

# The contemporary economic value of elasmobranchs in The Bahamas: Reaping the rewards of 25 years of stewardship and conservation



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## ABSTRACT

Elasmobranch populations in The Bahamas offer a unique juxtaposition to the widespread decline of many species around the world, largely due to management and conservation initiatives implemented over the last 25 years. Several industries have been built around the diverse and abundant elasmobranch assemblages found in The Bahamas, however a comprehensive assessment of the non-consumptive economic value of this resource has yet to be undertaken. In this study, we identified various sectors that benefit from elasmobranch populations in The Bahamas, which included tourism, film and television and research. We incorporated data from operator and participant surveys, government sources and information available on the Internet to calculate the economic value and location of these various sectors. This study establishes The Bahamas dive industry as the largest in the world, contributing approximately \$113.8 million USD annually to the Bahamian economy in direct and value added expenditures. Elasmobranch tourism generated 99% of the total revenue, and the balance generated by film and television and research. The relative economic importance of shark diving was greater in economically disadvantaged out-islands where specific charismatic species are sought. This was also in locations where a large proportion of the revenue generated by those activities does not enter the Bahamian economy. The sustained national stewardship demonstrated by the Bahamian government will ensure that this important economic resource continues to be productive, but also highlights the need for regional Caribbean-wide commitment to the management of highly migratory species that are important to many economically depressed areas of The Bahamas.

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## 1. Introduction

Worldwide, many shark populations have seen precipitous declines in recent years. The most current estimates indicate that approximately 24% of all chondrichthyan species are threatened with some risk of extinction (Dulvy et al., 2014). The primary reason for these declines is overfishing, either as bycatch or in directed fisheries (Baum and Myers, 2004; Baum et al., 2003; Clarke, 2007; Stevens et al., 2005). Furthermore, under-reporting and/or complete lack of reporting of shark catches has confounded attempts at regulating the harvest to sustainable levels (Clarke et al., 2006). Sharks are not the only chondrichthyan fish to see precipitous declines as of late; rays have also suffered considerable drops in population abundance. The same study found that approximately 20% of all rays and skates are threatened with some degree of extinction (Dulvy et al., 2014).

Despite the widespread decline of sharks, and their ecological importance (Baum and Worm, 2009; Brierley, 2007; Ferretti et al., 2010;

Terborgh, 2015), conservation and management measures have yet to have any discernible impact at reversing these trends for most at-risk species. This is largely due to lack of resources and/or political will for the effective implementation and enforcement of legislation, or lack of basic chondrichthyan life history data on which to base management plans (Shiffman and Hammerschlag, 2016). Furthermore, these mechanisms are irregular in their global distribution, making management and conservation measures for widely distributed and highly migratory species more problematic (Shiffman and Hammerschlag, 2016).

Establishing the non-consumptive value of natural resources is increasingly being used to support conservation and management legislation. Shark ecotourism is quickly becoming popular, especially as misconceptions of sharks fade, and the awareness of their threatened status is brought into the foreground (Friedrich et al., 2014; Neff and Yang, 2013). The shark diving industry is now widespread and takes place in 29 different countries with 376 different operators (Gallagher and Hammerschlag, 2011), and generates \$314 million USD in economic expenditures per year (Cisneros-Montemayor et al., 2013). Numerous case studies around the world have demonstrated the economic value of elasmobranchs (Anderson and Waheed, 2001; Anderson et al., 2010; Brunnschweiler, 2010; Clua et al., 2011; Vianna et al., 2012),

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which in many cases have consolidated and expanded management initiatives in these nations.

The Bahamas is home to healthy and diverse shark populations, largely due to a ban on longline fishing in the early 1990s (Burgess, 2005), followed by the establishment of the Bahamian shark sanctuary in 2011. Subsequently, it has arguably the most vibrant shark diving industry in the world, which in 2008 was estimated to contribute approximately \$78 million annually to the Bahamas GDP, in a white paper commissioned by the Bahamas Dive Association (Cline, 2008). Since 2002, there has been a ban in Florida on baiting or feeding sharks during for the purposes of viewing sharks while scuba diving (Dobson, 2006). In The Bahamas, no such ban exists, and given the proximity to the U.S., live-aboard dive boats from Florida are able to frequent the waters of The Bahamas for sharks-specific dive trips. This practice has generated controversy amongst Bahamian stakeholders as these foreign owned dive vessels take advantage of this unique Bahamian resource, but are thought to not contribute to the Bahamian economy in any measurable way.

The purpose of this study was to undertake a comprehensive and independent assessment of the economic revenue generated by Bahamian elasmobranchs, which despite the obvious importance of elasmobranchs to The Bahamas, has not been undertaken to date. Specific objectives included, 1) the quantification of financial revenues generated by elasmobranchs as a whole, and on a species and location specific basis, 2) quantification of the proportion of the economic revenue generated by Bahamian shark populations that actually enters the Bahamian economy, and 3) to gather qualitative data pertaining to the importance of conservation and the shark sanctuary to tourists.

## 2. Methods

We identified different sectors of the Bahamian economy that relied wholly, or in part on the presence of healthy elasmobranch populations. This included the shark diving and ray tourism industry, the film and television industry, and the research sector, and specified 2014 as the year of interest. Pilot studies were conducted in March of 2015, and survey work was conducted between April and August of 2015. All surveys and interviews began with a review of the research ethics statement, and consent to participate was obtained. The research was conducted under the Cape Eleuthera Institute's (CEI) Research Permit (MAF/FIS/17 & MAF/FIS/34) issued by the Bahamian Department of Marine Resources. CEI's Research Ethics Guidelines are in accordance with ethical standards for research involving human participants, which are developed within The College of The Bahamas Policy on Ethics Administration & Code of Ethics.

