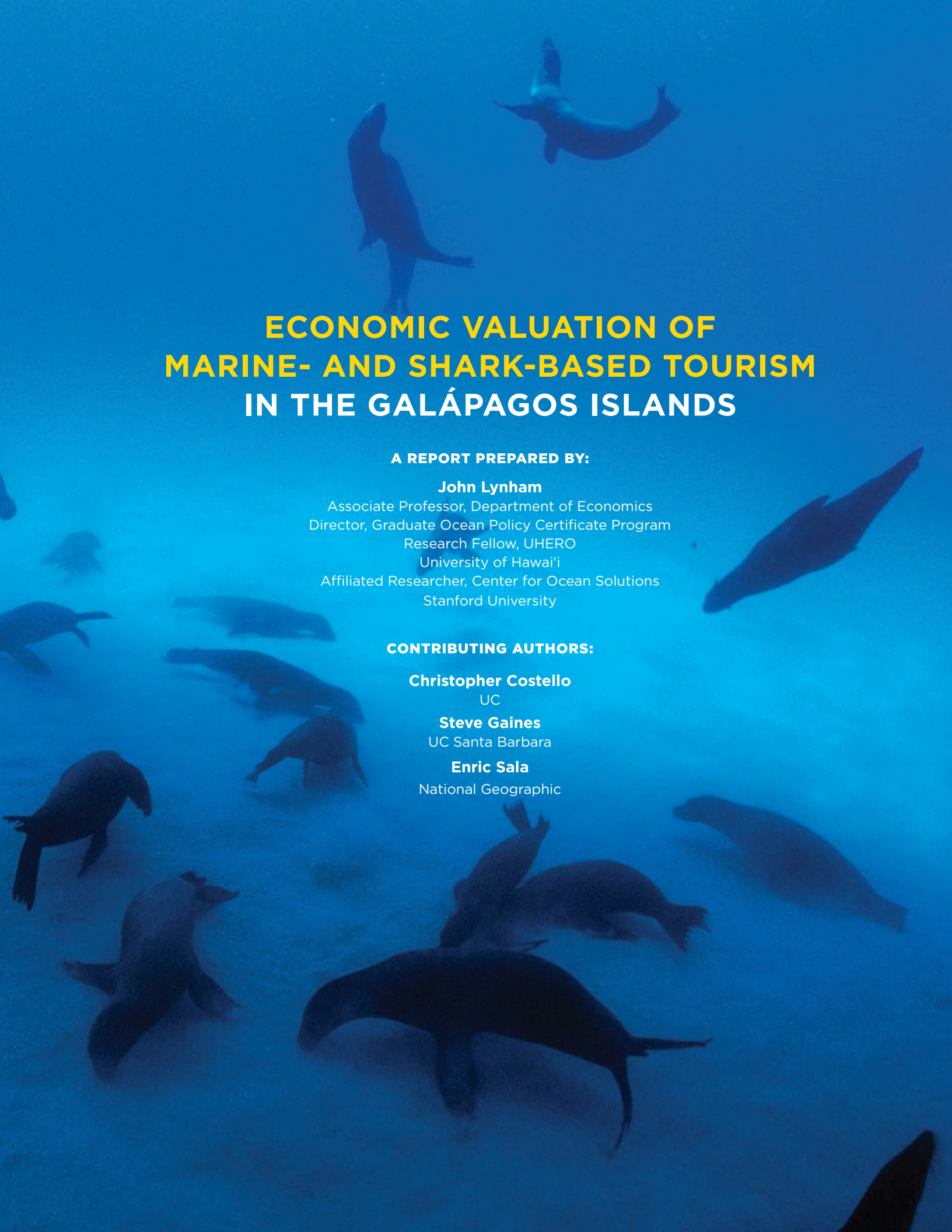

ECONOMIC VALUATION OF MARINE- AND SHARK-BASED TOURISM IN THE GALÁPAGOS ISLANDS

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RESUMEN **EJECUTIVO**

Galápagos es uno de los mejores destinos del mundo para el turismo de naturaleza y representa una importante fuente de ingresos para la economía ecuatoriana. Aunque es ampliamente aceptado que el ambiente marino constituye una gran parte de este valor económico, no existen estudios que calculen los ingresos generados por el turismo marino, en relación con el valor total del turismo en las islas. El valor turístico depende de la salud y el estado del ambiente marino; mientras más prístino el ambiente, turistas están dispuestos a pagar más por visitarlo. En este reporte estimamos el valor anual del turismo marino, y el valor de los tiburones – las especies más atractivas para buzos que visitan las islas, e indicadores de la salud del ambiente marino.

Usamos itinerarios de cruceros, encuestas a turistas, artículos científicos, documentos gubernamentales, y reportes de ONGs para calcular qué tanto de la experiencia turística en Galápagos depende de actividades marinas. **De los US$256 millones de dólares generados por turistas en 2014, estimamos que el 58% ($154 millones) es directamente dependiente de actividades y experiencias marinas.** Esto indica que la mayoría del valor turístico en Galápagos es dependiente del estado del ambiente marino. Debido a que estos ingresos impulsan otras actividades económicas por medio de un efecto multiplicativo, estimamos que **el impacto económico**

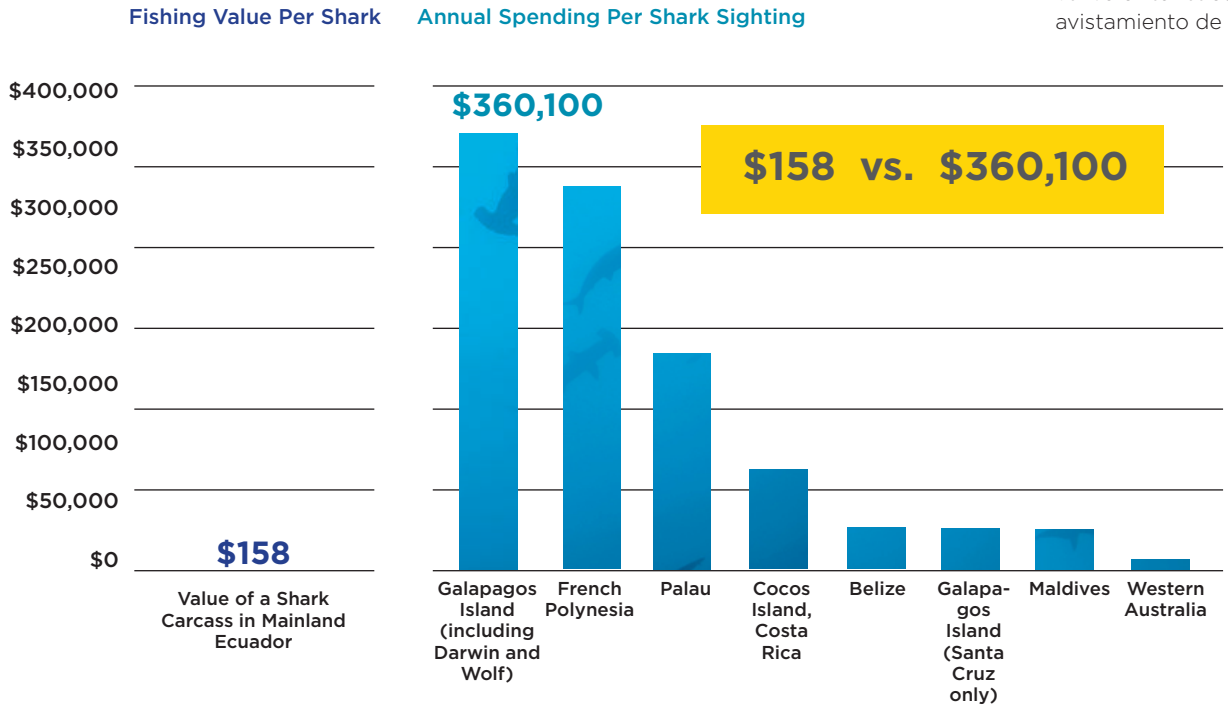
Valor económico del turismo marino vs. Valor económico de pesquerías

del turismo marino dentro de la economía de Galápagos es de $236 millones al año. También estimamos que el turismo marino genera 5,019 puestos de trabajo. Esto es equivalente al 37% de los puestos de trabajo en las Islas Galápagos. En otras palabras, **1 de cada 3 puestos de trabajo en las Galápagos existe gracias al turismo marino.**

Aunque actualmente el ambiente marino contribuye en gran medida al turismo en Galápagos, es posible incrementar aún más los beneficios económicos. De acuerdo con encuestas realizadas a turistas, dentro de Galápagos y alrededor del mundo, estimamos que crear una red de áreas de uso no extractivo dentro de la Reserva Marina de Galápagos (RMG) podría incrementar los ingresos por turismo entre $14 y $90 millones por año, sin aumentar el número total de turistas. Esto se debe a que turistas están dispuestos a pagar más por un ambiente marino saludable y con menos congestión en los lugares atractivos para la práctica del buceo y snorkel. Como punto de comparación, el valor máximo de la pesca legal en Galápagos está alrededor de $4-5 millones de dólares al año, de los cuales una parte puede ser afectada (positiva o negativamente) por mayor protección en la RMG. Aunque mayor protección puede desplazar parte de la actividad pesquera, múltiples estudios han mostrado que pesquerías locales suelen ser más sostenibles y más rentables cuando están alrededor de áreas de uso no extractivo con un manejo adecuado. Por consiguiente, mayor protección puede beneficiar a todos los usuarios de la RMG.

Muchos turistas visitan Galápagos con el único propósito de bucear e interactuar con tiburones; en especial en las islas de Darwin y Wolf. Usando información publicada sobre cruceros de buceo, precios, itinerarios, y número máximo de pasajeros, estimamos los ingresos generados por el turismo de buceo con tiburones en Galápagos. **Encontramos que las islas de Darwin y Wolf generan la mayoría de (63%) de los ingresos generados por buceo con tiburones.** Combinamos esta información con datos de abundancia relativa de varias especies de tiburones en diferentes regiones de la RMG, para calcular el valor promedio por cada avistamiento de tiburón. Esta metodología ha

Valor pesquero por tiburón vs. Valor turístico por cada avistamiento de tiburón.



sido ampliamente utilizada en estudios similares en varias partes del mundo y se han estimado valores anuales por tiburón entre $8,779 y $316,699 dólares. Usando la misma metodología, encontramos que **los tiburones son más valiosos en Galápagos que en cualquier otra parte del mundo.** El valor promedio de cada tiburón para la economía de Galápagos es de $360,105 dólares al año. Debido a que tiburones adecuadamente protegidos tienen una larga esperanza de vida, estos pueden proveer valor turístico durante muchos años. **Estimamos que el valor turístico promedio de un tiburón durante la totalidad de su vida es $5.4 millones de dólares.** Esto claramente revela que los tiburones en Galápagos (particularmente los tiburones martillo) son, económicamente, los más valiosos en el planeta. En cambio, el valor máximo de un tiburón pescado y vendido en el continente por sus aletas y su carne es sólo $158 dólares.

Debido a que las poblaciones de tiburones en Galápagos han disminuido significativamente en comparación con sus niveles históricos, revertir este declive por medio de mayor y mejor protección puede generar beneficios substanciales. Nuestros resultados indican que **mayor protección (i.e., creación de mas áreas de uso no extractivo en la RMG) no sólo preservaría el valor actual del ambiente marino en Galápagos, sino además traería beneficios económicos adicionales sin incrementar el impacto generado por el turismo.** En contraste, mayor presión pesquera – particularmente en las valiosas islas de Darwin y Wolf – reduciría considerablemente el valor presente neto de la reserva mediante la erosión del capital natural más valioso del archipiélago.

EXECUTIVE **SUMMARY**

The Galápagos Islands are one the world's top destinations for nature tourism, and an important economic engine for Ecuador. Despite the widely-held view that the marine environment comprises a large fraction of this value, no reliable estimates have been made that separate out the spending generated by the marine environment, relative to total tourism revenue. Tourism value is dependent on the health of the marine environment; the more pristine the environment, the more tourists are willing to pay to visit. Here we report the annual value of marine-based tourism and the value of sharks – the most attractive species for dive tourists visiting the islands, and a strong indicator of the health of the marine environment.

