Economic Valuation of Curaçao's Marine Resources

June 2016

Executive Summary

- Curaçao's marine resources contribute substantially to the island's economy.
- Marine tourism contributes $373.5 million to Curaçao's economy annually. Hotel expenditures by tourists who visit beaches or participate in marine recreation activities comprise 91% of this value, while the rest stems from spending directly related to snorkeling, diving, and sport fishing. Caribbean-wide, dive tourists spend more money than the average tourist, heightening the economic importance of this sector.
- Cruise ship tourism contributes $57.5 million to the economy each year. Yacht tourism is another area for future growth, with the potential to add further value to the economy.

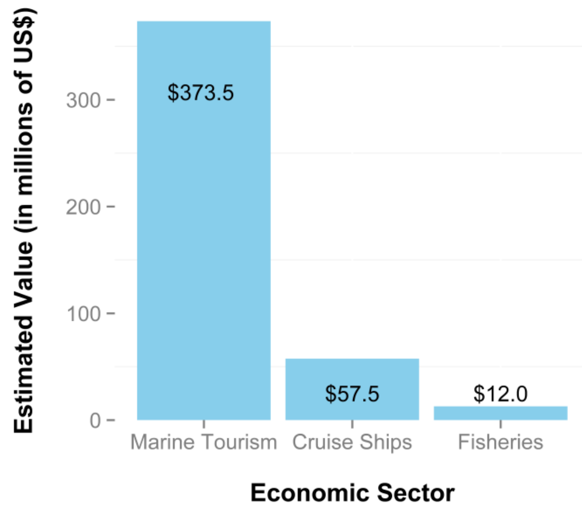

Figure 1. Estimated values of economic sectors relying on marine and coastal resources, including marine tourism and associated expenditures in the hotel sector; cruise tourism; and fisheries.

- Curaçao's fishing industry adds an additional $12 million to the economy each year. Local for-sale fisheries account for 85% of the total value, with the remaining value from subsistence fishing (7%), local recreational fishing (4%), and processing and cleaning (4%).
- Healthy marine and coastal ecosystems provide direct and indirect economic benefits such as shoreline protection and improved nearshore water quality. Curaçao's coral reefs generate about $57,500/hectare in direct and indirect value each year, while mangroves and seagrass beds generate $30,600/ha/yr and $35,500/ha/yr, respectively.

Habitat	Direct Value ($/ha/year)	Indirect Value ($/ha/year)	Total Value ($/ha/year)
Coral Reefs	$28,300	$29,200	$57,500
Mangroves	$500	$30,100	$30,600
Seagrasses	$6,200	$29,300	$35,500

Table 1. Estimated values of three coastal marine habitats in Curaçao. Direct values refer to values captured in the formal economy; indirect values are those that support human and economic health but are not formally reflected in the

- Some terrestrial and marine industries pose threats to marine resource health. Without appropriate resource management, environmental degradation may lead to economic losses.
- Comprehensive ocean zoning is a tool for reconciling the different uses of Curaçao's coastal and marine resources, promoting economic growth while preserving ecological health. Ocean zoning will help Curaçao "use the ocean without using it up."

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Introduction

Relative to other Caribbean islands, Curaçao has a robust and diversified economy. Curaçao's largest economic sectors include tourism, financial services, manufacturing, shipping and international trade, and oil refining (CBS 2014a; CAIPA 2015). In 2013, Curaçao had a per capita GDP of $19,830[1] (UNSD 2016), with relatively slow economic growth since the 2008 global recession (IMF 2014; Palm 2014; CBS 2015a; CBS 2015b).

As a small island state, many of Curaçao's economic sectors rely directly or indirectly on marine and coastal resources. Healthy marine and coastal ecosystems provide multiple benefits to Curaçao's economy, including directly supporting the marine tourism and fisheries sectors, as well as generating other values that are less directly monetized. For example, the coastal construction sector has some dependence on coastal and marine ecosystem health, as these ecosystems reduce shoreline erosion.