### 2.1. Study area and characteristics

The Bahamas is composed of 30 inhabited islands and over 600 uninhabited cays within the 600,000 km<sup>2</sup> EEZ located in the subtropical western Atlantic (Fig. 1). The tourism industry generates 60% of the GDP and employs 50% of the country's population (WTTC, 2015). The capital Nassau hosts about 70% of the country's total population, and Freeport (the second largest city on Grand Bahama) is home to another 14.5%. The remaining population of The Bahamas is scattered throughout the outlying islands known as the 'out-islands' or the 'family-islands' (The Bahamas Department of Statistics, 2013a).

### 2.2. Shark tourism

To effectively assess the shark diving industry, both dive operators and their customers were targeted for interviews and surveys respectively. In this study, we defined shark diving as "any diving where the primary motivation was to see sharks, either through provisioning (baiting, chumming or feeding) or by visiting locations where sharks are known to predictably aggregate". We identified 44 relevant diving

operations that utilize the waters of The Bahamas; 29 were shore-based operations within The Bahamas (hereafter "shore-based"), four were live-aboard dive operations based within The Bahamas (hereafter "domestic live-aboard"), and 11 were live-aboard operations that are based elsewhere and utilize the waters of The Bahamas for some or all of their dive operations (hereafter "foreign live-aboard"). Of the shore-based operations, there were "large" operations that serviced well over 10,000 divers in a year, and employ large numbers of local Bahamians. They have multiple boats in operation in a single day that take divers out to different locations. The remainder of the shore-based operations (for the purposes of this study) were categorized as "small", typically owner-operated dive shops with one or two boats with a maximum capacity of 10–12 divers that travel no more than a few nautical miles to their dive sites.

In regards to live-aboard boats, the "domestic" live-aboard boats are typically operated from Nassau where their guests embark and disembark, and where the vessel takes on fuel, food, water, and acquire other services such as laundering. The "foreign" live-aboard boats typically embark and disembark in Florida's major cities (i.e. Miami, Palm Beach, Fort Lauderdale, and Key West), and take on all their provisions and services there as well. These vessels may travel a distance of only 45 nautical miles to Bimini, or much farther depending on fuel and provisions on board. It is important to note this distinction here between domestic and foreign live-aboard dive operations from the standpoint of how diving-related expenditures are calculated and where economic benefits accrue.

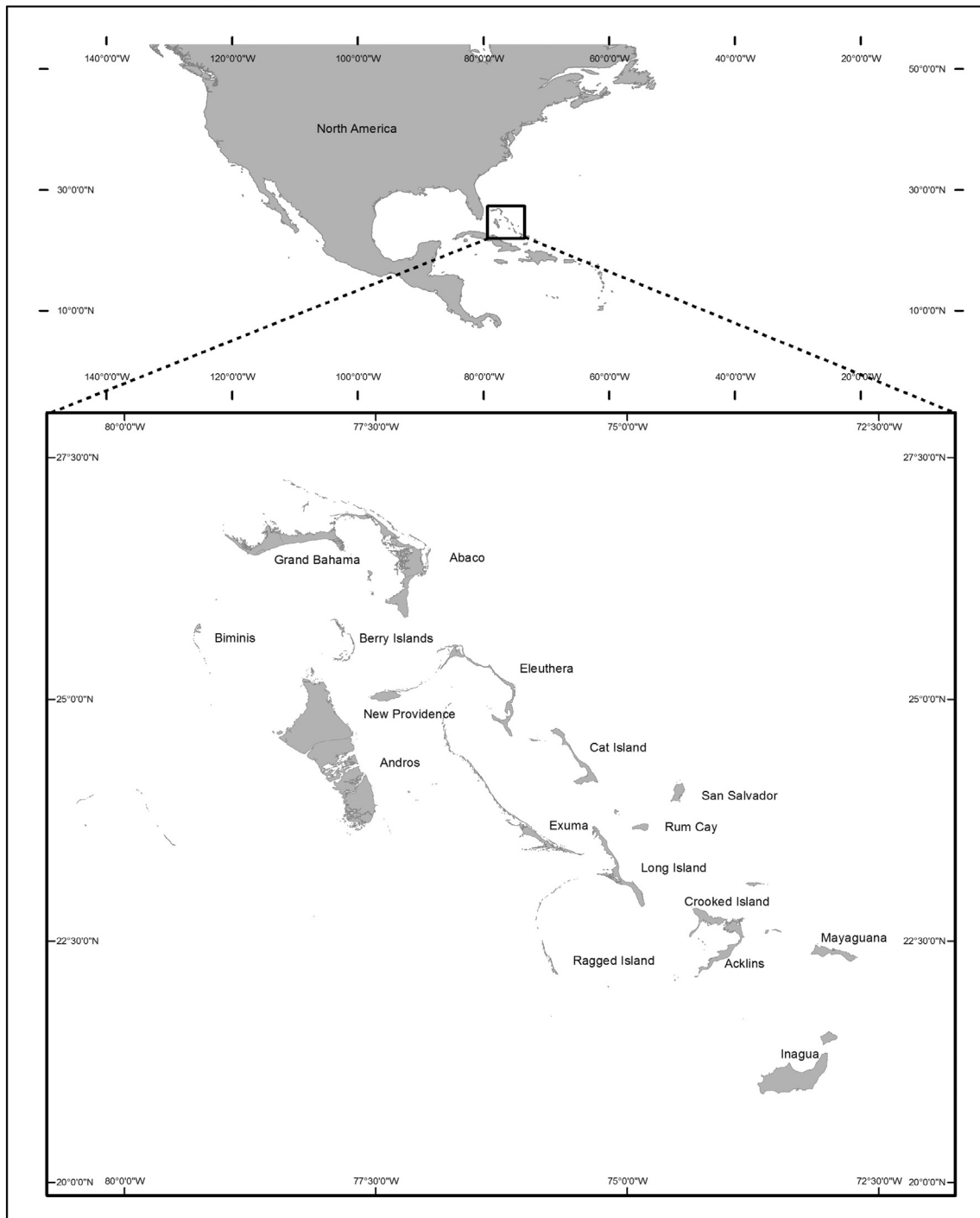
Dive operator interviews (Supplementary material 1) asked if they offered shark diving or not, and to estimate the percentage of their customers that undertook trips mainly due to shark diving opportunities ("shark divers"). When an operator did offer shark diving, the geographic location of the dive and the primary species that they were hoping to view were recorded as a "dedicated shark dive".