We used tour itineraries, exit surveys, academic articles, government documents and NGO reports to calculate how much of the tourist experience in the Galápagos depends on marine-based activities. **Of the $265 million spent by tourists within the Galápagos in 2014, we estimate that 58% ($154 million) was directly dependent on marine-based tours, activities and experiences.** This indicates that the majority of tourism value in the Galápagos is dependent on the marine environment. Since this expenditure supports additional economic activity through a multiplier effect, we estimate that **the economic impact of marine-based tourism within the Galápagos economy is $236 million per year. We estimate that 5,019 jobs are generated by marine-based tourism expenditures.** This is equivalent to 37% of jobs in the Galápagos Islands. In

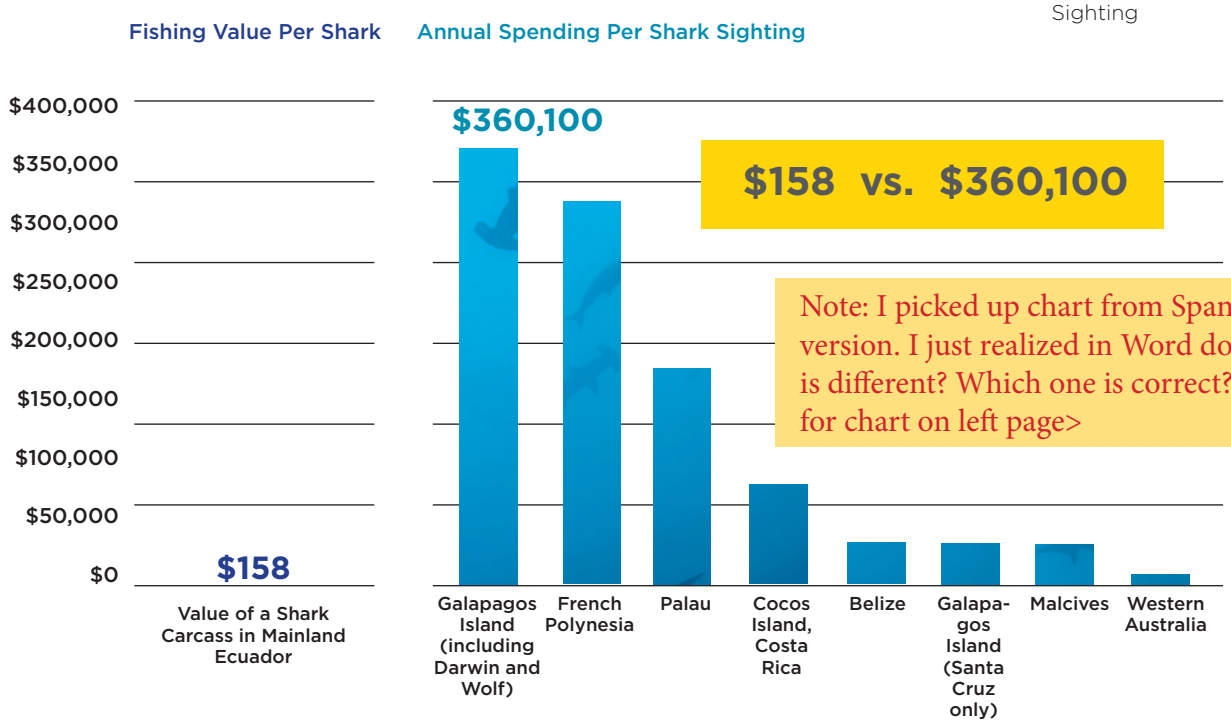
Annual Value of Marine-based Tourism vs. Value of Fishing

other words, **1 out of every 3 jobs in the Galápagos exist because of marine-based tourism spending.**

Although the marine environment currently contributes greatly to Galápagos tourism, there is considerable scope for even greater benefits. Based on tourist surveys within the Galápagos and findings in other parts of the world, we estimate that **creating a large network of no-take areas within the Galápagos islands could increase annual spending by tourists between $14 and $90 million, without increasing the number of tourists.** This is because tourists are willing to pay more for a healthier marine environment and less congestion at popular snorkeling and diving spots. As a point of comparison, the maximum value of legal fisheries in the Galápagos is in the range of $4 million per year, some of which may be affected (positively or negatively) by increased protection. While increased protection might displace some fishing activity, many studies show that local fisheries tend to be more sustainable and profitable around well-enforced no-take marine reserves. Therefore increased protection may benefit all stakeholders.

Many tourists come to the Galápagos for the sole purpose of swimming and diving with sharks, especially on trips to the uninhabited Darwin and Wolf islands. Using published information on shark diving tours, their prices, itineraries, and capacities, we estimated how much tourists currently spend on shark-diving tourism in the Galápagos. We found that **Darwin and Wolf generate the majority (63%) of shark diving expenditure.** We combined this information with data on the frequency of viewing different shark species at different locations to calculate the average spending generated per shark sighting. This is a popular approach in the literature and has produced estimates for the annual value of a shark ranging from $8,779 to $316,699. Using the same methods used in other studies, we found that **sharks are more valuable in the Galápagos than anywhere else on earth.** The average value of a shark to the tourism industry in the Galápagos is $360,105. Since protected sharks can live for quite some time, they provide value as a tourist attraction for many years. We estimate that the **average lifetime spending generated by a shark in the Galápagos**

Fishing Value of a Shark vs. Annual Spending Per Shark Sighting



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is $5.4 million. This clearly shows that sharks in the Galápagos (particularly hammerhead sharks) are some of the most economically valuable sharks on earth. Again, as a point of comparison, this value far exceeds the maximum value a shark can fetch when sold on the mainland for its meat and fins ($158).

Since shark populations in Galápagos have declined significantly from historical levels, reversing this trend through greater protection could generate substantial benefits. Our results strongly indicate that **increased protection (i.e. the creation of more no-take areas in the Galápagos Marine Reserve) would not only preserve the current value of the Galápagos marine environment, but could also bring in additional economic revenue without necessarily increasing the tourist footprint**. In contrast, increased fishing – in particular in the extremely valuable Darwin and Wolf islands – would significantly decrease the net present value of the reserve through erosion of the most valuable marine natural capital in the archipelago.

INTRODUCTION

When tourists are planning a trip to the Galápagos, their first priority is probably viewing the islands' most famous land-based creature: the Galápagos tortoise. But a surprising proportion of the visitor experience in the Galápagos (in terms of time, spending, and enjoyment) is actually marine-based. Many visitors come to the islands specifically to see animals found in the ocean, with sharks as one of the primary attractions. The purpose of this report is to estimate two economic indicators. First, what is the value of the marine-based tourism sector in the Galápagos? In other words, what percentage of tourism revenues depend on activities that take place underwater or involve viewing marine species? Second, what is the economic value of sharks to the tourism industry in the Galápagos?

The economic valuation of marine-based tourism consists of two components. First, an evaluation of the current situation in the Galápagos. Second, projections of how marine-based tourism in the Galápagos might develop in the future if greater marine area is converted to no-take marine reserves. For the first component, we estimate how much of existing tourism in the Galápagos can be classified as marine-based. We calculate this a number of different ways, which all provide generally consistent results. We use published itineraries provided by tour companies, in addition to surveys of tourists, to classify activities as land-based tourism, marine-based tourism, or neither. In order to generate projections of future growth, we rely on estimates from the existing literature and surveys of willingness to pay for greater marine protection. We compare this value to the potential loss in fisheries revenue if fishing grounds are converted to no-take marine reserves.

To calculate the value of sharks for tourism in the Galápagos we use the standard approach in the existing literature. We estimate how much divers spend to view sharks and then calculate the average spending per shark viewed while diving. Using published life history estimates we can project how much spending a shark generates over its lifetime. This value is then compared to the value a shark generates if it is killed and its fins and meat are sold on the mainland.

Why is this study important? The waters around the Galápagos Islands harbour unique marine species and ecosystems that are found nowhere else on Earth. However, less than 1% of the Galápagos Marine Reserve is currently protected from fishing as no-take areas. Furthermore, legal and especially illegal fishing threatens species in the wider Galápagos Exclusive Economic Zone (EEZ). Creating no-take areas presents a unique opportunity to protect the value of marine-based tourism for future generations. Protecting sharks should be a key focus of any future no-take areas since this report demonstrates that the tourism spending generated by sharks in the Galápagos is extremely large - larger than any other estimates in existing studies of dive tourism in other parts of the world.

This report is organized as follows. Section 2 presents the methodology and results for calculating the value of marine-based tourism in the Galápagos. Section 3 presents the results for shark-based tourism, including the value of a shark to the Galápagos Islands' economy. Section 4 concludes with some caveats to our findings and a general discussion of their importance and relevance.

ECONOMIC VALUATION OF **MARINE-BASED TOURISM IN THE GALÁPAGOS**

FIGURE 1.

Consumer and Producer Surplus

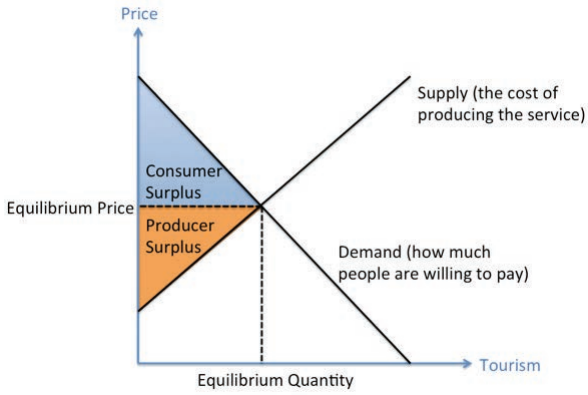
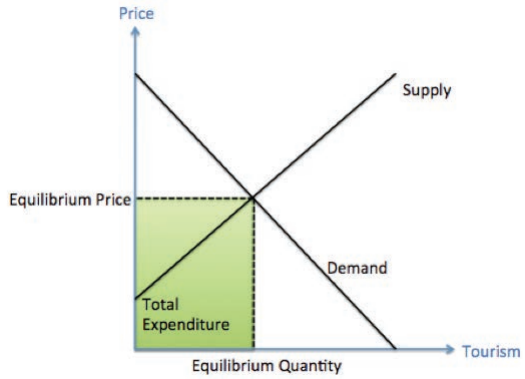


FIGURE 2.

The Market Price Approach (Total Expenditure)



Methodology

There are different methods for calculating the total economic value of a good or service. The value of a trip to the Galápagos is typically much larger than the dollar value spent on the trip. One might value a trip to the Galápagos at $20,000 but only end up paying $2,000 for the trip, The concept of Consumer Surplus attempts to capture the difference between how much a service is valued and how much someone actually pays for it (Figure 1). Producer Surplus captures the difference between how much it costs to produce a service and how much it is sold for.

To estimate the value of tourism in the Galápagos, we would like to calculate the blue area under the demand curve (Consumer Surplus) and the orange area above the supply curve (Producer Surplus) for the equilibrium quantity of tourism (Figure 1). But to do this we would need to observe, for every tourist to the Galápagos, the maximum amount they would have been willing to pay for their trip, not the actual amount they paid. We would also need to know the cost of providing various tourism services. This information is not available and, therefore, we adopt a more common methodology: the market price approach.

We plan to calculate the value of tourism as total expenditure: multiplying price by quantity (Figure 2), often referred to as the market price approach. This will tend to underestimate total economic value but it is much simpler to implement using readily available data. In terms of the Galápagos, this involves calculating the total number of marine-based tourists and summing up their total spending. For example, if 1,000 marine-based tourists each spent $1,000 on their trip to the Galápagos then the valuation of marine-based tourism would simply be 1,000 x 1,000 = $1 million. Most of the data necessary to perform this calculation are readily available. Note that it is possible to evaluate tourism value in terms of total spending on the trip (flights, insurance, stop-overs in mainland Ecuador, etc.) or in terms of total spending within the Galápagos. Since the primary purpose of this report is estimating the value of marine- and shark-based tourism to the Galápagos economy, we will generally restrict our analysis to spending that takes place within the Galápagos Islands.

Once we have calculated total expenditure by tourists, we will then apportion this spending between marine- and land-based tourism (Figure 3). We plan to do this analysis separately for three different sectors of the visitor industry: tourists on live-aboard vessels, tourists on primarily dive vessels, and "stay-over" tourists that stay on land. This appears to be the most natural way of categorizing tourists in terms of the degree to which their holidays in the Galápagos are land- or marine-based. Once we calculate total marine-based tourist expenditure, we can then multiply this by an appropriate economic multiplier to calculate the annual economic impact of marine-based tourism within the Galápagos Islands.

