately 14% of the tax revenue collected from all industries by the Palauan Government in 2008 (www.palaugov.net/stats). Compared to other industries, the taxes paid by shark divers were the third highest contributor to the gross tax revenue in Palau and were roughly 24 times higher than the taxes collected from the fishing industry in 2008.

We estimated that the provision of fish to restaurants for consumption by shark divers gave an additional annual income of approximately US$1,200 per fisher. The manager of the fish market reported that 55 fishers regularly sold their catches to supply both the tourism industry and the local population. If these fishers were engaged in shark-fishing activities, the maximum revenues that they could obtain for the capture and sale of the sharks interacting with the tourism industry would be around US$196, or only 16% of the annual income each one would have earned by keeping these sharks alive.

Wider context of results

This study clearly shows the vital importance of shark diving to the economy of Palau. The implications of our work are not limited to Palau, as our estimates of the economic contribution of shark diving are comparable to those of studies from a range of other localities. In the Canary Islands, the shark and ray-diving industry was estimated to be worth US$22.8 million annually. Palau hosts approximately half of the number of divers that visit the Canary Islands annually (De la Cruz Modino *et al.* 2010), implying that the total expenditure of divers in Palau is roughly twice that of visitors to the Canary Islands. Additionally, in 2009/2010 shark diving contributed significantly more to the GDP of Palau (8%) than the Canary Islands (0.11%) (De la Cruz Modino *et al.* 2010). These differences in relative importance reflect both a broader and more developed resource base in the economy of the Canary Islands than Palau and also the more sporadic nature of shark and ray encounters in the Canary Islands. This unpredictability limits the ability of operators to market their product and the prices that can be charged for their services (De la

Cruz Modino *et al.* 2010). Divers with an advanced level of experience are often willing to pay more and go to specific destinations if they can be assured that the product they seek will be delivered (Dearden *et al.* 2006; Jones *et al.* 2009) and this may influence their choice of diving destination. Shark aggregations in Palau are highly predictable, which implies that the dive operators can market and sell a product at a greater price with the expectation of reliable delivery to clients.

In the Maldives, a shark-diving industry based on interactions with grey reef sharks was estimated to complete 77,000 dives and yield approximately US$2.3 million annually in revenues in 1993 (Anderson and Ahmed 1993). The value of this industry was considerably lower than our estimate for Palau (Anderson and Ahmed 1993) and to some extent, this dissimilarity can probably be explained by the 17-year time lag between studies and substantial differences in methods. In the Maldives, estimates were based solely on the direct revenues from diving. Accommodation, restaurants and local businesses that also benefit from expenditures by divers were not considered. Even though earnings were likely to be underestimated, the shark-diving industry in the Maldives yielded twice as much as the export earnings of the three major shark-fishing industries in the country for the same period (Anderson and Ahmed 1993).

The economic benefits of shark diving are not restricted to well-established tourist markets such as the Canary Islands and the Maldives. In 2009, a developing tiger shark-diving industry at Aliwal Shoal, South Africa was estimated to have an annual value of approximately US$1.8 million. This industry delivered a specialized experience with reasonable predictability and a high rate of satisfaction (Dicken and Hosking 2009). In comparison to Palau, the total revenues were an order of magnitude less, which largely reflected the difference in the scale of shark-diving industries between the two locations, with Palau hosting 8,600 divers and the Aliwal Shoals only 1,000 divers in 2009. However, when all shark-diving industries in South Africa are considered together, economic values are more comparable to Palau. Overall, South Africa hosts 10,700 tourists in activities that include cage diving with great white sharks, snorkelling with whale sharks and diving with other sharks. These combined activities yielded a minimum of US$6.5 million yearly to the South African economy (Hara *et al.* 2003; Dicken and Hosking 2009).

Across the entire Indo-Pacific, shark diving (including whale sharks) generates at least US$40 million dollars annually (Anderson and Ahmed 1993; Hara *et al.* 2003; WWF-Philippines 2006; Rowat and Engelhardt 2007; Dicken and Hosking 2009; Catlin *et al.* 2010). In reality this value is likely to be much greater, since the economic value of many recent and developing industries has not yet been quantified (e.g. Fiji and French Polynesia; Brunnschweiler 2009; Clua *et al.* 2010).