Diver surveys were similar in design to Vianna et al. (2012). These self-administered questionnaires were distributed through dive operator's customer service desks and online (Supplementary material 2). Questions asked participants about their motivation for visiting The Bahamas, their awareness of the shark sanctuary, their economic expenditures, and willingness to pay for a one-time dive permit in The Bahamas if the funds were used to directly support shark conservation.

To quantify the volume of economic activity we estimated the number of diving days for all divers and shark divers. Estimates were calculated by multiplying the total number of operators in a category (shore-based "large" and "small", domestic live-aboard, or foreign live-aboard) by the mean number of divers serviced by those responding operators. Non-responding operators were filled in using means for that operator category. This provided estimates of the volume of economic activity in diver days at three levels: total trip days, total diving days, and shark diving days (Table 1).

Estimating the Total Economic Impact of shark diving in The Bahamas entailed quantifying the relevant direct expenditures by divers; those made only within The Bahamas ("National Expenditures") and those made in all countries ("Global Expenditures"), as well as the secondary ("Value Added") effects related to these direct expenditures (see Fletcher, 1989 for an explanation of these effects). "National Expenditures" were derived by subtracting the cost of airline ticket purchases from shore-based and domestic live-aboard diver costs and also excluded all expenditures associated with foreign live-aboard operators. In both of these cases, divers paid airline and foreign live-aboard package costs to businesses and dive operators outside The Bahamas, which have no effect on the Bahamian economy.

Value Added Effects are often represented by a "multiplier" that is applied to direct expenditures in order to yield a Total Economic Impact. This study used the value added multiplier for 2015 of 1.24 estimated by the World Travel and Tourism Council (WTTC) to quantify the Value Added Effect of diver spending (WTTC, 2015). Many previous non-consumptive value studies have only examined direct expenditures



**Fig. 1.** The Bahamas in relation to the North American continent, and the individual islands of The Bahamas (inset). The Bahamas shark sanctuary encompasses the entire EEZ of The Bahamas.

because the Value Added Effects were unable to account for “leakage” of tourism dollars that flow outside the country to purchase goods and services that support the tourism industry. The WTTC economic models specifically account for this leakage, and these models align with the standards set by the United Nations Statistical Division, the Statistical Office of European Communities, and the World Tourism Organization.

### 2.3. Ray tourism

Although the actions taken by The Bahamas government 25 years ago were primarily directed at shark conservation, it is still important

to attempt some valuation of rays as well. Tourism for stingrays in The Bahamas is primarily directed at non-divers, and the tours are generally bundled with other beach-type activities such as visiting ocean caves, fishing and snorkelling. These tours typically involve the tourists lined up on the beach in waist-deep water with chum or bait in their hands while wild stingrays (sometimes wild caught and kept in enclosures) come to feed. These animals are quite often very habituated to humans and will tolerate being touched by the tourists.

Quantifying the value that non-diving ray tourism brings to The Bahamas was challenging as, 1) operations and management were often inaccessible (i.e. on private islands owned by cruise ships), and 2) an

**Table 1**  
Parameters used in the calculation of economic expenditures on shark diving in The Bahamas (subscripts SB and LA indicate either shore-based or live-aboard diving).