FIGURE 3

Apportioning Expenditure to Marine-based Tourism

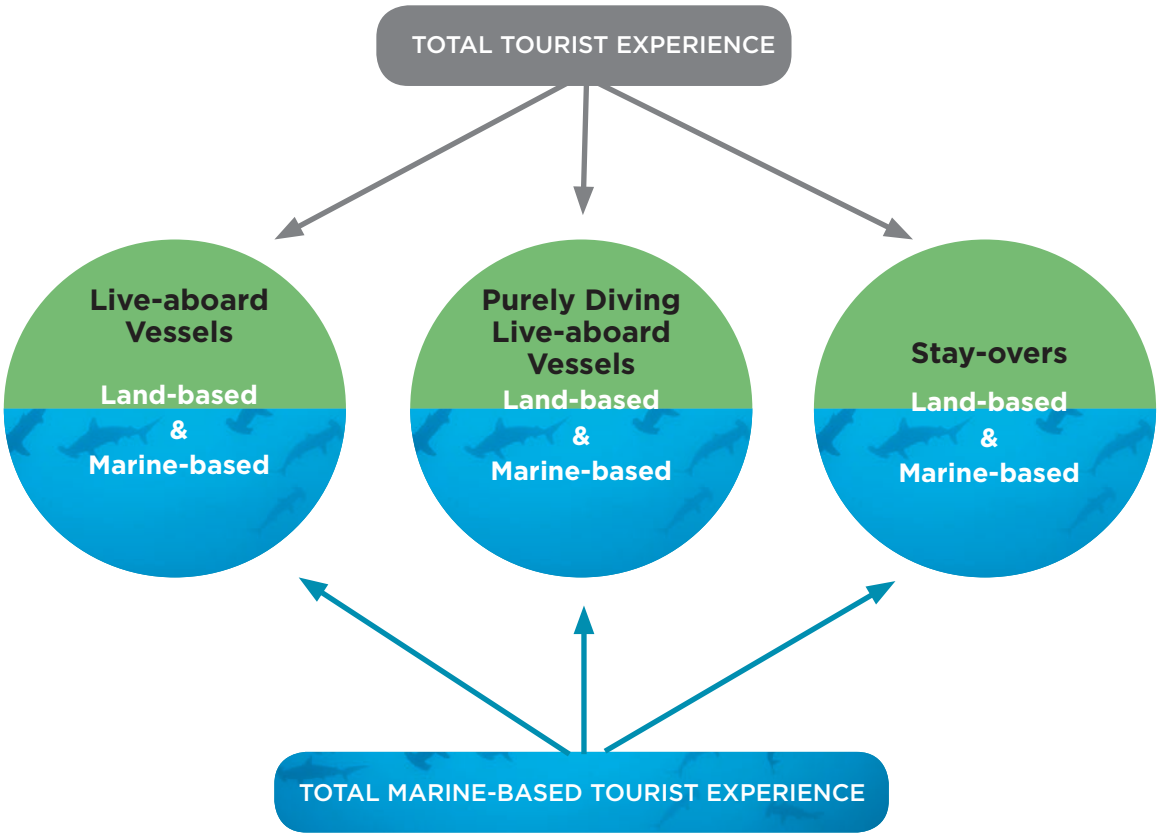


TABLE 1.

Number of visitors to Galápagos from 2013-2015

Year	Nationals	Internationals	Total
2013	72,276	132,119	204,395
2014	78,163	142,881	221,044
2015	82,060	146,588	228,648

Notes: 2015 projections were calculated by the Ecuadorian Ministry of Tourism. National tourists include continental Ecuadorians only. Source: Ficha Galápagos: Años 2013. Estadístcas e Investigación Observatorio de Turismo de Galápagos (2014).

TABLE 2.

Tourism revenues in Galápagos from 2012-2015

Year	Tourism Revenue in USD
2012	$217,000,000
2013	$245,000,000
2014	$265,000,000
2015	$274,000,000

Notes: 2015 projections were calculated by the Ecuadorian Ministry of Tourism. Source: Ficha Galápagos: Anos 2013. Estadístcas e Investgación Observatorio de Turismo de Galápagos (2014).

TABLE 3.

Average Expenditures by Foreign and Ecuadorian Tourists

Expenditures	Foreigners	Ecuadorians
International Travel	$1,455	N/A
Other International Expenditures	$325	N/A
In Mainland Ecuador	$715	N/A
Air: Ecuador/Galápagos/Ecuador	$362	$170
Galápagos Cruise	$1,730	55
Park Fee & Donations	$117	$7
In Galápagos Towns	$167	$267
Total	$4,871	$478

Source: Epler (2007)

Expenditure Data

Tables 1 and 2 summarize the total number of visitors and tourism revenues for the Galápagos from 2013 to 2015 (the 2015 numbers are projections). This information is compiled by the Ecuadorian Ministry of Tourism. In 2014, nearly a quarter of a million tourists visited the Galápagos. 35% of these tourists were from mainland Ecuador and the remaining 65% were from outside of Ecuador (tourists who live in the Galápagos were not included in the survey). The annual growth of tourist visitors since 2013 has averaged 13%.

In terms of revenues, visitors to the Galápagos spent $265 million US dollars within the islands themselves in 2014 (Table 2). Tourism revenue has grown approximately 11% per year since 2012. These numbers suggest that the average tourist to the Galápagos spends $1,199 in the islands. In terms of total expenditure on their holiday to the Galápagos, the number is obviously much larger. Based on the results presented in Epler (2007), Table 3 suggests that the average non-Ecuadorian tourist spends $4,871 on their holiday to the Galápagos (this includes airfare, other pre-departure expenses and money spent in mainland Ecuador). The average tourist from mainland Ecuador spends $478.

Apportioning Revenues to Marine-based Tourism

There are three main types of tourists in the Galápagos: those on live aboard vessels that do land and marine-based activities, tourists on purely diving focused live-aboard vessels, and land-based "stayover" tourists (see Figure 3). We start with the live-aboard vessels that do both land and marine activities, since these tourists represent the majority of tourism expenditure (Epler, 2007). We initially apportion value to marine-based tourism using a revealed preference approach. If a tourist goes to the Galápagos and spends 70% of their available time engaged in marine-based tourism, then this "reveals" that 70% of the tourism experience for this individual was marine-based. How do we calculate how much time live-aboard tourists spend doing land- or marine-based tourist activities? Thankfully, most operators publish their itineraries online and in brochures/pamphlets. We started by collecting as many published itineraries as we could find, both online and in the Galápagos. In total,

we found 89 itineraries for 42 different live-aboard vessels. We then took each itinerary and categorized tour activities as either land- or marine-based. We compiled a total list of 1,783 tourist excursions or activities. An example of a land-based activity would be a hike and a marine-based activity would be a snorkeling trip or viewing marine species from a dinghy. We found that 56% of these trips are marine-based (see Table 4 below). This is our first estimate of the proportion of live-aboard tourism that is marine-based. This is likely to be a slight underestimate of the true proportion of marine-based activities since many land-based activities (such as hiking) involve viewing marine animals and birds. An estimate in the region of 56 to 60% seems appropriate.

An alternative "stated preference" approach to measure how much of the tourist experience in the Galápagos is dependent on marine-based activities is to simply ask tourists which activities gave them the most enjoyment. For a report conducted for the WWF in 2014 (Schep et al., 2014), tourists at the airport were asked about their preferences over specific aspects of their trip. The sample includes 432 respondents, each of which ranked aspects of their experience from 1-4 (1 being their favorite aspect). These ranks were then converted into points, with a rank of 1 receiving a score of 4 points, a rank of 2 receiving a score of 3 points, etc. The results are presented in Table 5. The total number of

TABLE 4.

Marine-based Tourism Excursions for Live-aboard Vessels

Excursion Type	Number	Percentage
Land-based	783	43.9%
Marine-based	**1000**	**56.1%**
Total Excursions	1783	100%

Sources: Internet searches of 89 published itineraries for 42 different vessels. More detailed results are in the Appendix.

TABLE5 5.

Average Preference Ranking for Tourist Activities in the Galápagos

Color Key	Tourist Activity	Average Preference Ranking
	Marine-based	3.25
	Land-based	1.30
	Both	5.04
	Neither	0.6
	Total	10.19

Aspect	Average Preference Ranking	Percentages of Preference Ranking According to Aspect
The marine species	1.75	17.17%
Diving/Snorkeling	1.5	14.72%
Proximity	1.5	14.72%
The land species	1.3	12.76%
Tranquility	0.98	9.62%
The landscape scenery	0.96	9.42%
The beaches	0.95	9.32%
Friendly local people	0.43	4.22%
Daily trips	0.35	3.43%
Live aboard trips	0.15	1.47%
Local history (Darwin's Theory)	0.15	1.47%
The nightlife	0.1	0.98%
Types of visitors	0.05	0.49%
Other	0.02	0.20%

Source: Schep et al., (2014)

points was 10.19 and the points allocated to marine-based activities sum to 5.77 (3.25 + 50% of 5.04). This represents 57% of the total enjoyment points allocated; (3.25+2.52)/10.19 = 57%. Interestingly, this is almost the exact same percentage as we found using the revealed preference approach, suggesting that the live-aboard vessels are giving tourists exactly what they want. Therefore, we feel confident in apportioning 57% of live-aboard land/sea vessel tourism to marine-based tourism, especially since these tourists are spending the majority of their time in the Galápagos onboard a boat.

For the purely diving live-aboard vessels, we apportion 100% of the value to marine-based tourism. These tourists have come to the Galápagos to go diving, especially to see sharks. The primary (and often sole) purpose of their trip is marine-based tourism. Unfortunately, there is not much detailed information on what stay-over tourists spend their time and money doing. Stay-over tourists typically devise their own itineraries, often deciding on activities when they arrive in the islands. There is large variation across these tourists in terms of what they spend their time doing. There have been some surveys conducted of stay-over tourists that provide a few insights. Among stay-over tourists, 80% report going snorkeling. Interestingly, participation rates in many marine-based activities (kayaking, diving, surfing, and fishing) are actually higher for stay-over tourists than those on live-aboard vessels (Schep et al., 2014). In addition, stay-over tourists rank marine species as the thing they are most willing to pay to see in the Galápagos islands (Schep et al., 2014). Based on these survey results but without concrete information on how much time or money is spent on different activities, we assume that 45% of the value of stay-over tourism is marine-based.

Epler (2007) estimates that tour vessels (mixed activity and diving) account for 84% of tourist expenditures, so, if this proportion has remained the same over time, this would be approximately $222.1 million of the total expenditure in 2014. This number makes sense if we calculate how much revenue live-aboard vessels would make in a year if they were 100% full year-round (approximately $237 million). Based on published online prices and information on trips per year, we have estimated that dive-only vessels accounted for approximately $18 million of revenue in 2014 (Table 6). In other words, 8% of the total tour vessel revenue. These numbers suggest that 77% of tourism spending is coming from mixed-activity live-aboard vessels (i.e. 92% of 84%). Again, this estimate is supported by tabulating all of the published prices for live-aboard vessels

TABLE 6.

Potential Revenue Generated by Diving Live-aboard Vessels

Galápagos Live-aboard Dive Boats

Name	Capacity	Itinerary
Galápagos	16	Santa Cruz-Wolf-Darwin-San Cristobal-Isabella
Galápagos Sky	16	Santa Cruz- San Cristobal-Wolf-Darwin-Isabella
Humbolt	16	San Cristobal-Wolf-Darwin-Santa Cruz
Pinguino	16	Santa Cruz-Bartolome-Wolf-Darwin-Isabella-
Galápagos Master	16	Cousin Rock-Bartolome Island- Isabella-Fernandina-Darwin-Wolf
Galápagos Master	16	Cousin Rock-Bartolome Island- Isabella-Fernandina-Darwin-Wolf
Galápagos Master	16	Cousin Rock-Bartolome Island- Isabella-Fernandina-Darwin-Wolf
Nortada	8	Punta Carrion-Cape Marshall-Roca Redonda-Darwin-Wolf-Seymour
Total Revenue		

along with their capacities and assuming near-full capacity (95%) year round. Based on Epler (2007), land-based stay-over tourism (hotels, souvenirs, snorkeling tours) accounts for 16% of total tourism expenditure.

We now calculate the value of marine-based tourism for each sector. Mixed activity live-aboard vessels account for $204 million of spending. We apportion 57% of this value to marine-based tourism: $116 million. Diving live-aboard vessels account for $18 million, all of which is marine-based. Stay-over tourists account for $42.4 million of spending, and we assign 45% of this to marine-based tourism: $19 million. Adding this altogether we reach the following conclusion: **Marine-based tourism in 2014 was worth $154 million in revenues.** This accounts for 58% of total revenues (see Figure 4).