Shark sanctuary

In 2009, Palau created a nation-wide shark sanctuary in the waters of their Exclusive Economic Zone (EEZ). Since this time, the Maldives and Honduras have followed suit, also banning shark fishing within their EEZs. Most divers (66%) had no knowledge about the creation of the sanctuary prior to their arrival in Palau, probably reflecting the recent nature of sanctuary legislation. However, it is important to note that a high percentage of divers (78%) stated that the sanctuary had a reasonable degree of importance on their decision to re-visit Palau, suggesting that the creation of the sanctuary could play an important role on the selection of a destination by shark divers in the future.

Demography and profiles of dive tourists

Tourists that visit Palau generally come from four main regions, with a predominance of Asians (Japanese, Taiwanese, Korean and Chinese), followed by Americans (USA and Guam), Europeans (Germans, Italians, Russians, Swiss, British and others) and people from Oceania (Australians, New Zealanders and Micronesians) (Table 1). Virtually all tourists visiting Palau are in some way engaged in marine recreation, although there are differences in preferences and motivations among nationalities (Anon. 2001b). Respondents to our surveys did not entirely replicate the pattern of origin of all tourists, being dominated by Europeans, followed by Asians (mostly Japanese) and Americans. After the Japanese, Taiwanese and Koreans are the two most numerous nationalities of tourists in Palau (Table 1). Koreans accounted for a small percentage of respondents to our survey and most of these tourists do not dive. While few Taiwanese visitors dive, they form a large percentage of the tourist market thus are important in terms of absolute numbers of divers. These divers were not represented in our respondents and we assumed that their motivations and expenditures were equivalent to those of Japanese divers.

We estimated that most tourists spent an average of 5.6 days of their stay engaged in diving activities. This value is consistent with an estimate of 5.1 days calculated in 2001 (Anon. 2001b) and suggests that there has been little change in this variable over the last decade. The average length of stay of the dive tourist in our survey was 8.1 days, a value higher than the 7.1 days obtained by a survey of all tourists visiting Palau (Anon. 2001a) and of 6.9 days obtained by a survey of divers and snorkelers in 2001 (Anon. 2001b). In these 2001 surveys, the length of stay varied among nationalities with European and Americans staying from 7.5 to 11 days, while Korean and Taiwanese tourists stayed for 4 and 4.5 days, respectively. The longer length of stay found in our survey could thus be related to the relatively low frequency of Korean and Taiwanese divers in our sample. Ultimately, the variation of the length of stay of tourists from different nationalities appears to be related to flight schedules, particularly for tourists of Asian origin (Anon. 1999; Anon. 2001b; Anon. 2001a; Anon. 2004).

Of the divers surveyed by our study, 81% were in their 30s or older and 70% had annual income exceeding US$50,000. Although the age profile was similar to the profile of tourists surveyed in 2004 (78% of divers older than 29 years of age), the proportion of tourists earning more than US$50,000 was higher in our survey (60% in 2004) (Anon. 2004). This difference between surveys could be due to a general increase in income of tourists over time. Most of our sample (57%) was composed of divers who had completed more than 100 dives, indicating that divers who choose Palau as a tourism destination are, in general, reasonably experienced and are therefore likely to cause less damage to the reefs than are novice divers (Davis and Tisdell 1995).

Potential Sources of Error

Considerable effort was made in our study to obtain samples that were representative of most nationalities involved with the shark-diving industry in Palau. However, the length of stay of tourists in Palau is related to nationality (Anon. 2001b; Anon. 2001a) and for this reason, the low numbers or absence of Taiwanese and Koreans in our sample could have resulted in an overestimation of the average length of stay by our study, which in turn could affect our calculations of the economic value of tourists in Palau. Government surveys showed that the total tourist expenditure per trip was similar irrespective of nationality (Anon. 2004), suggesting that the length of stay and differences in nationality would not affect our estimates of economic value. However, it is also important to note that divers were surveyed only in March and May/June 2010 and seasonal variations in the proportion of divers from different nationalities were not captured by our results.

Taiwan provides the second largest group of tourists visiting Palau. Between 2007 and 2009, the Taiwanese nationals accounted for 27% of the total number of tourists and 12% of the divers (Table 1). As mentioned above, Taiwanese divers were not represented in our respondents and we assumed that their motivations and expenditures were equivalent to those of Japanese divers. The nature of the Taiwanese tourism industry, which is controlled by Taipei-based companies, implies that a share of the revenues generated by this sector might not reach Palau. However, Taiwanese companies typically have a Palauan workforce as part of their staff and services such as transportation are often provided by Palauan businesses (Anon. 1999). This indicates a degree of interaction between the local economy and the Taiwanese sector, which reduces the potential for overestimates of the value of this part of the tourism industry.