Parameter	Description	Calculation	Value	Source
Average days stayed (ADS)	The average number of days divers reported they stayed in The Bahamas	n/a	5.55	Diver surveys
Total diving days (TDD)	The number of days divers spent scuba diving in The Bahamas	$\sum$ (diving days for all operators)	157,344	Diver surveys
Percent shark diving (SD)	The percent of divers that come on trips because of a “shark diving” opportunity	n/a	Varied based on operator	Operator interviews
Shark diving days (SDD)	The number of days that were spent “shark diving” in The Bahamas	$\sum$ (TDD <sub>operator</sub> * SD <sub>operator</sub> )	63,191	Operator interviews
Average days diving (ADD)	Mean number of days diving during a trip	n/a	ADD <sub>SB</sub> = 3.09 ADD <sub>LA</sub> = 5.43	Diver surveys
Individual divers (ID)	Based on the category of operation utilized by divers (shore-based vs. live-aboard)	TDD / ADD	45,082	Operator interviews
Individual shark divers (ISD)	Based on the category of operation utilized by divers (shore-based vs. live-aboard)	SDD / ADD	19,288	Operator interviews
Total trip days (TTD)	The total number of day's divers spent in The Bahamas during their trip	ID * ADS	250,205 (general divers and shark divers)	Diver surveys and operator interviews
Mean trip cost for divers (MTC)	Mean cost of the diver's trip to The Bahamas	n/a	MTC <sub>SB</sub> : \$3546 MTC <sub>LA</sub> : \$3640	Diver surveys
Total direct shark diving expenditures (TDSDE)	The direct expenditures that divers made in The Bahamas in order to see sharks (ISD <sub>LA</sub> * MTC <sub>LA</sub> ) + (ISD <sub>SB</sub> * MTC <sub>SB</sub> )	\$48,820,104 USD	Diver surveys	
Average daily expenditure (ADE)	The mean daily expenditures divers made on their trip	(MTC * ID) / TTD	Shore-based: \$428/day Live-aboard: \$528/day	Diver surveys
Direct expenditures on dedicated shark dives (DESDS)	The direct expenditures that divers made to see a specific species of shark	SDD * ADE	SDD varied based on species	Diver surveys and operator interviews

appropriate medium for participant survey dispersal was unavailable. Hence, this portion of the analysis relied heavily on Internet research, personal inquiries, and reasonable assumptions about tourist activity throughout the islands based on discussions with two of the five major stingray tour operators. Each operator was assessed for trip price point, maximum passenger capacity, and the proportion of the tour devoted to ray tourism (many tours were bundled with other sightseeing) through the operator's website and/or other tourism review websites (e.g. [www.tripadvisor.com](http://www.tripadvisor.com)). Based on informal discussions with operators that could be reached, assumptions were made about trip occupancy, the number of trips per month, and the duration of the operating season.

#### 2.4. Film and television

The Bahamas Film and Television Commission (BFTC) records data from its permitting process such as the production company, filming dates and locations, the number of crew, and their estimated expenditures. Records were filtered to specify projects that focused on elasmobranchs. During conversations with professionals within the wildlife film industry, it was reported that some elasmobranch filming activities might be absent from BFTC statistics. To account for this, online surveys were distributed throughout the wildlife film industry and the two datasets reconciled by cross-referencing BFTC data with the online surveys to identify new records and remove duplicate reports. Where similar records were reported, the official data from the BFTC was accepted, and where there were online survey responses that detailed a new but incomplete record, missing data was filled in using category means. The reconciled dataset was used to calculate total film and television related expenditures in the country.

#### 2.5. Research and conservation activities

Several elasmobranch focused research stations exist throughout The Bahamas that fund their operations through grants, private donations, field courses and internships - the majority of which feeds directly into the Bahamian economy. In addition, researchers from overseas institutions undertake short-term elasmobranch focused research trips.

Online surveys were employed to gathered data on the size of the overall research budget for an individual researcher or a research organisation, the proportion of it spent within The Bahamas and on what categories (e.g. accommodation, equipment, etc.), the species of interest, and location of the study.

#### 2.6. Shark species and location-specific economic importance

A portion of the Bahamian shark diving industry targets specific species in key locations, which tend to be in the less economically developed Bahamian ‘out-islands’. For example, the poverty rate in Nassau is 12.58%, 9.69% in Grand Bahama, and 17.16% in the ‘out-islands’ (The Bahamas Department of Statistics, 2013b). This portion of the study sought to quantify the relative economic importance of these species in these locations, as the revenue is thought to be proportionally more important than that generated in the tourism and banking centers of Nassau and Freeport.

Dedicated shark diving days for targeted species in key locations were summed from the location and species data collected from dive operators, and then multiplied by the mean daily expenditure of shore-based divers. This generated species-specific National Expenditures (those made by shore-based divers into the Bahamian economy) on a local scale. We then divided these expenditures by the population of the island in question (using the 2010 Bahamas Population Census) to derive the per-capita revenues from shark diving that are realized by the local Bahamian people. We also summed the dedicated shark diving days for the same species and locations undertaken by live-aboard divers and multiplied this by the mean daily expenditure of live-aboard divers. This was added to the National Expenditures to yield the Global Expenditures (those made in The Bahamas and all other countries) on these species. These Global Expenditures were again divided by the population of the island in question from The Bahamas 2010 population census, to understand the difference between the revenues realized by local Bahamians (Per Capita Revenue from National Expenditures) and what is not being realized by local Bahamians (the difference between Per Capita Revenues from Global Expenditures and Per Capita Revenues from National Expenditures).