Wider Impacts on the Galápagos Economy

We can now take this expenditure estimate and calculate the economic impact of marine-based tourism in the Galápagos. This is done using a multiplier. Economic impact analysis recognizes that the contribution of market transactions to an economy may be substantially larger than what is revealed by the total expenditure or market price approach. For example, tourism expenditures serve to generate additional revenues, incomes and employment in the wider economy.

A portion of each dollar spent by a tourist represents revenue earned by someone else in the economy. As some of that generated income is used to purchase other goods and services, each new dollar spent and earned ripples through numerous other businesses and households creating an economic multiplier effect. As only a portion of each dollar that is earned is spent, the amount of money from a particular transaction that continues on in the economy tends to get smaller. For example, a tourist spends $100 on a dive tour. The dive tour operator spends $50 out of that $100 on a meal at a nice restaurant. The restaurant owner spends $25 out of this $50 on a new shirt. Thus, the $100 spent on the dive tour generates 100+50+25 = $175 worth of economic activity. In this case, the multiplier would be 1.75.

An important question now becomes what is the appropriate multiplier to use? Based on Jacobsen (2014), the average multiplier for economic activity in the marine sector was 1.82, indicating that every dollar generated by a direct marine industry leads to an additional 82 cents generated by associated industries. Taylor et al. (2014) is an input-output

	# Days	#	# Dives per trip	Price	Price per dive	Potential
	7	40	20	$5,395	$269.75	$3,452,800.00
	7	52	19	$5,495.00	$289.21	$4,571,840.00
	8	40	17	$4,695.00	$276.18	$3,004,800.00
	8	40	19	$3,575.00	$188.16	$2,288,000.00
	7	26	20	$4,850	$242.5	$2,017,600.00
	10	13	30	$6,250	$208.3	$1,300,000.00
	14	3	40	$9,050	$226.3	$434,400.00
	8	15	20	$4,263	$213.2	$511,560.00
						$17,581,000.00

study specifically focused on the Galápagos Islands. They calculate tourism multipliers net of airfares, travel agent commissions, and spending en route to and from the islands (which is the relevant multiplier for the type of local spending we have been analyzing). The estimated effect of $1,000 of tourist expenditures is $467 for international tourism and $654 for domestic tourism. This suggests a multiplier between 1.467 and 1.654. Weighting by the percentage of total visitors (65% international tourists and 35% from Ecuador) suggests a multiplier of 1.532. Earlier studies have suggested much smaller multipliers. Taylor and Yúnez-Naude (1999) found that a $100 increase in spending by international tourists increased the gross island product by $28. Although small, this impact is nearly four times that estimated by de Miras (1995).

Given that there is a range of potential multipliers, we have decided to use the one calculated by Taylor et al. (2014) since it is (i) the most recent, (ii) specific to the Galápagos Islands, (iii) comprehensively calculated, and (iv) lies within the range of the other multipliers. The Taylor et al. (2014) estimate also seems reasonable when compared to estimates from other remote island economies that are heavily dependent on tourism. For example, Tian et al. (2013) perform a comprehensive evaluation of tourism's impact on Hawaii's economy and conclude that direct tourism generates additional economic activity equivalent to 78% of the direct contribution. This is equivalent to an economic multiplier of 1.78. Therefore, we estimate that the **annual economic impact of marine-based tourism within the Galápagos Islands economy is 1.532 x $154 million=$236 million.**

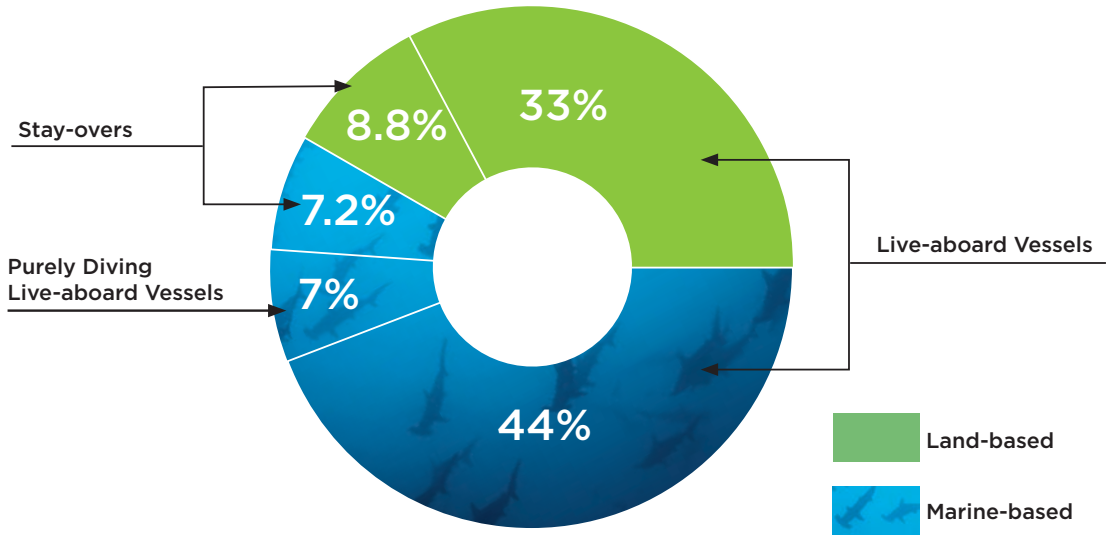
Apportioning Jobs to Marine-based Tourism

One of the challenges (and potential criticisms) of simply apportioning total spending to marine-based tourism is that many Galápagos residents feel that they do not benefit directly from this spending. It is widely believed, and there is some empirical evidence to support the idea, that most of the tourism expenditure in the Galápagos leaves the islands. This is because non-residents own many of the live-aboard vessels, which generate most of the tourism expenditure. An alternative measure to estimating the total expenditure that occurs in the Galápagos due to marine-based tourism is to estimate the total number of jobs in the islands that depend on marine-based tourism. This is likely to be a much more salient statistic for local residents.

Based on estimates from the Ecuadorean Ministry of Tourism (Ficha Galápagos, 2015), there are at least 2,770 jobs directly generated by the tourism industry in the Galápagos. 972 are on

FIGURE 4.

Estimates of Marine-based Expenditure



board live-aboard vessels, 824 in hotels, 497 in food and beverage, 497 in travel agencies, 277 on boats without accommodation, and 31 in land transportation. In terms of location, 71% of these jobs are on Santa Cruz (including the airport island of Baltra), 18% on San Cristobal, 11% on Isabela and 0.5% on Floreana. We believe these to be very conservative estimates of the numbers employed directly by the tourism industry, especially when we compare these to the estimates of Epler (2007). Epler estimated that in 2007, 1,100 crew and guides worked on board live-aboard vessels. This is more than the Ministry of Tourism's 2015 estimate even though tourism has greatly expanded since 2007.

We are obviously interested in more than just the jobs directly generated by tourism. However, estimating the number of jobs indirectly caused and induced by the tourism sector is challenging. We adopt two approaches. The first is to estimate the total number of people employed in the Galápagos Islands and then apportion jobs based on estimates of the size of each economic sector's contribution to the overall economy. The second approach is to take the number of people directly employed by the tourism sector and then apply an economic multiplier to estimate the additional indirect and induced employment.

We start with the first approach. The Galápagos Islands had a resident population of over 25,000 inhabitants in 2010 (INEC, 2010), and it is most likely close to 30,000 at present. Based on the World Development Indicators series published by the World Bank (2012), we know that the total population between the ages of 15 to 64 as a percentage of the total population in Ecuador is 64%. If we extrapolate this number to the Galápagos Islands, this implies a potential labor force of 19,200 people between the ages of 16 and 64 (64% of 30,000). Not all of the potential labor force is economically active and the World Bank estimates that in Ecuador 69% of the labor force is engaged in productive economic activity. If we apply the same proportion to the Galápagos, this implies that 13,248 people are employed in the islands (69% of 19,200). We use the labor force participation rate instead of the employment to population ratio (66%) for Ecuador because there is such a large difference between unemployment on the mainland and unemployment in the Galápagos. Numerous sources including Epler (2007) report that there is a labor shortage in the islands. It is reasonable then to assume that the Galápagos Islands are close to full employment (4 to 6.4% unemployment) and we are justified in using the labor force participation rate for the whole country as an estimate of Galápagos Islands employment.

The National Institute of Statistics and Censuses (INEC), periodically collects information

TABLE 7.

Estimates of the Total Jobs Generated by Tourism

Method	Number of Jobs
Total employment (World Bank estimates) apportioned using Epler (2007)	11,658
Total employment (INEC estimates) apportioned using Epler (2007)	12,408
Total employment (World Bank estimates) apportioned using Wilen et al. (2000)	5,299
Total employment (INEC estimates) apportioned using Wilen et al. (2000)	5,640
Total employment (World Bank estimates) apportioned using Jones (2013)	10,333
Total employment (INEC estimates) apportioned using Jones (2013)	10,998
Direct employment increased by Taylor et al. (2014) multiplier	4,244
Average	8,65

on population and employment in the Galápagos Province. As of 2002, INEC calculated that 8,772 people were economically active in the archipelago. According to INEC, total population was 18,640 in 2001. This implies that 47% of the total population was economically active in 2001/2002. INEC's most recent total population estimate is 25,124 in 2010. If the ratio has remained roughly the same this would imply that 11,823 people were economically active in the Galápagos in 2010. Extrapolating this out to 2015 (assuming a current population of 30,000) implies that 14,100 people currently are economically active (i.e. employed) in the Galápagos. This matches very closely our own estimates using the World Bank Development Indicators. Our next question then is, of these 13,248 to 14,100 jobs, how many are dependent on the tourism industry?

According to Epler (2007), if park entrance fees and donations are considered as tourism revenue (since they come from tourists), the tourism industry would account for roughly 88% of the revenues in the Galápagos economy. In the absence of more reliable data, we assume that employment is directly proportional to revenues generated within the islands. Therefore we estimate that **11,658 jobs** (88% of 13,248) are directly or indirectly generated by tourism expenditures in the Galápagos using the World Bank estimates of total employment. Wilen et al. (2000) reported that in 1999, 40% of the Galápagos population was employed within the tourism sector or connected businesses. If this proportion were still true 16 years later, this would imply that there are **5,299 jobs** in the tourism sector. Jones (2013) states that tourism is responsible for 78% of all employment in the Galápagos. This would imply a total of **10,333 jobs**. If we use the INEC estimates instead of those generated using the World Bank data, this revises the three estimates above to **12,408 jobs** (using Epler (2007), **5,640 jobs** (using Wilen et al. (2000), and **10,998 jobs** (using Jones (2013)).

We now adopt the second approach. As stated earlier, the Ecuadorean Ministry of Tourism (Ficha Galápagos, 2015) estimates that there are at least 2,770 jobs directly generated by the tourism industry in the Galápagos. We believe this to be an underestimate of direct employment but it is currently the only estimate available. As stated by Epler (2007, p. 22), "A large but unknown labor force is employed selling souvenirs, jewelry, art, handicrafts, ice cream, water, soft drinks, and other small items to tourists. The number of employees identified here represents a fraction of the total directly employed by tourism." The work of Taylor et al. (2014) suggests that the appropriate tourism multiplier for the Galápagos islands is 1.532. This would imply total employment as a result of tourism (direct and indirect effects) of **4,244 people** (1.532 x 2,770).

We take the average of all of these estimates (8,654 jobs) as our estimate of choice although this is likely to be a slight underestimate of the total jobs generated by the tourism industry. We now apportion these tourism jobs to marine-based tourism using the same formula as before. 58% of tourism revenue is generated through marine-based tourism; therefore, of the 8,654 jobs generated by tourism spending, we estimate that **5,019 jobs are generated by marine-based tourism expenditures**. Depending on which estimate we use for the total number of jobs in the Galápagos, the percentage of the workforce employed as a result of marine-based tourism ranges from 23% to 51%. The average of the World Bank and INEC estimates suggests that current total employment is 13,674 people. If we use this number, then 37% of jobs in the Galápagos are dependent on marine-based tourism. In other words, **1 out of every 3 jobs in the Galápagos exist because of marine-based tourism**. Thus, even if a large percentage of tourist dollars leave the islands, the livelihoods of a significant proportion of local residents in the islands critically depend on marine-based tourism.