In this report, we use methods developed by the World Resources Institute (WRI) to estimate the net economic benefits of fisheries and marine-related tourism, representing two major sources of economic value derived from Curaçao's marine ecosystems. WRI developed a suite of tools to guide the economic valuation of fisheries and marine tourism and recreation in the Caribbean region. We also provide estimates of the annual economic values per unit area of coral reefs, mangroves, and seagrass habitats,

[1] All monetary values are reported in US dollars.

combining the values of multiple ecosystem goods and services. In light of the significant economic value generated by healthy marine resources, comprehensive ocean zoning is an important tool to reconcile the different uses of Curaçao's marine and coastal resources and ensure their continued health, thus protecting the foundation of Curaçao's economy.

Value of Curaçao's Fisheries

Although fishing accounts for less than 1% of Curaçao's GDP, it is a socially and culturally important activity that provides income and protein to a portion of the population (LVV 2003). All fishing that takes place in Curaçao's waters is artisanal (Dilrosun 2002). Five large purse seining vessels targeting primarily skipjack tuna (*Katsuwonus pelamis*) are registered under Curaçao's flag, but these are Spanish vessels fishing exclusively in international waters (ICCAT 2016) and are thus excluded from our valuations. Total annual landings in Curaçao's artisanal fishery are estimated to be 200 t (Dilrosun 2002; LVV 2003). Pelagic species account for the majority of the catch (about 80%), with the remainder composed of demersal and reef species (Dilrosun 2002). There are approximately 15 full-time and 229 part-time fishers utilizing 98 boats at 26 landings sites across the island. Most of Curaçao's artisanal fishers sell some of their catch at local markets and retain a portion for home consumption (Johnson 2011).

The WRI Fisheries Valuation Tool estimates the economic value of the fisheries sector and was developed specifically for application to the Caribbean. We used it to calculate the value of four fishery components: local fishing for sale, fish cleaning and processing, fishing for personal consumption, and local fishing for enjoyment. We used landings reported to the FAO, data from short-term fisheries monitoring projects, and information collected through fisher interviews to estimate the economic value of Curaçao's fisheries. Appendix A provides a detailed description of our methods and the parameters we used to estimate the value of Curaçao's fisheries sector.

We estimated that the total economic value of the fisheries sector in Curaçao is $12 million[2]. Figure 2 presents a breakdown of the value by fisheries subsector. The local fishing for sale subsector contributed about 85% ($10.25 million) of the total fisheries value. Of this $10.25 million, 19% of the value came from landings reported to the FAO, while unreported landings constituted 81% of the value. Fishing for personal consumption accounted for 7% ($910,000) of the total fisheries value, while fishing for enjoyment contributed 4% ($480,000), and fish processing, cleaning, sales, and distribution accounted for the remaining 4% ($460,000).

[2] All estimates of the value of fisheries, tourism, and ecosystem goods and services are adjusted for inflation to 2015 US$.