From information provided by dive guides and from community monitoring programs (Meekan *et al.* unpublished data) it was estimated that approximately 100 sharks were interacting with the industry over five of the most popular sites for shark diving. During shark dives it is often possible to view most of the animals present at a site at the same time and for extended periods (up to an hour). This provides an opportunity to estimate numbers with a reduced likelihood of double counting. The consistency in the average numbers of sharks estimated by each dive guide and for each dive site suggested that these estimates were reasonably accurate. An average

estimate of 20 sharks per dive site (100 sharks in 5 dive sites) is also consistent with the abundance of reef sharks in aggregations at the Maldives, Johnston Atoll and the Marshall Islands (McKibben and Nelson 1986; Anderson and Ahmed 1993; Economakis and Lobel 1998). It is however, important to consider that the movement patterns of reef sharks in Palau remains unknown. Migration of individuals between dive sites could result in an overestimation of the total number of sharks interacting with the industry and consequently, an underestimation of the value of each animal to the dive industry. Alternately, the estimate of 100 sharks does not necessarily mean that these are the same animals at all times, which implies that the total number of individuals could be higher than that estimated by the guides. This would imply an overestimation of the value of each shark. Neither of these two scenarios would affect the estimate of the total economic value of reef sharks to the Palauan economy.

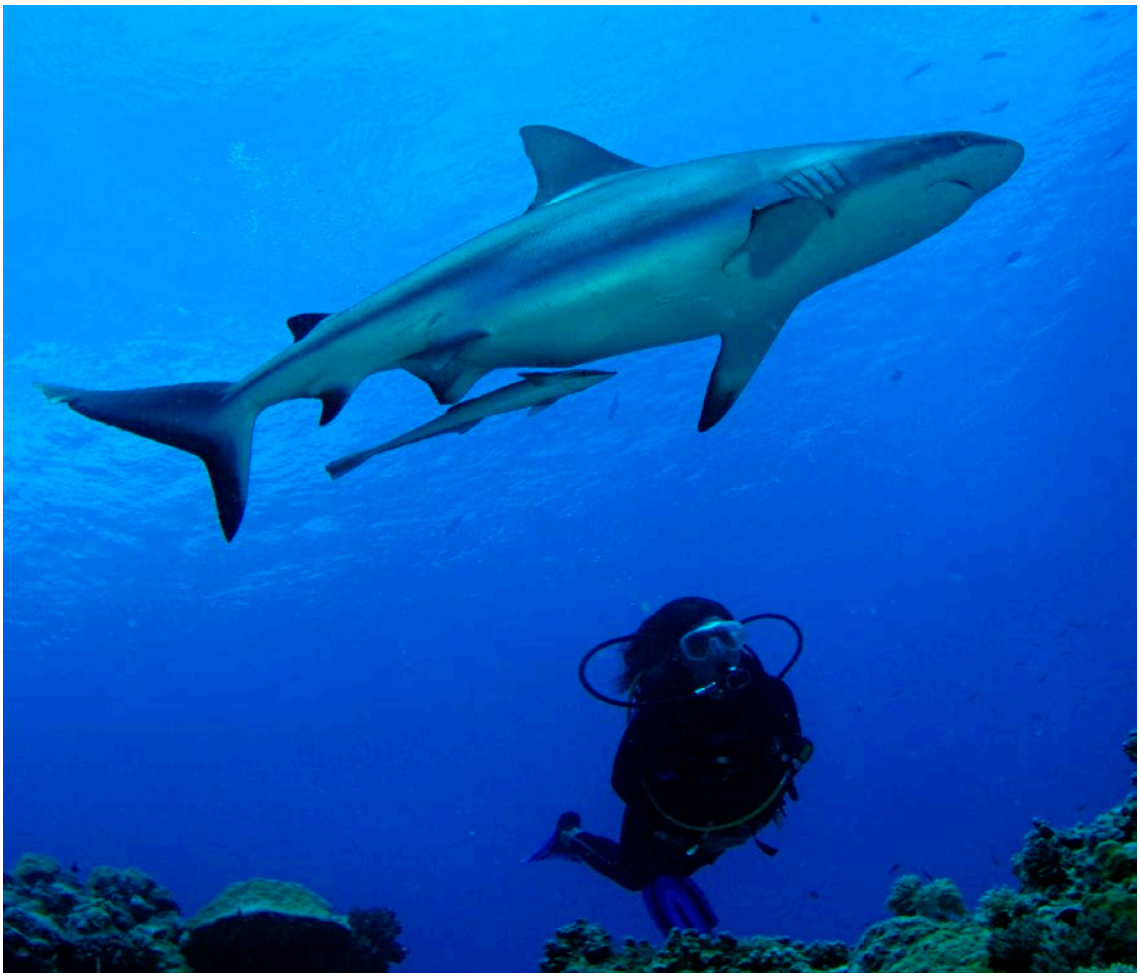
Our study quantified salary flow, indirect benefits to fishers and the taxes paid by shark divers as the principal returns of the shark-diving industry to the Palauan economy. A range of indirect benefits, such as revenues from suppliers of dive operators, tax revenues from landing fees at the airport and the induced benefits of suppliers of other sectors of the tourism industry (such as hotels, restaurants and souvenir shops) were not included. As these indirect links depend on the degree of interaction among business (Milne 1992), they lay beyond the scope of our study and for this reason, the total value of sharks to the Palauan economy is almost certainly underestimated by our work.