Projections Based on Potential Marine Protected Area (MPA) Expansion

We now wish to forecast how much the value of marine-based tourism might increase if no-take marine reserves increased in size, for example from 1% to 10-20% of available area. Based on data obtained from the Galápagos National Park, we have identified that 55 out of the 81 main marine tourism sites (67%) are located in no-take areas. This means that the majority of marine-based tourism is already taking place in the very small number of no take areas. This suggests that tourists strongly prefer recreating inside of no-take areas (which presumably have enhanced diversity relative to fished sites) and that increasing the size of no-take areas could reduce congestion at certain sites. Based on Schep et al.

(2014)'s survey of tourists, the average willingness to pay (WTP) to enjoy improved marine quality and less congestion in the Galápagos Islands is $350 + $47 = $397. As stated earlier, the average tourist currently spends $1,199 in the Galápagos. So, comprehensive marine reserves that improved marine quality and reduced congestion in popular spots could increase spending by 397 ÷ 1,199 = 33%. This suggests that the Galápagos could generate an additional $90 million a year in within-island spending without increasing the number of tourists but by increasing the number and size of no-take areas.

Stewart and Wilen (2001) conducted an exit survey of tourists on their willingness to pay to create marine reserves in the Galápagos in 1998 and 1999. According to the exit surveys, foreign tourists spend an average of $3,676.67 for vacations that include a visit to Galápagos, of which 15.1%, or $553.68 goes directly to the Galápagos. Visitors to the Galápagos who are Ecuadorian residents spend an average of $932.32 on their vacations. Ecuadorian visitors spend $339.26 (or 36.7% of their total expenditures) directly to Galápagos accounts. Stewart and Wilen (2001) find that the mean foreign tourist willingness to pay for the creation and maintenance of marine reserves is approximately $53 per person per trip, and the mean willingness to pay of Ecuadorian resident visitors is $6.36. Given the number and composition of visitors to Galápagos, this implies that the aggregate annual benefits, expressed as a willingness to pay, are on the order of $2,745,000. This would only amount to $4 million in 2015 dollars. However, note that there were only 64,791 total visitors to the Galápagos in 1998. There are now 3.5 times as many tourists so this suggests the present-day equivalent of the Stewart and Wilen (2001) study is $14 million. In terms of increased local spending, their numbers suggest increases of 10% for international and 2% for Ecuador tourists. One possible explanation for these lower numbers is a lack of awareness of the value and impact of no-take marine reserves back in 1998. Almost 20 years later, tourists tend to be much more informed about both the need and benefits of fully protected parks. However, this number represents a useful lower bound.

How does this projection compare with other parts of the world that have created reserves to boost tourism? Unfortunately, very few studies on this topic have been conducted to date and most are hypothetical in nature. Williams and Polunin (2000) investigate the degree to which certain tropical marine protected area (MPA) attributes attract dive tourists. The major finding is that for Caribbean MPAs, better protection (e.g., MPAs with higher fishing restrictions) leads to a greater preference for dive tourists to visit that site. Divers reveal their preference for diving in areas that are well protected, as half of all the diving tourism in the Caribbean occurs within MPAs (Green and Donnelly, 2003). Peters and Hawkins (2009) assess

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the viability of marine park entrance fees to fund the operational costs associated with MPAs. This study indirectly measures WTP to visit no-take reserves. The study focuses on dive and snorkel tourism. They reviewed 18 WTP survey studies from MPAs of various sizes and regions. Some MPAs had already established park entrance fees while others had not. They found that there is a significant level of support for paying park entrance fees and to even increase the existing ones. This is especially true for divers, as long as their money goes toward conservation. Finally, a business model approach strongly suggests that any additional costs that may be created as a result of creating reserves are easily offset by the benefits of diving tourism (Sala et al. 2013), which includes charging higher park fees. In fact, it is well documented in the Galápagos that tourists are willing to pay more for tours with a more in-depth nature experience and higher levels of environmental protection (Viteri Mejía and Brandt, 2015). One potential idea to raise funds to pay for marine conservation in the Galápagos that would minimize the impact on other tourism activities is to charge a special fee to dive in a fully protected no-take area at Darwin and Wolf islands.

In terms of actual documented impacts in other locations, we can draw on a small number of existing studies in the literature. Badalamenti et al. (2000) examine data on MPAs in the Mediterranean (including Spain, France, Italy and Greece). They observe a general increase in tourist activities after the creation of marine reserves. McCook et al. (2010) document increasing revenue from tourism since the creation of the Great Barrier Reef Marine Park. Alcala and Russ (2006) find that following the creation of a no-take marine reserve on Apo Island in the Philippines, tourism has generated an additional $100,000 annually for the community, with an additional US$35,000 annual income in diver's fees. This is a large impact for a very small island with a total population of less than 1,000 people. Aburto-Oropeza et al. (2011) report how the ecological success of a no-take area in Cabo Pulmo, Mexico is being translated into economic benefits with locally owned, small-scale tourism operators in the area generating $538,800 in 2006. This amount is generated by less than 30 people, producing approximately $18,000 per capita, which is significantly higher than the per capita Gross National Income in Mexico. In New Zealand, Cape Rodney Okakari Point Marine Reserve attracts thousands of school children and tens of thousands of members of the public every year; Hunt (2008) estimated there were 375,000 visitors in 2007 and the tourism value of the no-take area was over NZ$8 million a year, but with a management budget of only NZ$70,000.

Potential Losses to the Fishing Industry

There is currently a sizable fishing industry in the Galápagos Islands, both legal and illegal. There are approximately 1,000 registered fishers in the islands but only around 400 are active (Galápagos Report 2011-2012). However, detailed information about the value of fishing to the Galápagos economy is difficult to come by. The creation of no-take areas in current fishing grounds will certainly impact the fishing industry. At least initially, we would expect no-take areas to have a small negative impact on the local fishing industry. In the long-term, it is possible that the fishing industry might actually benefit from the creation of no-take reserves but this will depend on a variety of factors, many of which are both hard to measure and hard to predict (Hastings and Botsford,

TABLE 8.

Fish Sales Off Island in 2005

Island	Lobster	Sea Cucumber	Dry-salted	Total
Santa Cruz	$523,500	$783,764	NA	$1,307,264
San Cristobal	$240,280	$334,360	NA	$574,640
Isabela	$282,690	$272,559	NA	$555,249
Total	$1,046,470	$1,390,683	$496,000	$2,437,153

Source: Taylor et al. (2008) and Hearn et al. (2007)

1999; Costello and Polasky, 2008; Smith et al., 2010; Sala et al. 2013).

The primary species that have been targeted in the Galápagos include sea cucumbers, sharks, lobster, tuna, and other finfish (whitefish). One of the more reliable estimates of the total value of domestic fisheries in the Galápagos comes from Taylor et al. (2008) and Hearn et al. (2007), although these are slightly out of date. The numbers are reproduced below in Table 8. The total value of fish sales off island was $2.4 million in 2005. However, Hearn et al. (2007) estimate that the maximum gross income generated by the fishing sector was $7 million in 2003. Although there is a lack of detailed information on total catch of whitefish after 2003, Hearn et al. (2007) estimate that the gross income for 2005 would not have exceeded $4 million, indicating a decline in the revenues generated by fishing in the Galápagos and in line with the estimate in Taylor et al. (2008). In 2006, the sea cucumber fishery was closed, so the gross income from fishing in this year was estimated to be less than $2.5 million (Hearn et al., 2007).

Based on Utreras et al. (2014), we know that total landings in 2011 were approximately 398,399 kilos of fish (with the majority landed on Santa Cruz island) but we don't have an accurate estimate of the total revenue. Based on the calculations in Utreras et al. (2014), the agriculture and fishing sectors combined declined by 31% from 2005 to 2011. If we assume that this decline is representative of the fishing sector, then this suggests that the current value of the fishing sector is only $1,681,636. Adjusting this number for inflation over this period (3 to 5% per annum) generates a value of $2,007,961 to $2,253,552. This decline in the value of the fishing sector is also reflected in declining landings (Galápagos Report 2011-2012).

More recent but mostly unpublished information is also available. From Galápagos National Park (2013), the total gross income of the lobster fishery in 2013 was $1,235,547. Viteri Mejía and Moreno (2015) estimate that the total gross income in 2014 was $2,028,720 (see Table 9). In terms of finfish (whitefish and tuna), it is difficult to work out current revenues but based on an unpublished document (Viteri Mejía, 2013) exploring a pilot fishery project, the total income is estimated to be around $2.36 million ($3,090 per trip x 756 trips). These numbers are summarized in Table 9, suggesting that the total value of legal fisheries in recent years has ranged between $3.56 and $4.39 million. There is very little recent information on the sea cucumber fishery since this fishery has been in moratorium since 2011. Hence, we do not include it in our analysis.

Taken together, these various reports suggest that the current value of fisheries is approximately $4.39 million. However, it should be pointed out that other local experts with detailed knowledge of these fisheries believe the total value excluding sea cucumber could be closer to $7.2 million (P Salinas de León, *pers. comm.*). In the absence of more extensive and reliable detail, we assume that the current economic value of legal fisheries is $4.39 million.

Thus, the *maximum* economic loss associated with no-take reserves in the Galápagos is under $5 million. This would be the case if 100% of the waters in the Galápagos EEZ were turned into no-take reserves. Contrast this value with our estimate for the value of marine-based tourism ($154 million), which relies heavily on a relatively pristine, healthy, and functioning marine environment. Clearly, protecting nature instead of removing it can generate much greater income for the Galápagos

TABLE 9.

Estimated Total Fisheries Value

	2013	2014
Lobster	$1.2 Million	$2.03 Million
Finfish*	$2.36 Million	$2.36 Million
Total fisheries	$3.56 Million	$4.39 Million

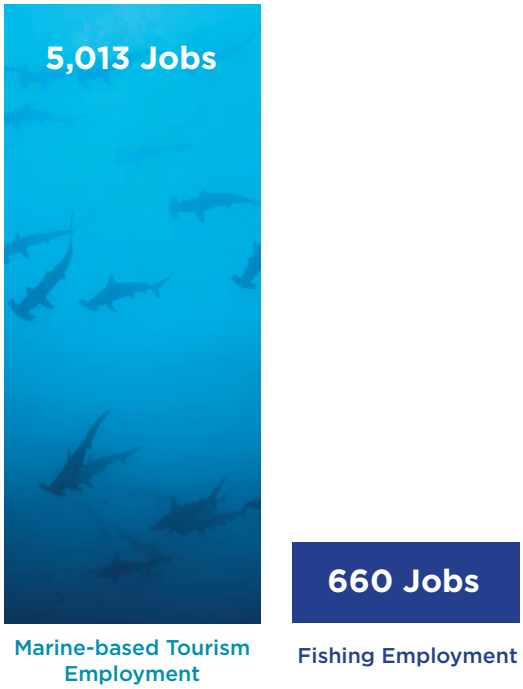
* Finfish value for 2014 is not available so we used 2013.

FIGURE 5.

Annual Value of Marine-based Tourism vs. Value of Fishing

FIGURE 6.

Annual Marine-based Tourism Employment vs. Fishing Employment



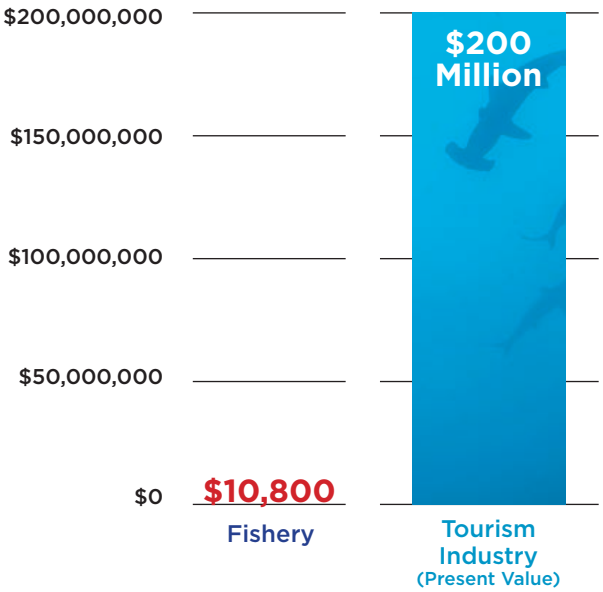
Islands (Figure 5). Furthermore, our lower bound for the economic benefits of no-take reserves for tourism is $14 million and the upper bound is $90 million. Thus, the tourism benefits outweigh the fishing losses, even under the hypothetical scenario of full closure to fishing. In the case of 10-20% of the Galápagos Marine Reserve designated as no-take areas, the losses to fishing would be considerably lower. The losses would be even lower when the indirect benefit of tourism spending on fishing revenues is considered (greater tourist spending means more demand and higher prices for locally caught fish).