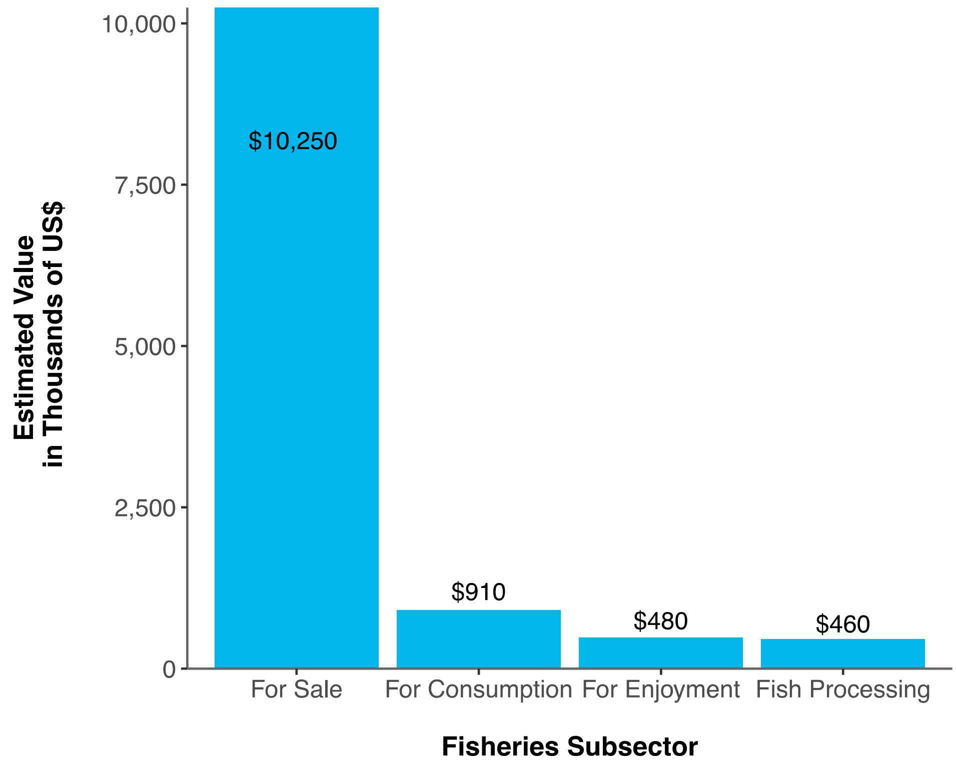

Figure 2. Estimated values of Curaçao's fisheries subsectors.

Value of Marine Tourism and Recreation

Tourism is a vital sector in Curaçao, representing over 18% of the economy and directly or indirectly sustaining 23% of jobs (Croes *et al.* 2015). Despite slow growth in the overall economy, the tourism sector has grown at an average annual rate of 8.7% since 2000. In 2014, Curaçao welcomed more than 450,000 stay-over tourists and approximately 600,000 cruise ship tourists aboard 300 cruise ships (CBS 2014b; 2015c). In support of tourism's important role in Curaçao's economic development, the construction industry represents 5% of GDP and much of the new development occurs along the coast, which is protected from wave action and storm surges by mangroves and fringing coral reefs.

We used the WRI Tourism and Recreation Valuation Tool to estimate the value of accommodation and marine recreation expenditures by tourists who participate in marine activities such as diving, snorkeling, and visiting beaches, as well as the secondary economic value of these tourists' expenditures on accommodation, reflecting how marine-associated accommodation spending ripples through the economy. We used data from the Curaçao Tourist Board (CTB), the Central Bureau of Statistics Curaçao (CBS), and an original survey administered to dive and snorkel operators (n = 6) to produce our estimates. See Appendix B for a detailed description of the methods and data used in the estimation and Appendix C for the dive and snorkel operator survey. Because cruise tourism is less dependent on the health of the marine environment, we estimated total cruise industry expenditures separately and did not include them in our calculation of the total value of marine recreation and tourism[3]. We lacked data to estimate expenditures by yacht tourists, and their participation in diving, snorkeling, and sport fishing likely adds further value to Curaçao's economy not captured in our estimates. Finally, we did not have sufficient data to calculate the economic value of local residents' marine recreation: this value, while largely uncaptured by formal markets, is likely to be significant, as the majority of residents surveyed in the Blue Halo Initiative's 2016 Listening Tour reported visiting beaches or snorkeling at least once a month. Appendix B describes methods that could be used to estimate the value of local recreation.

Overall, we estimate the total economic value of marine-associated tourism to be approximately $373.5 million**,** composed of $208.9 million in direct expenditures (on diving, snorkeling, sport fishing, and accommodation), and $164.6 million in secondary value generated by accommodation expenditures[4] (Figure 3). Marine-associated tourism (excluding cruise tourism) represented about 38% of the total economic value of tourism in 2014. Stay-over tourists contribute to this total through expenditures related to accommodation ($173.8 million), the secondary value of spending on accommodation ($164.6