The estimate of the value of the tourism industry included the expenditure of non-diver tourists, which was based on costs for accommodation, food, drinks and souvenirs and an estimated cost for non-diving tourist activities. A survey in 2004 that included non-divers showed high rates of participation in activities such as repeated day trips to the Rock Islands, land tours, snorkelling trips and kayaking, with the average expenditure for the latter two activities estimated as US$448 and US$164, respectively (Anon. 2004). Consequently, our assumption that a non-diver tourist would be engaged in one land-based and one marine-based tour spending a total of US$200 is a very conservative estimate of their expenditures. For this reason, it is unlikely that we have overestimated the economic value of the tourism industry in Palau. Furthermore, according to the International Monetary Fund, the estimated tourism incomes for Palau for the financial year of 2008/2009 and projected to 2009/2010 were US$113 and US$124 million, respectively (Anon. 2010). Our estimate of the economic value of the tourism industry (US$144 million) was broadly in accordance with these projections and for this reason we believe that our study provides a reasonable evaluation of the economic value of the shark-diving industry to Palau.

Conclusion

Our report demonstrates the economic benefits of a well-organised shark-diving industry and the value of sharks as a non-consumptive resource. Each year, the number of tourists visiting Palau is four times greater than the population of permanent inhabitants and due to the demand this places on resources, the Palauan Government aims to target tourists that have high expenditure and low environmental impact. Shark divers fit this profile and represent a major source of revenue that accounts for approximately 8% of the GDP. Shark diving in Palau was responsible for the generation of the annual tax revenue of US$1.5 million to the government and US$1.2 million per year in salaries to the local community. The economic benefit of shark diving outweighed the profits available from these animals as a harvested resource by a factor of 10^4 on an individual, lifetime basis. In other terms, for a shark fishing industry to replace the economic revenues available from shark diving in Palau, it would require the harvest of over 100,000 sharks per year. Such an industry would be unsustainable and would swiftly cause the collapse of stocks. In contrast, the shark diving industry is a sustainable use of these resources that provides not only a renewable, permanent source of income, but also retains the ecosystem services of these key-stone predators within the reefs of Palau.

Palau's success in exploiting sharks as a profitable, renewable and non-consumptive resource is a model that could be applicable to other diving destinations throughout the tropics. Although the shark-diving industry is an important driver for the conservation of the sharks, over the long term very large numbers of divers might also have the potential for negative impacts on shark populations. The identification of critical habitats and studies of movement patterns and behaviour of the main species interacting with the shark-diving industry are necessary to ensure shark diving remains compatible with shark conservation in Palau.



Diver observing a grey reef shark (*Carcharhinus amblyrhynchos*) swimming near drop-off of the barrier reef in Palau.
Photo: Carlos Villoch: contributed by Micronesian Shark Foundation.

References

Anderson R, Ahmed H (1993) The shark fisheries of the Maldives. MOFA, Malé and FAO, Rome. 73pp.