Fishing also generates employment in the Galápagos Islands. It may be of interest to policymakers to compare the number of jobs generated by commercial fishing with those generated by marine-based tourism. As stated earlier, the most recent estimate of employment in the fishing sector suggests that 400 people are actively involved in commercial fishing (Galápagos Report 2011-2012). We categorize these jobs as direct employment attributable to the fishing sector. There are also jobs indirectly generated by the fishing sector such as fish buying and selling (especially on Santa Cruz island), fish preparation, seafood restaurants etc. We employ two approaches to estimate total jobs generated by fishing. The first is to multiply the direct jobs by the economic multiplier in Taylor et al. (2014). This produces an estimate of 613 jobs (400 x 1.532). The second approach is to approach total employment to fishing based on estimates of the percentage of the workforce employed in fishing related work. There is only one estimate we could obtain: Jones (2013) claims that less than 5% of all employment in the Galápagos is in fishing. Based on our previous estimates of the total number of jobs in the Galápagos, this would imply fishing sector employment between 662 and 705 jobs. Taking an average of all three estimates suggests that an upper bound for the total number of jobs generated by fishing in the Galápagos is 660. Again, this total employment is dwarfed by the total employment generated by marine-based tourism (5,019 jobs). As the following figure clearly illustrates, almost eight times as many jobs in the Galápagos rely on marine-based tourism compared to commercial fishing.

ECONOMIC VALUATION OF **SHARKED-BASED TOURISM IN THE GALAPAGOS**

FIGURE 5.

Estimated Value of
100 Sharks in Palau (Annually?)



Source: Vianna et al. (2012).

Background

What is the value to the Galápagos Islands of a shark in the water versus its fins in a store? This comparison has been calculated in other parts of the world and the difference has tended to be quite stark. The value of a shark in the water as a tourist attraction is typically much higher than its value as a commodity in a restaurant. The difference tends to be even greater once you consider that a shark can be viewed by tourists day after day, year after year, whereas the payoff from finning a shark is a one-time payment. See for example, Figure 7, which is based on Vianna et al. (2012): the present value to the tourism industry in Palau of a population of 100 sharks is estimated to be $200 million whereas the market value if the sharks were killed and sold is $10,800.

Methodology and Literature Review

All of the existing studies in the literature on the value of sharks for tourism tend to use a very similar approach: divide the total spending on shark diving by the average number of sharks seen per trip. For example, the approach of Vianna et al. (2012) is to multiply total spending by all divers by the percentage of shark divers. This is then compared to the value of harvesting all of the sharks that are regularly seen by shark divers. In an earlier unpublished version of this paper (Vianna et al., 2010), they estimate an annual value per shark of $179,000 and a lifetime value of $1.9 million. How is the lifetime value calculated? Divers typically come to see grey and white tip sharks in Palau, which have an average life span of 16 years. Assuming a discount rate of 5% and a time horizon of 16 years, an annual payment of $179,000 produces a lifetime or net present shark value of approximately $1.9 million.

One of the most relevant studies for this report is Peñaherrera et al. (2013), which is currently the only shark valuation study that has been conducted in the Galápagos. It is important to note that this study just focused on Santa Cruz Island, which is not the primary shark diving destination. The approach of Peñaherrera et al. (2013) was to estimate the Annual Gross Income of each dive agency, work out the percentage associated with shark diving (this is based on the perceptions of guides regarding the percentage

of passengers that demonstrated that their primary interest was diving with sharks), and then estimate the income per shark seen using the frequency of shark observations per week and the average number of sharks seen per trip. It was estimated that each shark (independent of species) may directly generate approximately $34,000 per year from single-day dive tours. Excluding whale sharks (which are very seldom seen near Santa Cruz), the average lifespan of sharks seen in the Galápagos Islands is 23 years (see Table 12). Assuming a discount rate of 5% and a time horizon of 23 years, this implies an average lifetime value of $492,611.

Friedlander et al. (2012) adopt a similar approach for a study of hammerhead sharks in Cocos Island, Costa Rica. They calculated total spending on dive tourism and then multiplied this by the percentage of trips that go specifically to observe sharks. This number was then divided by the average number of sharks seen per trip. They calculate that the average shark generates over $82,000 of spending every year and that each shark generates $1.6 million over its lifetime (assuming no discounting but assuming that each shark spends 20 of its 35 years at the island). Anderson and Ahmed (1993) estimate the annual value of a grey reef shark in the Maldives to be $33,500. In Western Australia, the average annual value of a whale shark is estimated by Norman and Catlin (2007) to be approximately $8,779 and the lifetime value to be $210,725. Clua et al. (2011) examine lemon sharks in French Polynesia and come up with an annual value ranging from $138,573 to $316,699, and a total lifetime value of $2.6 million. An attempt to establish the individual worth of a live whale shark to tourism was made by Graham (2004) for whale sharks in Belize. Her calculation resulted in an annual value of $34,906 and a lifetime value of $2,094,340 per shark. Although a wide range of estimates have been produced for the tourism value of a shark, the methodology used has remained consistent across most studies. We plan to follow the literature and will calculate the average spending per shark sighting as follows:

$$\text{Average Spending per Shark Sighting} = \frac{\text{Total spending on shark dive tourism in region X} \times \text{\% of sharks observed in region X that are Species Y}}{\text{Average number of species Y observed in region X per dive trip}}$$

Data

The majority of shark diving in the Galápagos takes place in the far north, at Darwin and Wolf islands. Table 10 summarizes the relative shark abundances in different regions of the Galápagos. It can be clearly seen that hammerhead sharks are very abundant in the Far North (Darwin and Wolf). This is one of the primary attractions for dive trips to these islands: to view large numbers of hammerhead sharks. Viewing hammerheads at Darwin is often rated as one of the best diving experiences in the world. This is also the only area where whale sharks are regularly observed at certain times of the year and many divers come simply to see whale sharks and nothing else.

We collected published itineraries and prices for the main shark diving tour operators and used this to estimate total revenues by operator and by region. Table 6 previously summarized the main operators, their capacity, itineraries, and prices. We estimate that total annual revenue in 2014 in the purely diving sector was $17,581,000. This estimate is very much in line with Epler (2007). In Table 11, we use published itineraries of where shark diving vessels go to separate out these revenues in terms of the different diving regions (Far North, West, and Central). Far North refers to Darwin and Wolf and we allocate $11 million of the almost $18 million spent on shark diving to this region. In other words, 63% of shark diving revenues is generated by the uninhabited islands of Darwin and Wolf.

Average Spending Per Shark Sighting

We now know how much divers spend to go to different regions and the abundance of different shark species in these areas, so we can apportion the revenue in each region in terms of the frequency of observing each species (Table 12). This is a crude measure but generally captures the reason why divers go to certain locations. For example, most divers are spending most of their money to go to the Far North region ($11 million). The reason they go there is to view the relatively large proportion of hammerhead sharks, so the bulk of revenues in the Far North region is apportioned to hammerhead sharks ($10 million). As another example, no revenue in the West and Central regions is attributed to whale sharks since they are hardly ever observed there. It wouldn't make sense to attribute the value of shark diving off Santa Cruz Island to whale sharks. Furthermore, the majority of revenues in the Central region is apportioned to Galápagos and Whitetip sharks.

We now take these total revenues per shark and, following the approach outlined above, we divide the total spending per shark species by the average numbers of sharks of this species seen per dive trip. We sum this spending across all regions to generate the annual value per shark sighting for different species (Table 12). The values range from $83,000 per shark for silvertips to $697,000 for hammerheads. The average annual value of a shark in the Galápagos is $360,105.

TABLE 10.

Relative Shark Abundances per Region by Shark Species

Shark Species	Far North Region (n=483)	West Region (n=31)	Central Region (n=93)	Total
Silvertip Shark	0.008	-	-	0.008
Silky Shark	0.25	-	0.063	0.313
Galápagos Shark	4.042	0.25	12.410	16.702
Black Tip Shark	0.733	-	0.188	17.623
Scalloped Hammerhead Shark	125.7	6.563	2.854	152.74
Whitetip Reef Shark	0.192	-	1.396	1.588
Whale Shark	0.683	-	-	0.683

Notes: Abundances are expressed as individuals observed per hour per diver recorded during underwater surveys conducted from 2007 to 2012.
Source: CDF-UCD-PNG Pelagic Census Database, as referenced by Hearn et al (2014).

TABLE 11.

Revenue per Region by Number of Dives

	Far North Region		West Region		Central Region	
Vessel Name	# Dives	Revenue	# Dives	Revenue	# Dives	Revenue
Galápagos Agressor III	12	$2,071,680.00	4	$690,560.00	4	$690,560.00
Galápagos Sky	12	$2,887,477.89	3	$721,869.47	4	$962,492.63
Humbolt Explorer	13	$2,297,788.24	0	0	4	$707,011.76
Pinguino Explorer	10	$1,204,210.53	3	$361,263.16	6	$722,526.32
Galápagos Master	12	$1,210,560.00	4	$403,520.00	4	$403,520.00
Galápagos Master	18	$780,000.00	6	$260,000.00	6	$260,000.00
Galápagos Master	24	$260,640.00	8	$86,880.00	8	$86,880.00
Nortada Yatch	12	$306,936.00	2	$51,156.00	6	$153,468.00
Total Revenue		$11,019,292.66		$2,575,248.63		$3,986,458.71

Source: Published online itineraries.

TABLE 12.

Revenue per Region by Shark Species

	Far North Region		West Region		Central Region		Total
Shark Species	Abun-dance	Relative Revenue	Abun-dance	Relative Revenue	Abun-dance	Relative Revenue	Total Revenue
Silvertip Shark	0.008	$669.83	0	0	0.000	0	$669.83
Silky Shark	0.25	$20,932.03	0	0	0.063	$14,851.10	$35,783.13
Galápagos Shark	4.042	$338,429.13	0.25	$94,497.60	12.410	$2,925,430	$3,358,357
Black Tip Shark	0.733	$61,372.72	0	0	0.188	$44,317.56	$105,690
Scalloped Hammerhead Shark	125.7	$10,524,626.8	6.563	$2,480,751	2.854	$672,778	$13,678,156
Whitetip Reef Shark	0.192	$16,075.80	0	0	1.396	$329,081	$345,157.25
Whale Shark	0.683	$57,186.32	0	0	0	0	$57,186.32
Totals	131.608	$11,019,292	6.813	$2,575,248	16.911	$3,986,458	$17,581,000

Notes: Abundances are expressed as individuals observed per hour per diver recorded during underwater surveys conducted from 2007 to

We obtained published estimates of the average lifespan of each shark (except for silvertips where we make a conservative guess based on similar species from the same genus), and combine this with an annual discount rate of 5% to calculate the total lifetime value of a shark:

$$\text{Lifetime Value} = \sum_{(t=0)}^{n} \frac{\text{Annual Value}}{(1+0.05)^t}$$

where n is the average lifespan of the shark species. Note that our decision to use a discount rate will bias our estimates down relative to most of the studies in the literature, which do not discount future revenues from shark tourism. Vianna et al. (2012) is the only other study we are aware of that uses a discount rate. The results are in the final column of Table 13. The lifetime values range from $1 for silvertips to $12 million for hammerheads. **The average lifetime value of a shark in Galápagos is $5.4 million**.

These estimated annual and lifetime values deserve some discussion. These values are higher than any others in the literature (see Figures 8 and 9 for comparisons with estimates from other studies). It should be noted that we are using the same methodology as these other studies and we are actually being more conservative by discounting future revenues. These numbers suggest that sharks in the Galápagos Islands generate more revenue than any other existing study on shark diving. In particular, hammerhead sharks in the Galápagos Islands are the most economically valuable sharks on earth. They generate more spending per shark in their lifetime than any other species in the world (Figure 9). One of the primary reasons for why sharks are so valuable in the Galápagos is the large total expenditure on shark diving. Most of the other studies in the literature examined shark diving operations where annual total expenditure was less than $10 million. For example, the closest annual estimate to our own is from Clua et al. (2011) but they evaluated a shark diving industry in French Polynesia with a total annual expenditure of $5.4 million.