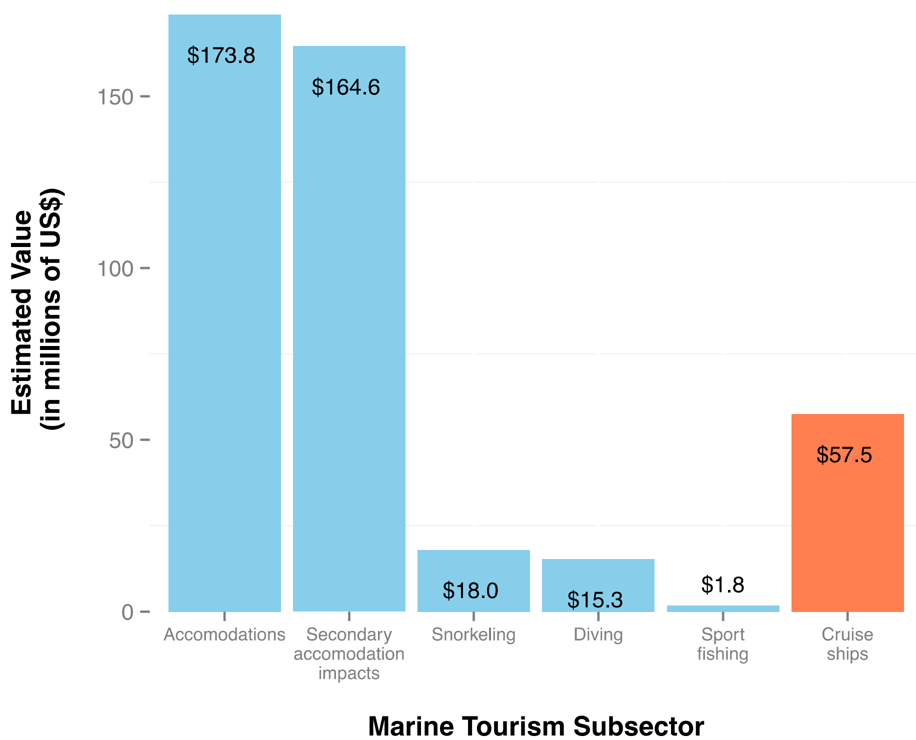

Figure 3. Estimated value of marine-associated tourism in Curaçao.

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[3] Our calculation of the value of tourism excludes tourism value that leaves the island's economy immediately by excluding the revenue of foreign-owned hotels and cruise ship companies.

[4] This secondary value represents the impact that tourists' spending on accommodation has on the entire local economy, reflecting how these expenditures reverberate beyond the original transaction. For example, hotels spend money in the local economy on supplies, and hotel employees use their wages to purchase goods and services (Croes *et al*. 2011).

million), and marine recreation activities such as diving ($15.3 million), snorkeling ($18 million), and sport fishing ($1.8 million). Because dive tourists in particular spend more money than the average tourist in the Caribbean, it is possible that stay-over tourists who participate in marine recreation while in Curaçao contribute further value that was not captured in our estimates: our estimates only included direct expenditures on diving (*e.g.*, the cost of renting dive equipment), but if dive tourists spend more money in the local economy than the average stay-over tourist (on goods and services such as souvenirs and meals that are not directly related to marine tourism), then the presence of attractive dive sites may drive additional spending in the local economy (Burke & Maidens 2004). The most popular dive sites indicated by participants in our survey were Tugboat, Marie Pampoen, Porto Marie, Mushroom Forest, and the Superior Producer.

Expenditures from the cruise sector contributed a total of $57.5 million to the economy in 2014 (Figure 3), of which 71% came from onshore expenditures by passengers who disembarked in Curaçao. The remainder of this value is attributed to onshore expenditures by crew members and expenditures by cruise lines on local supplies, services, port fees, and taxes. The expenditures from passengers and crew members include all onshore expenditures, such as food, souvenirs, and tourist activities: these expenditures are more comprehensive than the values we estimated for marine-associated stay-over tourists, which were restricted to those directly related to marine recreation and associated accommodation.