Anderson R, Waheed Z, Whitevaves H (1999) Management of shark fisheries in the Maldives. FAO Fisheries Technical Paper (FAO).

Anon. (1999) Palau's Taiwanese tourism industry: Assessment of issues and suggestions for the future, Palau Conservation Society. 42pp.

Anon. (2001a) Comprehensive exit survey 2001- Analysis report, Palau Visitors Authority. 44pp.

Anon. (2001b) Dive tourism in Palau: Resource use, value and management, Palau conservation Society. 141pp.

Anon. (2003) Ecotourism development in the Pacific Islands. ESCAT Tourism Review No 23, United Nations. 70pp.

Anon. (2004) Palau tourism economic valuation. Koror, Office of Planning and Statistics, Bureau of Budget and Planning of Palau. 48pp.

Anon. (2010) Republic of Palau: 2010 Article IV Consultation- Staff report; a public information notice; and a statment by the executive director of the republic of Palau on the executive board discussion. 116. I. C.R. No10. Washington, DC 20431, International Monetary Fund: 24.

Baum J, Myers R, Kehler D, Worm B, Harley S, Doherty P (2003) Collapse and conservation of shark populations in the Northwest Atlantic. Science 299: 389.

Brunnschweiler JM (2009) The Shark Reef Marine Reserve: a marine tourism project in Fiji involving local communities. Journal of Sustainable Tourism First: 1-14.

Carlile L (2000) Niche or Mass Market? The Regional Context of Tourism in Palau. Contemporary Pacific 12: 415-436.

Carwardine M, Watterson K (2002) Shark-watcher's handbook: a guide to sharks and where to see them. Princeton University Press.

Catlin J, Jones T, Norman B, Wood D (2010) Consolidation in a wildlife tourism industry: the changing impact of whale shark tourist expenditure in the Ningaloo coast region. International Journal of Tourism Research 12: 134-148.

Chen V, Phipps M (2002) Management and trade of whale sharks in Taiwan." TRAFFIC East Asia-Taipei.

Cisneros-Montemayor A, Sumaila U, Kaschner K, Pauly D (2010) The global potential for whale watching. Marine Policy 34: 1273-1278.

Clarke S, Milner-Gulland E, Bjørndal T (2007) Social, economic and regulatory drivers of the shark fin trade. Marine Resource Economics 22: 305-327.

Clua E, Buray N, Legendre P, Mourier J, Planes S (2010) Behavioural response of sicklefin lemon sharks *Negaprion acutidens* to underwater feeding for ecotourism purposes. Marine Ecology Progress Series 414: 257-266.

Compagno LJV (1984) Sharks of the world. An annotated and ilustrated catalogue of sharks species known to date. Part 2- Carcharhiniforms. FAO species catalog. 125: 251-655.

Davis D, Tisdell C (1995) Recreational scuba-diving and carrying capacity in marine protected areas. Ocean & Coastal Management 26: 19-40.

De la Cruz Modino R, Esteban A, Crilly R, Pascual-Fernandez J (2010) Bucear con tiburones y rayas en Espana. Analisis de su potencial en Espana y en las Islas Canarias., Instituto Universitario de Ciencias Politicas y Sociales NEF- The New Economics Foundation: 8-16.

Dearden P, Bennett M, Rollins R (2006) Dive specialization in Phuket: Implications for reef conservation. Environmental Conservation 33: 353–363.

Dearden P, Topelko K, Ziegler J (2008) Tourist interactions with sharks. Marine Wildlife and Tourism Management: Insights from the Natural and Social Sciences: 66-90.

Dicken M, Hosking S (2009) Socio-economic aspects of the tiger shark-diving industry within the Aliwal Shoal Marine Protected Area, South Africa. African Journal of Marine Science 31: 227-232.

Economakis A, Lobel P (1998) Aggregation behavior of the grey reef shark, *Carcharhinus amblyrhynchos*, at Johnston Atoll, Central Pacific Ocean. Environmental Biology of Fishes 51: 129-139.

Field I, Meekan M, Buckworth R, Bradshaw C (2009) Susceptibility of sharks, rays and chimaeras to global extinction. Advances in Marine Biology 56: 275-363.

Garrod B, Wilson J (2004) Nature on the edge? Marine ecotourism in peripheral coastal areas. Journal of Sustainable Tourism 12: 95-120.