**3. Results**

**3.1. The tourism industry**

Amongst the 44 scuba dive operators in The Bahamas or utilizing its waters, a total of 28 interviews were completed (64% response rate). We estimated 45,082 divers came to The Bahamas in 2014, with 43% (n = 19,228) being shark divers. Our estimates of the number of divers were verified with independent data from the Bahamas Ministry of Tourism. Total visitor arrivals were multiplied by the percentage of visitors indicating scuba diving as their primary motivation to visit on their departure cards. This resulting difference between the two figures was <100 divers. Additionally, 674 divers responded to the survey questionnaire, but only 492 responded to the type of accommodation, and hence type of dive operation they utilized (31% on live-aboard boats, the remaining 69% utilized shore-based dive operations). All divers made a total of 157,344 diver days, and shark divers represented 63,191 of those diver days. Overall, shark divers made \$68.4 million USD in direct Global Expenditures to see sharks in The Bahamas, but not all of those expenditures contributed to the Bahamian economy. National Expenditures totalled \$48.8 million USD, and the balance was made on airfares and foreign live-aboard dive trips outside of The Bahamas. When Value Added Effects were included in the National Expenditures the combined National Economic Impact from shark diving on the Bahamian economy was \$109.4 million (Table 2).

Five different ray tourism operations were identified almost exclusively interacting with the southern stingray (*Dasyatis americana*), which generates \$1.4 million USD annually in direct National Expenditures. This is based on the assumption that the tour operators run trips at approximately 50% occupancy for 21–28 days per month (depending on the type of tour) for 11 months per year; however this figure could range from almost \$571,000 USD to approximately \$2.9 million USD (based on 20% to 100% occupancy respectively). If the Value Added Effects are accounted for, then this figure increases to \$3.2 million USD in Total National Economic Impact from stingray tourism.

**3.2. Film and television**

The online survey yielded n = 11 records. Six of those 11 records were not recorded in official statistics, revealing that the expenditures from filming and television activities associated with elasmobranchs in The Bahamas were under-reported by approximately 36%. The BFTC statistics estimated that \$136,800 USD entered The Bahamas economy for the filming of sharks and rays, with a further \$77,268 USD derived from online surveys indicating combined National Expenditures in this sector of \$214,068 USD. Assuming that the film crews coming for film shoots spend in a manner consistent with tourists, then the Value Added Effects increase this value to \$479,512 USD in National Economic Impact.

**Table 2**

The total economic effect of all diving, and shark diving, in The Bahamas economy, broken down based on operation type: 1) large shore-based hosted >10,000 customers/yr, 2) small shore-based hosted <10,000 customer/yr\*.

All diving	National expenditures	95% CI	Value-added effects	95% CI	Total	95% CI
Shore-based (small)	\$24,008,694	±\$147,726	\$29,770,781	±\$183,181	\$53,779,475	\$53.4–54.1 M
Shore-based (large)	\$75,823,458	±\$6,174,451	\$94,021,088	±\$7,656,319	\$169,844,546	\$156.0–183.7 M
Domestic live-aboard	\$6,884,336	±\$160,292	\$8,536,577	±\$198,762	\$15,420,913	\$15.1–15.8 M
<b>Total</b>	<b>\$106,716,488</b>		<b>\$132,328,445</b>		<b>\$239,044,933</b>	<b>\$224.5–253.6 M</b>
Shark diving	National expenditures	95% CI	Value-added effects	95% CI	Total	Total 95% CI
Shore-based (small)	\$6,499,770	±\$37,550	\$8,059,715	±\$46,561	\$14,559,485	\$14.5–14.6 M
Shore-based (large)	\$40,481,970	±\$3,697,445	\$50,197,643	±\$4,584,832	\$90,679,613	\$76.9–104.4 M
Domestic live-aboard	\$1,838,364	±\$42,508	\$2,279,571	±\$52,710	\$4,117,935	\$4.0–4.2 M
<b>Total</b>	<b>\$48,820,104</b>		<b>\$60,536,929</b>		<b>\$109,357,033</b>	<b>\$95.4–123.2 M</b>

**Table 3**

Total National Economic Impact of elasmobranchs on the Bahamian economy, broken down on a sector-by-sector basis.

Activity	National expenditures	Value added effects	Total economic impact
Shark diving	\$48,820,104	\$60,536,929	\$109,357,033
Ray tourism	\$1,429,401	\$1,772,457	\$3,201,858
Film and television	\$214,068	\$265,444	\$479,512
Research	\$794,141	–	\$794,141
<b>Total</b>	<b>\$51,257,714</b>	<b>\$62,574,830</b>	<b>\$113,832,544</b>

**3.3. Research activities**

Online surveys yielded a sample of n = 11 responses indicating an estimated \$1.6 million USD was raised for Bahamian elasmobranch research, but \$794,000 USD of this were expenditures made within the islands of The Bahamas (National Expenditures). As it is uncertain that research dollars are spent in a manner consistent with tourism activities, Value Added Effects were not calculated here.

**3.4. Total National Economic Impact**

The Total National Economic Impact of elasmobranchs on the Bahamian economy is estimated to be \$113.8 million USD annually (Table 3). This includes the shark diving industry, stingray tourism, film and television, and research activities.

**3.5. Species of economic importance**

Caribbean reef shark (*Carcharhinus perezi*) dives are widespread throughout The Bahamas (Fig. 2) and contribute 93.7% of the National Expenditures generated by dedicated shark dives (Table 4). In addition to the Caribbean reef shark, there were three other notable species including the great hammerhead (*Sphyrna mokarran*), oceanic whitetip (*Carcharhinus longimanus*), and tiger shark (*Galeocerdo cuvier*), which dominated dedicated shark dives in Bimini, Southern Cat Island and the West End of Grand Bahama respectively (Fig. 2). These three species contributed a further 5.4% of National Expenditures and 17.5% of Global Expenditures made respectively (Table 4).