We did not directly attribute the value of cruise tourism expenditures to the health and quality of Curaçao's marine resources, since many cruise ship passengers do not make use of coral reefs or other marine and coastal ecosystems during their visits. Nevertheless, Curaçao's natural beauty no doubt plays a role in attracting cruises, as cruise ship passengers expect a high level of environmental quality in their destinations (Baker 2014). Furthermore, without appropriate management, Curaçao's continued growth as a cruise ship destination may impact the health of its marine resources, which in turn may affect its popularity as a destination for both cruise and non-cruise tourists (Herz & Davis 2002; Dinica 2012).

Habitat Valuations

Curaçao's coral reefs, mangroves, and seagrasses generate considerable value, underpinning large portions of the island's economy and providing a range of different benefits, including both consumptive and non-consumptive use values, as well as non-use values (Figure 4). Consumptive use values and direct non-consumptive use values (hereafter referred to as "direct values"), such as fisheries harvest and tourism revenues, are more easily monetized and captured by formal markets, while indirect non-consumptive use values ("indirect values") benefit human society in a manner that is less readily captured by formal markets. Indirect values include ecosystem services such as flood control and nutrient cycling, as well as habitat support functions such as the role that mangroves play in providing nursery habitat for many reef fish species.

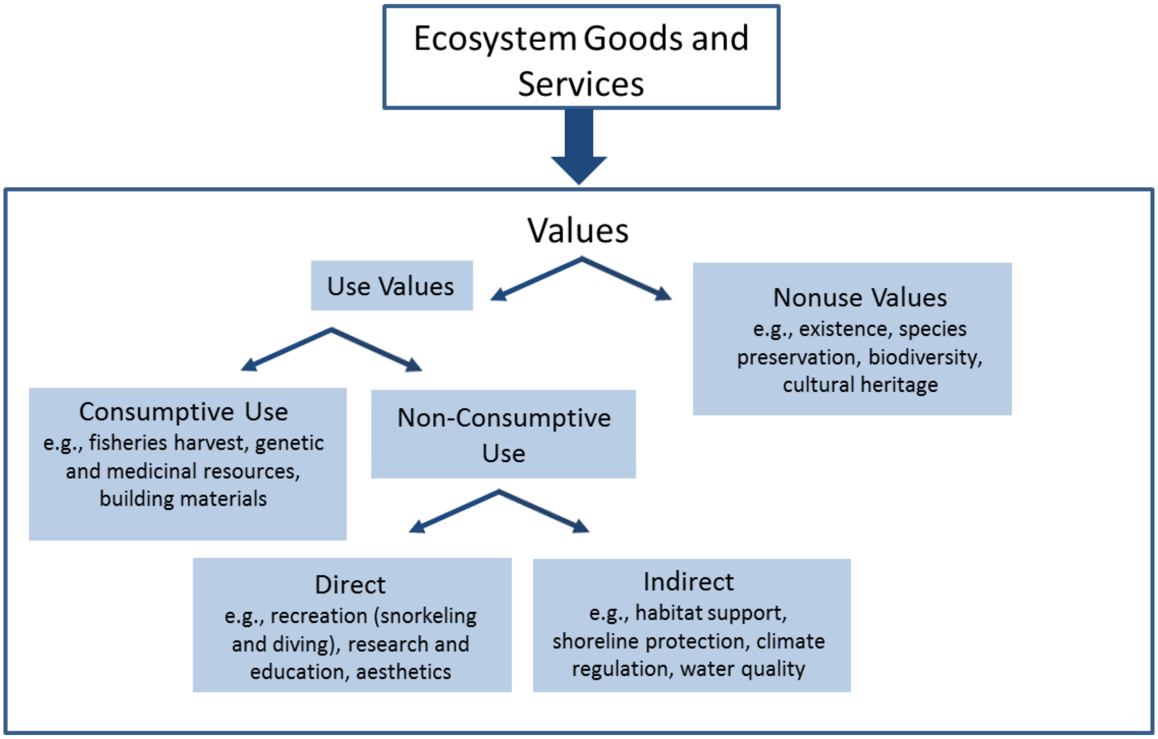

Figure 4. The relationship between ecosystem goods and services and economic values. Adapted from Barbier *et al*. 2011, Fig. 2. In our analysis, we report the combined value of consumptive uses and direct non-consumptive uses as "direct value," as both of these types of value are more easily captured in formal markets than indirect non-consumptive values. We report the value of indirect non-consumptive uses as "indirect value."