The Value of Sharks to the Fishing Industry

Fishing directly for sharks is banned by law in Ecuador. Nevertheless, the landing of "incidental" shark catches with their fins intact is allowed on the mainland. In the Galápagos archipelago, fishing, landing, and trading of sharks is illegal. In 2004 the president signed a decree that banned all exports of shark fins. However, because of the high value of fins ($400-$1000 per kg (WildAid, 2007)), illegal operations and smuggling remained a serious issue. In 2007, the president overturned the ban and currently the export of shark fins from incidental catch is allowed on the mainland.

TABLE 13.

Individual Valuation of Shark Sightings by Species

Shark Species	Annual value per shark	Average lifespan?	Discount rate	Total lifetime value
Silvertip Shark	$83,728.14	19	0.05	$1,095,609.54
Silky Shark	$319,459.83	25	0.05	$4,821,909.01
Galápagos Shark	$697,450.24	24	0.05	$10,321,316.25
Black Tip Shark	$319,459.83	12	0.05	$3,150,912.72
Scalloped Hammerhead Shark	$697,450.24	35	0.05	$12,117,635.95
Whitetip Reef Shark	$319,459.83	25	0.05	$4,821,909.01
Whale Shark	$83,728.14	70	0.05	$1,703,254.42

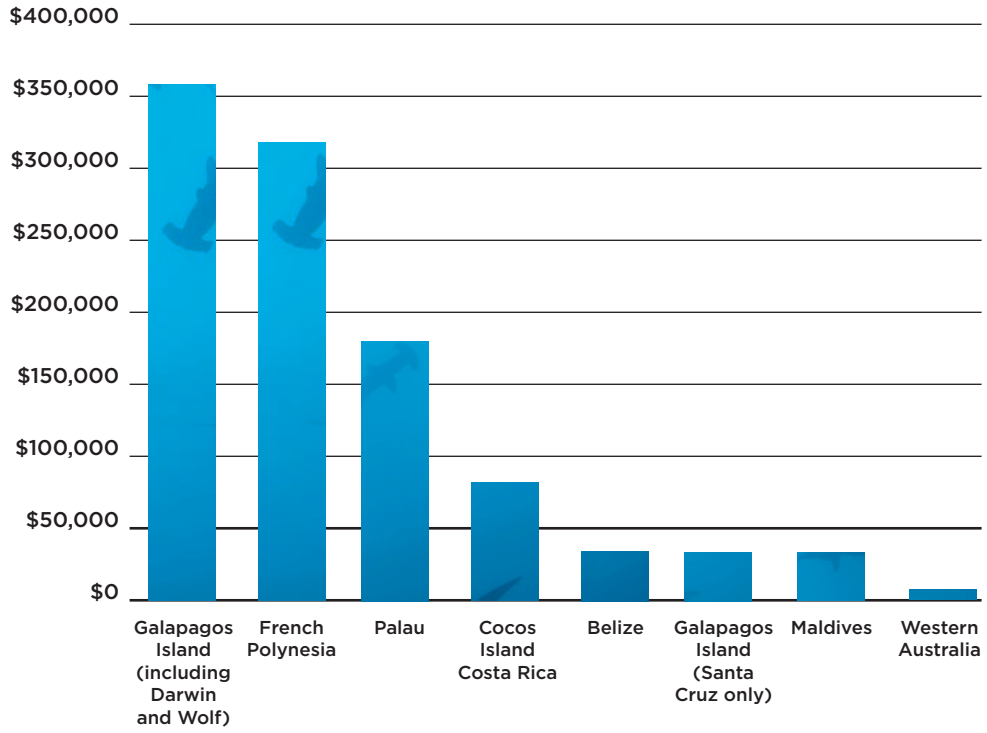


FIGURE 8.

Comparison of Annual Shark Tourism Value by Global Area

Sources: Clua et al. (2011), Vianna et al. (2012), Friedlander et al. (2012), Graham (2004), Peña-herrera et al. (2013), Anderson and Waheed (2001), Norman and Caitlin (2007).

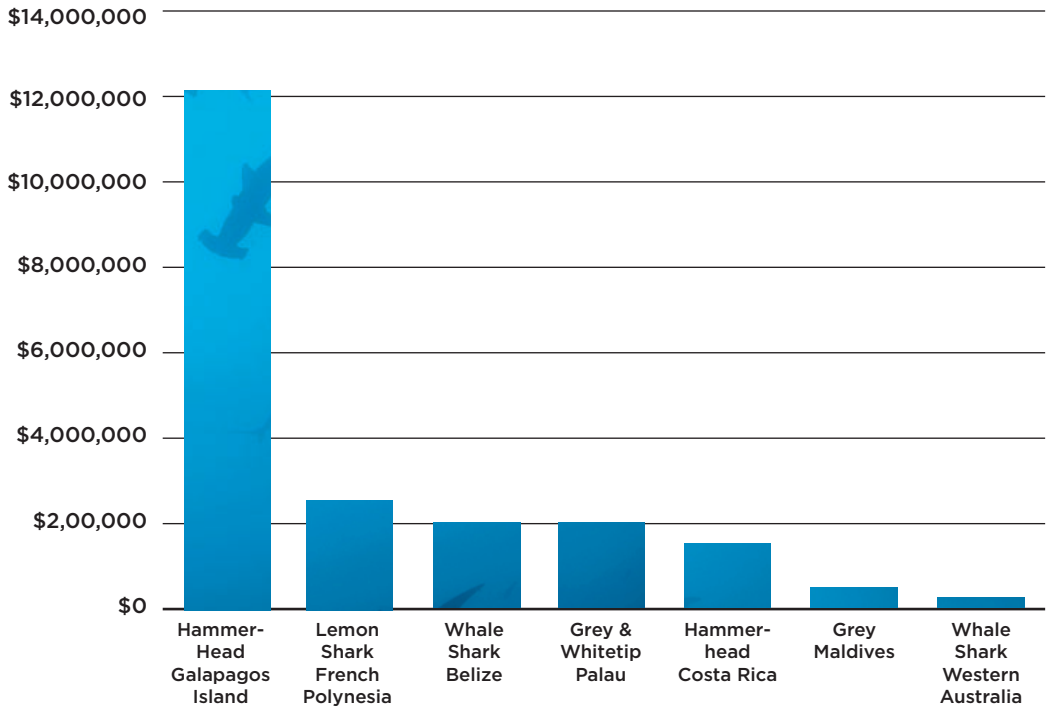


FIGURE 9.

Comparison of Lifetime Tourism Value of a Shark by Species

Sources: Clua et al. (2011), Vianna et al. (2012), Friedlander et al. (2012), Graham (2004), Anderson and Waheed (2001), Norman and Caitlin (2007).

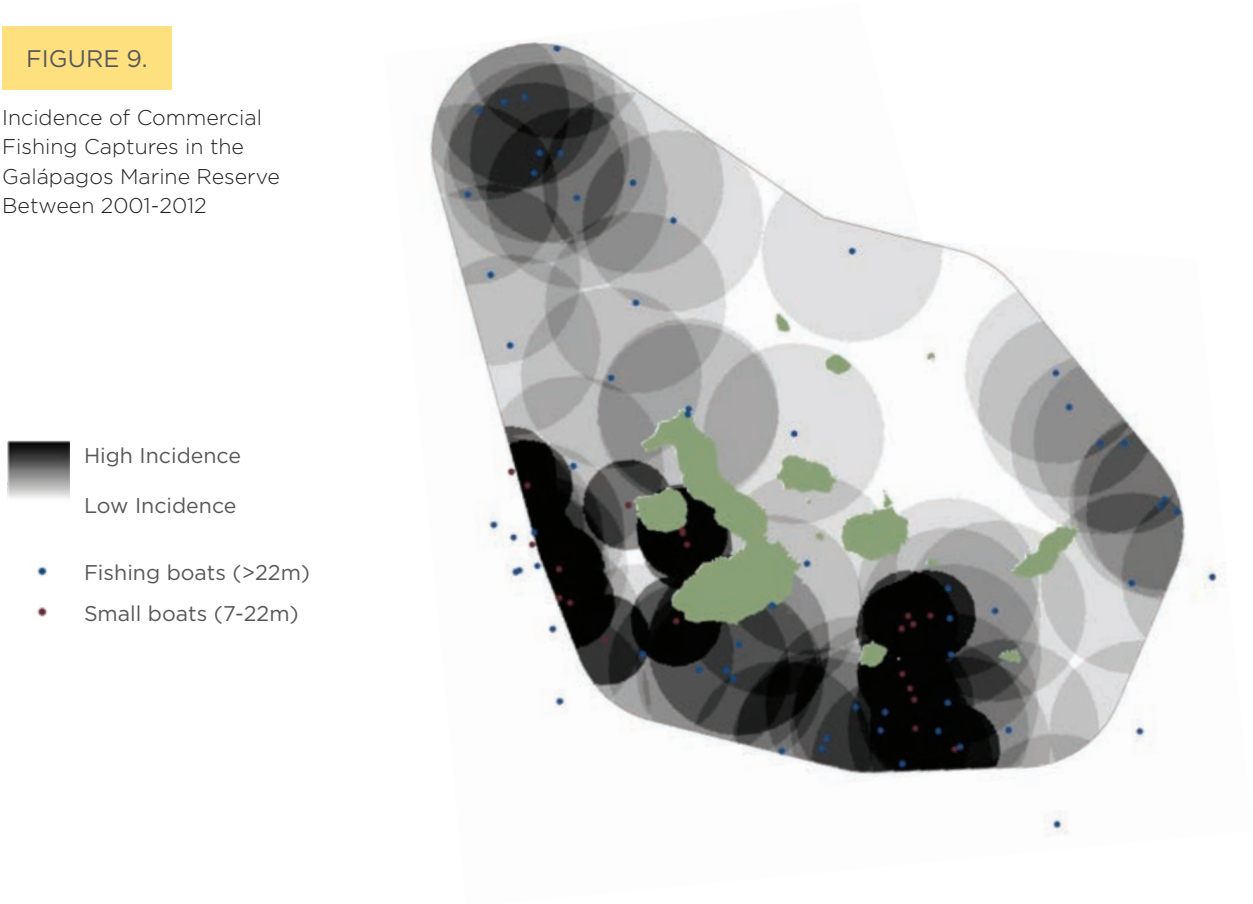
Although industrial fishing is prohibited in the Galápagos Marine Reserve since 1998, there is illegal fishing by large fishing vessels, including in the waters around Darwin and Wolf (Figure 10), which are the most valuable in the archipelago in terms of shark diving revenue. WildAid estimates that, at any given time, there are 1 to 5 vessels fishing illegally in the waters of the reserve, often targeting sharks. This illegal activity, added to fishing by local fishers, jeopardizes the natural resource that provides the largest source of revenue for diving tourism in the Galápagos.

A reconstruction of Ecuador fisheries by Jacquet et al. (2008) estimated shark landings from 1979 to 2004. The main findings are that they estimate landings on the mainland of 7,000 tonnes per year or nearly 500 million sharks (this number is 3.6 times greater than what's reported by FAO). Fin exports exceed mainland catches by 44% or 3,850 tonnes per year. The authors suggest that this difference may come from sharks illegally caught in the Galápagos. WildAid (2007) estimate that 80% of Ecuador's fin exports originate from the Galápagos. Carr et al. (2013) compile all of the illegal shark vessels seized in Galápagos waters from 2001 to 2004 and document the illegal catch onboard one of these vessels: 379 sharks from seven species, including mainly female and juvenile sharks. In another catch reconstruction study, Schiller et al. (2014) estimated that from 1950 to 2010, 105,500 tonnes of sharks have been taken from the Galápagos EEZ by Ecuadorian boats only (this is equivalent to 13% of all fish landings over this period). This was estimated as the difference between shark exports and reconstructed shark landings on the mainland.

Shark fishing is obviously big business in the Galápagos and Ecuador. So what is the market value of a shark caught in the Galápagos? Most of these sharks are sold on the mainland and data on prices

FIGURE 9.