**3.6. Relative economic impact in the ‘out-islands’**

The expenditures generated by dedicated shark dives in the key locations, and translated into per-capita shark diving revenue, are shown in Table 5. Figures for both per-capita revenue (from National Expenditures) and the global per-capita revenue (from Global Expenditures) are presented; the difference between the two represents what is actually realized by local Bahamians, and what could be realized by local

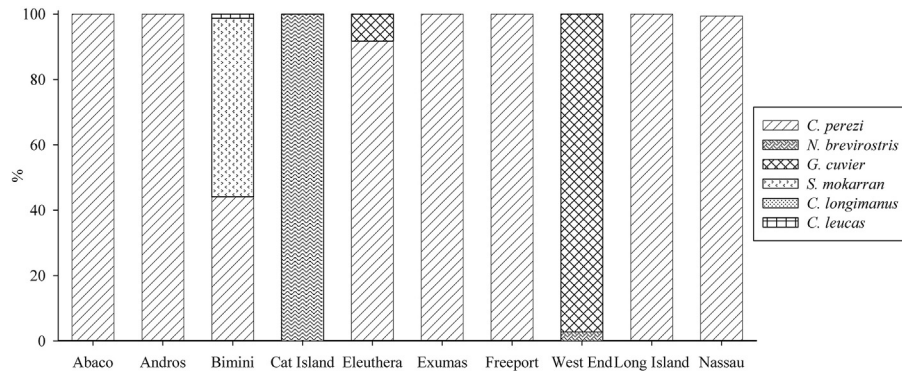


Fig. 2. The locations and primary targeted species on dedicated shark dives in The Bahamas.

Bahamians if the shark diving industry were structured and regulated differently.

### 3.6.1. Great hammerhead sharks in Bimini

Bimini is one of the closest islands to the United States mainland, located just over 45 nautical miles (~83 km) from southern Florida, and consequently, is easily accessed by U.S.-based live-aboard dive boats. Dedicated shark dives for all species in Bimini contributed \$1,882,800 USD to the island's economy. An estimated 55% of the dedicated shark dives in Bimini focused on the great hammerhead shark (Fig. 2) with the remaining 45% focusing on the Caribbean reef shark, and to a lesser extent the bull shark (*Carcharhinus leucas*). Bahamian shore based operators undertook 74.9% of the hammerhead dives, with the balance being made up by mostly foreign live-aboard dive boats. The great hammerhead shark generated \$992,850 USD in Global Expenditures annually of which only \$583,600 USD were National Expenditures.

### 3.6.2. Tiger sharks at the west end of Grand Bahama

The West End of Grand Bahama is also close to southern Florida and also easily accessible to U.S.-based live-aboard dive vessels. Of the 5124 diver days that were dedicated tiger shark dives throughout The Bahamas, 98.5% were conducted in this single location. Foreign live-aboard dive boats undertook 94.7% of these dives. Tiger sharks in this location generate \$2,695,330 USD in Global Expenditures; however, only 2.4% (\$79,200 USD) were National Expenditures (expenditures made in The Bahamas).

### 3.6.3. Oceanic whitetip sharks at Southern Cat Island

Cat Island lies on the eastern side of The Bahamas approximately 290 nautical miles (537 km) from Florida, and thus represents a more significant investment in time and effort to reach by live-aboard dive

Table 4

Species specific revenue of species targeted by the Bahamian shark diving industry. Valuations are based on the revenue generated by dedicated shark dives operated in The Bahamas.

Species	National Expenditures	%	Global Expenditures	%
Caribbean reef shark	\$16,223,802	93.7	\$21,920,448	81.8
Great hammerhead shark	\$638,070	3.7	\$1,029,126	3.8
Tiger shark	\$176,370	1.0	\$3,289,608	12.3
Oceanic whitetip shark	\$122,610	0.7	\$371,718	1.4
Lemon shark	\$74,262	0.4	\$91,164	0.3
Nurse shark	\$66,000	0.4	\$80,250	0.3
Bull shark	\$17,982	0.1	\$23,754	0.1
Total	\$17,319,096*	100	\$26,806,068*	100

\* Value represents dedicated shark dives only, rather than shark diving in general.

operations departing from the U.S. The oceanic whitetip shark was overwhelmingly the target species in this area (Fig. 2). Foreign live-aboard dive operations, despite the added investment required, still accounted for 58% of the dedicated oceanic whitetip shark dives conducted at Cat Island (the remaining 42% was split almost evenly amongst domestic live-aboard and shore-based dive operations). Global Expenditures from dedicated oceanic whitetip shark dives were \$334,670 USD each year, but the National Expenditures made by those shore-based divers into the limited economy of Southern Cat Island itself equate to only \$59,770 USD each year.

### 3.7. Attitude and perceptions of divers

Divers were presented with several questions about if they had knowledge of the shark sanctuary in The Bahamas before coming on their trip. This produced an almost even 50:50 split, with 49.7% reporting “no” and 50.3% reporting “yes” (n = 517). For divers who did have knowledge of the sanctuary prior to coming on their trip, the survey yielded interesting results. Over two thirds of the respondents stated that the sanctuary either had no influence (33.9%) on their decision, or greatly influenced their decision (34.4%), for coming to The Bahamas. For divers who did not know about the sanctuary before coming on their trip, the vast majority (75.0%) stated that the sanctuary was either very important (31.1%) or extremely important (44.1%) to their future decisions to come to The Bahamas. Furthermore, an overwhelming number of divers (91%, n = 513) were either somewhat interested (14.0%) or very interested (77.0%) in diving with sharks. Only 1% of divers stated that they were very disinterested in diving with sharks.