Graham R (2004) Global whale shark tourism: a "golden goose" of sustainable and lucrative income. Shark News 16: 8-9.

Hall H (1994) Jewels of the Caribbean Sea. Ocean Realm: 51-54.

Hara M, Maharaj I, Pithers L (2003) Marine-based tourism in Gansbaai: A socio-economic study. Final report for the Department of Environmental Affairs and Tourism (DEAT), South Africa. 55pp.

Higham J, Lück M (2008). Marine wildlife and tourism management: Insights from the natural and social sciences, CABI Publishing.

Jacobson S, Robles R (1992) Ecotourism, sustainable development, and conservation education: Development of a tour guide training program in Tortuguero, Costa Rica. Environmental Management 16: 701-713.

Johannes R (1981) Words of the lagoon: fishing and marine lore in the Palau district of Micronesia, Univ of California Pr.

Jones T, Wooda D, Catlinb J, Normanc B (2009) Expenditure and ecotourism: predictors of expenditure for whale shark tour participants. Journal of Ecotourism 8: 32-50.

Just, R.E., Hueth, D.L. and Schmidtz, A., 2004. The Welfare Economics of Public Policy, A practical Approach to Project and Policy Evaluation, Edward Elgar, Cheltenham, UK.

Kirkwood R, Boren L, Shaughnessy P, Szteren D, Mawson P, Hückstädt L, Hofmeyer G, Oothuizen H, Schiavini A, Campagna C (2003) Pinniped-focused tourism in the Southern Hemisphere: a review of the industry. Marine mammals: Fisheries, tourism and management issues: 257–276.

Mau R (2008) Managing for conservation and recreation: The Ningaloo whale shark experience. Journal of Ecotourism 7: 213-225.

McElroy J (2003) Tourism development in small islands across the world. Geografiska Annaler: Series B, Human Geography 85: 231-242.

McKibben J, Nelson D (1986) Patterns of movement and grouping of gray reef sharks, *Carcharhinus amblyrhynchos*, at Enewetak, Marshall Islands. Bulletin of Marine Science 38: 89-110.

Milne S (1990) The impact of tourism development in small Pacific Island States: an overview. New Zealand Journal of Geography 89: 16-21.

Milne S (1992) Tourism and development in South Pacific microstates. Annals of Tourism Research 19: 191-212.

Myers R, Baum J, Shepherd T, Powers S, Peterson C (2007) Cascading effects of the loss of apex predatory sharks from a coastal ocean. Science 315: 1846.

Myers RA (2003) Rapid worldwide depletion of predatory fish communities. Nature 423: 280.

O'Connor S, Campbell R, Cortez H, Knowles T (2009) Whale Watching Worldwide: tourism numbers, expenditures and expanding economic benefits, a special report from the International Fund for Animal Welfare. Yarmouth MA, USA, prepared by Economists at Large.

Orams M (2002) Humpback whales in Tonga: an economic resource for tourism. Coastal Management 30: 361-380.

Quiros A (2005) Whale shark ecotourism in the Philippines and Belize: evaluating conservation and community benefits. Tropical Research Bulletin 24: 42-48.

Robbins WD, Hisano M, Connolly SR, Choat JH (2006) Ongoing collapse of coral-reef shark populations. Current Biology 16: 2314.

Rowat D, Engelhardt U (2007) Seychelles: A case study of community involvement in the development of whale shark ecotourism and its socio-economic impact. Fisheries Research 84: 109-113.

Smith S, Au D, Show C (1998) Intrinsic rebound potentials of 26 species of Pacific sharks. Marine & Freshwater Research 49: 663-678.

Topelko K, Dearden P (2005) The shark watching industry and its potential contribution to shark conservation. Journal of Ecotourism 4: 108-128.

Ward-Paige C, Mora C, Lotze H, Pattengill-Semmens C, McClenachan L (2010) Large-scale absence of sharks on reefs in the Greater-Caribbean. PLoS ONE 5(8): e11968.

Wetherbee B, Crow G, Lowe C (1997) Distribution, reproduction and diet of the gray reef shark *Carcharhinus amblyrhynchos* in Hawaii. Marine Ecology Progress Series 151: 181-189.

WWF-Philippines (2006) Whale shark ecotourism contributes to Philliphine economy. Biota Filipina: 6-7.