Incidence of Commercial Fishing Captures in the Galápagos Marine Reserve Between 2001-2012



Source: http://www.huffingtonpost.com/ocean-unite/nontraditional-allies-wor_b_7800260.html

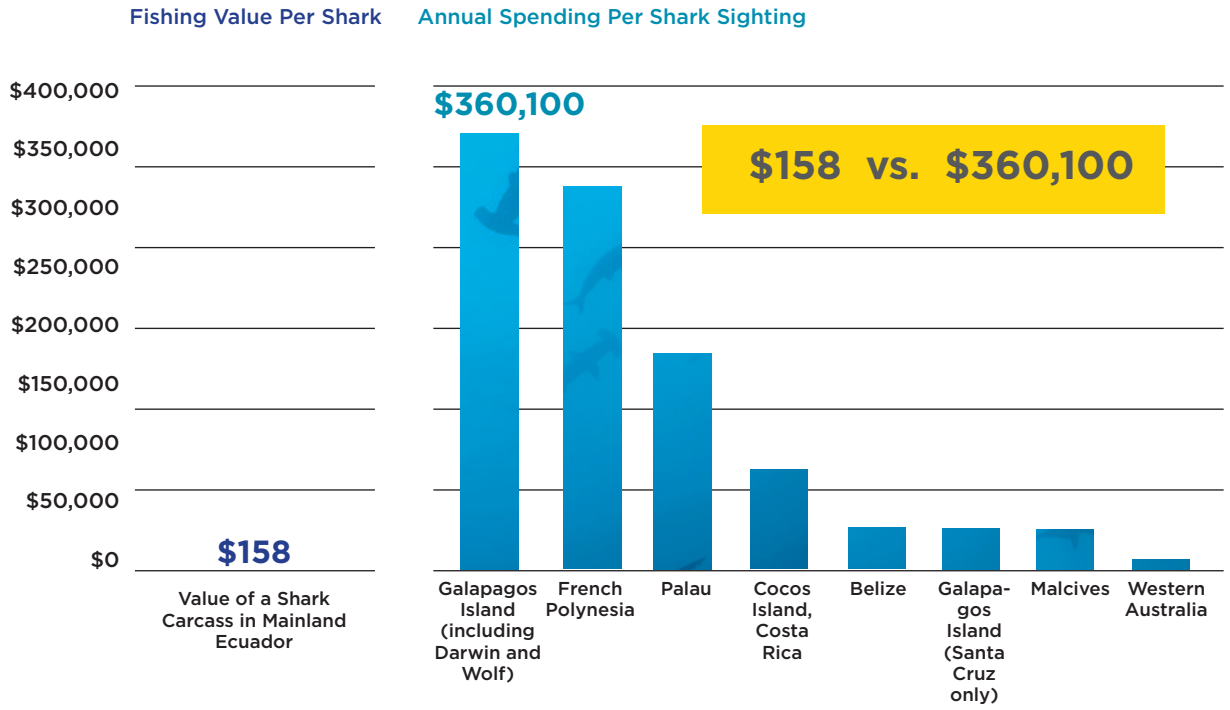
are not easily obtained. Sharks are typically sold as a whole carcass and prices range from $0.65 to $0.75 per pound (O. Rosero, *pers. comm*). If fins are large enough (15cm at the base), fishermen additionally receive between $3 to $8 as a bonus payment. Fins will often pass between 2 and 3 middlemen before they reach a final buyer at a much higher price. Sharks typically have a weight between 140 to 200 pounds (O. Rosero, pers. comm) so the value of a shark lies somewhere between $91 to $158. This roughly compares to estimates from other parts of the world: $108 in Palau (Vianna et al., 2012) and $195 in Costa Rica (Friedlander et al., 2012). Clearly, the tourism value of a shark far exceeds the value of its meat and fins (Figure 11). The economy of Ecuador is much better served with more sharks in the water.

Marginal vs. Average Value of a Shark

A standard criticism of the approach we have taken in this report to calculate the value of a shark is that this represents the average value and not the marginal value of a shark. This is certainly true. We do not expect that if one hammerhead shark in the Galápagos is killed tomorrow that this will decrease tourist spending this year by $697,000. A more accurate interpretation of our estimates is that they capture the marginal value of losing all sharks in the Galápagos Islands. Certainly if all of the hammerheads at Darwin and Wolf were harvested this would impose a massive loss on the shark diving industry on the order of many millions of dollars. This loss would far exceed the marginal benefit of selling these sharks on the mainland or to Asia. An interesting discussion of the pros and cons of using average and marginal values to value animals for tourism purposes is contained in Catlin et al. (2013) and

FIGURE 9.

Fishing Value of a Shark vs. Annual Spending per Shark Sighting



Vianna et al. (2013). A similar argument to our own is made by Vianna et al. (2013, p. 301):

"Questions such as "should a shark sanctuary be created?" are not about marginal changes in the shark population, but about large changes – potentially from none or almost none to a large population. In such cases, it is theoretically sound to compare the average value of sharks for tourism with the average value of sharks for fishing. Indeed, the comparison is simply a scaled down version of comparing the value of a whole shark population for tourism with its value for fishing."

However, it would be useful for accurate cost-benefit analysis to know the marginal value of a shark in the Galápagos. We now propose a potential solution to this issue. Suppose demand for sharks is given by $P = a - bX$ where P is marginal value, X is the quantity of interest (shark population), and a and b are fixed parameters. Let the "choke quantity" be given by the parameter L, so $b = a \div L$. And let X be denoted as a fraction of L (for example, if $X = L \div 2$ then the relevant quantity is half the choke quantity size).

Definition 1. *The* Reduction Ratio, *denoted RR, is the percentage decrease in average value that equals the marginal value.*

Then we have the first result:

Proposition 1.

$$RR = \frac{X}{(2L-X)}$$

Which leads to our first lemma:

Lemma 1.

$$\frac{dRR}{dX} > 0$$

In other words, the reduction ratio is increasing in X — the larger is X the larger is the percentage wedge between average and marginal value.

Now, suppose the shark population is at most half what it would have to be to drive all demand to zero, so $X \leq L \div 2$. Then, by Lemma 1, and invoking Proposition 1, we find that the reduction ratio is:

$$\mathbf{RR < 1 \div 3}$$

In other words, as long as you believe that the shark population is at most half of the choke quantity, then it follows that, to convert an average value to a marginal value requires reducing the average value by, at most, 33%. This would imply that our estimate for the annual value of $360,105 for the average shark should be adjusted to $237,669. And the estimate for the lifetime value of the average shark in the Galápagos should be re-scaled from $5.4 million to $3.6 million. Both of these numbers far exceed the maximum marginal value of harvesting a shark: $158.

CONCLUSION

The Galápagos Islands are one the world's top destinations for nature tourism, and an important economic engine for Ecuador. If spending on flights and mainland tourism trips is included, Galápagos tourism accounts for 55% of all tourism revenue in Ecuador (Epler, 2007). A significant proportion of the visitor experience in the Galápagos in terms of time, spending, and enjoyment) is actually marine-based. We used tour itineraries, exit surveys, academic articles, government documents and NGO reports to calculate how much of the tourist experience in the Galápagos depends on marine-based activities. By separating tourists into three groups (land-based "stay-overs", tourists on live-aboard vessels that do land and marine activities, and tourists on purely diving live-aboard vessels), we calculated how much of the tourist experience is marine-based. We then allocated within-island spending based on these proportions to calculate the value of marine-based tourism in the Galápagos islands. Of the $265 million spent by tourists within the Galápagos in 2014, we estimate that 58% ($154 million) is directly dependent on marine-based tours, activities and experiences. This suggests that the majority of tourism value in the Galápagos is dependent on the marine environment. We estimate that 5,019 jobs in the Galápagos depend on marine-based tourism. In other words, 1 out of every 3 jobs in the islands.

Based on tourist surveys within the Galápagos and findings in other parts of the world, we estimate that creating a large network of no-take areas within the Galápagos islands could increase annual spending by tourists between $14 and $90 million, without increasing the number of tourists. This is because tourists are willing to pay more for an enhanced marine environment and less congestion at popular snorkeling and diving spots. Fishing may be impacted by the creation of no-take areas but since the maximum value of legal fisheries in the Galápagos is in the range of $4 million, it should be possible to find a win-win solution that benefits all stakeholders. There are obviously very important distributional and equity concerns that would need to be addressed with the designation of new no-take areas.

Many tourists come to the Galápagos for the sole purpose of viewing sharks. This is one of the primary reasons for tours to Darwin and Wolf islands. Using published information on shark diving tours, their prices, itineraries, and capacities, we estimated how much tourists currently spend on shark-diving tourism in the Galápagos. We find that the majority of shark diving expenditure relies on the two uninhabited islands of Darwin and Wolf. We combined information on tourist spending with data on the frequency of viewing different shark species at different locations to calculate the average spending generated per shark sighting. This is a popular approach in the literature and has produced estimates for the annual value of a shark ranging from $8,779 to $316,699. We found that sharks are more valuable in the Galápagos than anywhere else on earth. The average value of a shark to the tourism industry in the Galápagos is $360,105. Since sharks can live for quite some time, they continue to provide value year after year. We estimate that the average lifetime spending generated by a shark in the

Galápagos is $5.4 million. This is, again, larger than any other estimate from other parts of the world. This strongly suggests that sharks in the Galápagos (particularly hammerhead sharks) are the most economically valuable sharks on earth. This value far exceeds the maximum value a shark can fetch when sold on the mainland for its meat and fins ($158).

A number of caveats to our main findings are worth mentioning. The biggest limitation in terms of our estimate of marine-based tourism is that we don't have detailed and reliable information on how stay-over tourists spend their time and what provides them with the most enjoyment. We have assumed 45% of their experience in the Galápagos is marine-based but this may not be accurate. However, given that stay-over spending is such a small percentage of total spending, this assumption is not pivotal. For example, if we assume that 0% of the stay-over experience is marine-based then our total expenditure estimate only drops from $154 million to $135 million. A second caveat is that our projection of future spending if large no-take areas are created is inherently uncertain. We cannot predict the future, but it is certainly the case that tourists are willing to pay more for a pristine marine environment with less congestion. Combining this with documented increases in spending in other parts of the world gives us confidence that no-take reserves will increase spending but the exact magnitude of this change is impossible to predict.

In terms of the average value per shark sighting, the methodology we use will tend to undervalue sharks that are very abundant since total expenditure will be divided by a larger number. In a slight departure from the previous literature we have attempted to mitigate this concern by apportioning revenues to each species based on their relative abundance in a particular region. For example, hammerheads are apportioned the majority of the expenditures for the Darwin and Wolf areas whereas Galápagos and Whitetip sharks get most of the spending for the Central Galápagos region. An additional caveat to the interpretation of our estimate of the value of a shark is that this value is the average spending per shark sighting and not the marginal value of an additional shark to the tourism industry. We have proposed a sensible re-scaling to derive the marginal value to the local economy and it does not change our overall conclusion.

Despite these caveats, our results strongly indicate that the benefits of creating large no-take areas in the Galápagos Marine Reserve far outweigh the costs. In particular, full protection of the waters around Darwin and Wolf are necessary (but not sufficient) to preserve the largest source of economic benefits for the Galápagos economy. In terms of funding the management and enforcement of new no-take areas, a special fee for visitors to Darwin and Wolf islands certainly appears to be a viable option worthy of further discussion.

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APPENDIX

Marine-based Tourism for Live-aboard Vessels (A,B,C)

Navigable A

Total Excursions	1696
Total Marine-based Execursions	944
% of Marine-based Execursions	56%
Total Annual Revenues for Vessels Navigable A*	$213,162,372.50
Total Annual Revenues for Vessels Navigable A* Marine-based Activities	$119,370,928.60

* These values are based on the lowest fare of the shortest itinerary for each vessel.

Sources: Internet-based searches

Number of Vessels	39
Total Sample Size (Itineraries}	85

Navigable B

Total Excursions	38
Total Marine-based Execursions	16
% of Marine-based Execursions	42%
Total Annual Revenues for Vessels Navigable B*	$4,591,700.00
Total Annual Revenues for Vessels Navigable B* From Marine-based Activities	$2,571,352.00

* These values are based on the lowest fare of the shortest itinerary for each vessel.

Sources: Internet-based searches

Number of Vessels	2
Total Sample Size (Itineraries}	2

Navigable 3

Total Excursions	49
Total Marine-based Execursions	40
% of Marine-based Execursions	82%
Total Annual Revenues for Vessels Navigable B*	$1,092,262.50
Total Annual Revenues for Vessels Navigable B* From Marine-based Activities	$611,667.00

* These values are based on the lowest fare of the shortest itinerary for each vessel.

Sources: Internet-based searches

Number of Vessels	1
Total Sample Size (Itineraries}	2

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