### 3.8. Willingness-to-pay for shark conservation measures

Divers were asked what fee is the most they would willing to pay for a one-time scuba diving permit in The Bahamas, if it were to be used directly towards shark conservation. Discrete categories were offered as a multiple-choice - as opposed to open-ended - question (n = 452), and the categories offered (in USD) and their preference by participants is shown in Fig. 3.

## 4. Discussion

This study indicates that elasmobranchs have a Total National Economic Impact of \$113.8 million USD annually to the Bahamian economy, or 1.3% of the \$8.5 billion GDP in 2014 (The World Bank, 2016). The majority of this (98.8% or \$112.6 million) was derived from shark diving and ray tourism. This study firmly establishes The Bahamas as the largest shark diving economy in the world that has been formally assessed, as the direct National Expenditures of \$48.8 million USD are

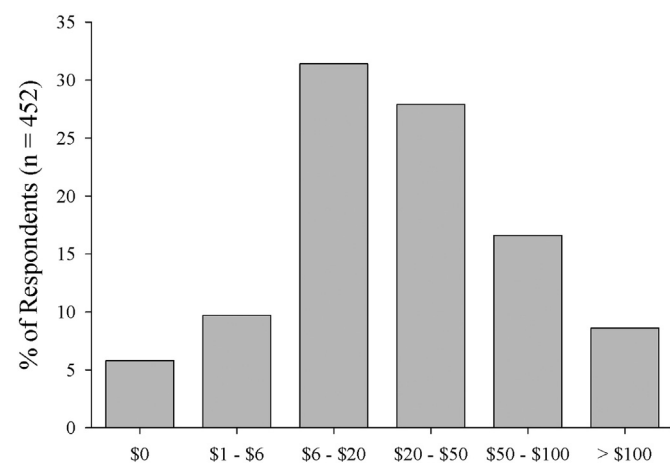
**Table 5**

Per-capita revenue generated by the major dedicated shark dives, the primary species of interest, and its location of operation. Per-Capita Revenue from National Expenditures reflects the realized revenues in these islands, whereas Per Capita Revenue from Global Expenditures reflects the expenditures made in all countries (The Bahamas and elsewhere, such as on live-aboard dive boats).

Island	Target species	Per-Capita Revenue from National Expenditures	Per-Capita Revenue from Global Expenditures
Freeport, Grand Bahama	Caribbean reef shark	\$84	\$84
Nassau	Caribbean reef shark	\$40	\$40
West End, Grand Bahama	Tiger shark	\$17	\$536
Bimini	Great hammerhead	\$294	\$392
Southern Cat Island	Oceanic whitetip	\$98	\$461

larger than Fiji's (\$42.2 million USD), Palau's (\$18 million USD), and French Polynesia's (\$5.4 million USD) shark diving industries (Clua et al., 2011; Vianna et al., 2011, 2012), in addition to several others. This study has followed the concepts and methods similar to other economic valuations of elasmobranchs (Clua et al., 2011; Vianna et al., 2012), however, we did not attempt to place a value per individual animal which has proved controversial in past studies (Catlin et al., 2013; Vianna et al., 2013). Rather, we assessed the relative contribution of specific species to the Bahamian economy, which indicated that the Caribbean reef shark was responsible for generating 93.7% of the revenue generated by dedicated shark dives, making this the most economically important species of shark in The Bahamas.

In other regional economies which have been assessed (see Davis et al., 1997; Dicken and Hosking, 2009; Anderson et al., 2010; Clua et al., 2011; Vianna et al., 2012), the economic revenue generated by elasmobranchs, with the exception of airfares, is mostly retained within the country. In contrast, due to The Bahamas' proximity to the U.S. and the ease of access by live-aboard dive vessels, 6% of the economic revenue from shark diving is not entering the Bahamian economy. While 6% does not appear that high across the whole industry, location specific values are much higher, for example at 'Tiger Beach' at the West End of Grand Bahama 97.6% of the \$2.69 million generated by tiger sharks in this location stays in the U.S. and does not benefit The Bahamas in any way. While all attempts were made to ensure operators of confidentiality, and remove controversial questions that could have led to bias in results, it should also be recognized that some operators (mainly foreign live-aboard boats, but also others) might have incentives to under-state their figures to researchers. Consequently, it is possible that the present study has underestimated the revenue generated by foreign live-aboard vessels.



**Fig. 3.** The fee preferences of divers when asked about how much they would be willing to pay for a one-time dive permit in The Bahamas, if the fee were used towards shark conservation.

While shark diving brings millions of dollars to the economic centers of Nassau and Freeport, the relative economic impact of the shark tourism industry in the Bahamian 'out-islands' is greater. A quick comparison of the poverty rate of 17.16% in the out-islands compared with 12.58% and 9.69% in Nassau and Grand Bahama respectively illustrates the disparity in economic prospects (The Bahamas Department of Statistics, 2013b). The potential importance of the shark diving industry to out-island economies is further illustrated by the per-capita Global Expenditures generated by the oceanic whitetips in the south of Cat Island (\$461 USD person<sup>-1</sup> yr<sup>-1</sup>), great hammerheads in Bimini (\$392 USD person<sup>-1</sup> yr<sup>-1</sup>) and the tiger sharks off the West End of Grand Bahama (\$536 USD person<sup>-1</sup> yr<sup>-1</sup>) compared to Freeport (\$84 USD person<sup>-1</sup> yr<sup>-1</sup>) and Nassau (\$40 USD person<sup>-1</sup> yr<sup>-1</sup>). However, not all of these revenues are realized by local Bahamians in the locations that generated them, as illustrated by the fact that only 21% and 3% of the per-capita revenues in Cat Island and West End Grand Bahama respectively are retained in these Bahamian island economies (the National Expenditures). This would suggest that the economic benefits to the out-islands could be further improved by some degree of legislation for foreign live-aboard dive vessels.

The economic importance of sharks to The Bahamas underscores the significance of the conservation measures implemented by the Bahamian government over the last 25 years in the form of the ban on longline fishing in 1993 and the establishment of the shark sanctuary in 2011. The importance of these conservation measures is further emphasized by the results of the participant surveys. Approximately 50% of those surveyed did not know about the establishment of the shark sanctuary in 2011, and of those that did know, 33.9% indicated that it had no bearing on the decision to visit. This suggests that they are visiting because of the healthy shark populations that are mostly due to the ban on longline fishing in 1993. However, a further 34.4% indicated that the shark sanctuary did have a positive influence on their decision to visit, and for those that did not know about the shark sanctuary 75% indicated that it would have a positive effect on their decision to return. As a whole, this suggests that the combined effect of the longline ban creating healthy shark populations, and the political will exhibited by the more recent establishment of the shark sanctuary resonates with the shark diving community and will encourage them to make repetitive visits in the future.

The economic importance of highly-migratory species such as the oceanic whitetip, tiger and great hammerhead sharks which are listed as 'vulnerable', 'near threatened' and 'endangered' respectively by the IUCN (Baum et al., 2015; Denham et al., 2007; Simpfendorfer, 2009), highlights the need for The Bahamas to continue to advocate for regional conservation of these species. All three are known to undertake large migratory journeys throughout the Caribbean basin and Atlantic Ocean (Hammerschlag et al., 2011; Howey-Jordan et al., 2013; Lea et al., 2015) where they are still at risk from high-seas fisheries. Consequently, these natural resources that are very important to some of the more economically depressed regions of The Bahamas are at risk of being depleted despite the conservation measures implemented by the Bahamian government. Collaborative management initiatives on a regional

and ocean-wide scale are needed if these important resources are to be effectively conserved.

This study identified broad support within the shark diving community for an additional fee or tax in the \$6–\$50 range that would support ongoing shark conservation and management initiatives in The Bahamas. This approach has been taken in other parts of the world; for example, Ningaloo Marine Park in Western Australia charges visitors a \$15 premium on their tour fee to snorkel with whale sharks, in order to support monitoring and management activities (Davis et al., 1997). The Bonaire National Marine Park charges scuba divers an annual fee of \$25 and Sipadan Island near Borneo (Malaysia) charges users \$10 per day to dive at the protected site (author's personal experience). Although this study asked respondents about a marketed good (a dive permit fee), the question still shares features of contingent valuation (paying for the conservation of a species) that required our attention. Contingent valuation is a methodology used to elicit the non-market value of items being debated in environmental policy. Although it can be a useful tool, it has its criticisms (Diamond and Hausman, 1994; Hanemann, 1994; Harrison, 1992). Much of the critiques are aimed at the notion that contingent valuation tends to overestimate the value of non-market goods (i.e. clean air, un-polluted lakes, etc.) due to the hypothetical nature of the monetary transaction, as well as the ability of survey design to drastically alter results. The mechanism by which the fee is collected and administered (the 'payment vehicle') can also have an effect on respondent's willingness-to-pay (Bateman et al., 1994). This study attempted to overcome at least some of the controversy of contingent valuation (specifically, the overestimation problem) by choosing discrete categories of payment amounts that are commensurate with real-world fees in effect today, rather than phrasing this as an open-ended question with respondents being able to fill in any hypothetical value. Additionally, as this was the only 'contingent valuations' question asked, there was very little potential for the question ordering to impact the respondent's willingness-to-pay in this study.

Currently, the Bahamas National Trust is launching an initiative that aims to get divers to voluntarily buy a dive tag for \$10 USD, with the proceeds directly supporting shark conservation. While making the fees mandatory (as in the other examples previously mentioned) would be an important step in enhancing the monetisation of elasmobranch resources, the exact mechanism and payment vehicle requires further investigation to avoid the unintended consequence of pushing divers away from, rather than drawing them to the waters of The Bahamas.

This study has confidently established The Bahamas as the largest shark diving economy in the world, highlighting the importance of the key conservation and management steps the Bahamian government has implemented over the last 25 years. The long line ban in the 1990s preserved this ecologically important resource on which the shark diving industry is based, and furthermore, the ongoing stewardship demonstrated by the establishment of the shark sanctuary in 2011 will have a positive effect on divers returning in the future. This study also identifies the need for regional and ocean-wide commitments to the management of highly migratory species that are important to many economically depressed areas of The Bahamas. Given the need for continued persuasive arguments for the management and conservation of elasmobranchs around the world, generating robust estimates of non-consumptive economic value in The Bahamas can be a convincing case for furthering conservation efforts, including the establishment of increased protection for these taxa in the Greater Caribbean region.

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### Appendix A. Supplementary data

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.biocon.2017.01.007>.

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