We provide estimates of the overall value generated by each of the three habitat types on a per hectare (ha) basis. We estimated coral reefs to generate a value of about $57,500/ha/year; 49% of this is in the form of direct values (fishing, diving and snorkeling, and research), while the rest comes from indirect non-consumptive values (Table 2). Mangroves generate an estimated $30,600/ha/year of economic value, while seagrass beds provide an estimated $35,500/ha/year through research, climate regulation, and habitat support for fisheries, diving, and snorkeling.

Based on these per-hectare values, we estimate that the 7.85 km^2 of coral reefs in Curaçao generate a total of approximately $45 million each year, while the 55 ha of mangroves generate $1.7 million/year and the 8 ha of seagrass beds generate almost $300,000/year (Table 3). Appendix D contains detailed descriptions of the different ecosystem goods and services and our methods for calculating their values.

These estimates of the economic value per hectare of habitat should be interpreted with caution due to limitations in the data and methods used to calculate them. For many of the values, we were unable to obtain the data required to calculate the values for Curaçao and thus relied on estimates from other locations. However, the value may not be the same in Curaçao, since many of these values depend on local ecological and socioeconomic factors.

Table 2. The values of ecosystem goods and services provided by coral reef, mangrove, and seagrass habitats in Curaçao. Values determined through sector analyses and benefit transfers. All values are in 2015 US$.

Habitat	Type of Value	Good or Service	Value per Hectare	Location	Source(s)
Coral Reefs	Direct	Fisheries (Direct Extraction)	$7,400	Curaçao	WRI calculation
		Diving & Snorkeling Tourism	$20,400	Curaçao	WRI calculation
		Research	$500	Curaçao	Vermeij, pers. comm. (2011 estimate)
	Indirect	Fisheries (Habitat Support)	$7,400	Curaçao	WRI calculation
		Diving & Snorkeling Tourism (Habitat Support)	$20,400	Curaçao	WRI calculation
		Carbon Sequestration	$1,400	Global average	Emerton 1998; Emerton & Asrat 1998; Mohd-Shahwahid & McNally 2001; Charles 2005
Mangroves	Direct	Research	$500	Curaçao	Vermeij, pers. comm. (2011 estimate)
	Indirect	Fisheries (Habitat Support)	$7,400	Curaçao	WRI calculation
		Diving & Snorkeling Tourism (Habitat Support)	$20,400	Curaçao	WRI calculation
		Carbon Sequestration	$2,300	Brazil	Sanders *et al.* 2010
Seagrasses	Direct	Research	$6,200	Curaçao	Vermeij, pers. comm. (2011 estimate)
	Indirect	Fisheries (Habitat Support)	$7,400	Curaçao	WRI calculation
		Diving & Snorkeling Tourism (Habitat Support)	$20,400	Curaçao	WRI calculation
		Carbon Sequestration	$1,500	Indo-Pacific	Unsworth *et al.* 2012

Table 3. The total direct and indirect values of ecosystem goods and services provided by coral reef, mangrove, and seagrass habitats in Curaçao. Values are in 2015 US$/year.

Habitat	Total Area (ha)	Direct Value ($/year)	Indirect Value ($/year)	Total Value ($/year)
Coral Reefs	785	$22,215,500	$22,922,000	$45,137,500
Mangroves	55	$27,500	$1,655,500	$1,683,000
Seagrasses	8	$49,600	$234,400	$284,000

Additionally, we were unable to provide estimates for some values because they had not been rigorously assessed in the literature. As one important example, coral reefs and mangroves provide the additional ecosystem service of shoreline protection, reducing the effects of wave action and storm surges. This ecosystem service has significant value, particularly for the Willemstad UNESCO World Heritage Site, and the value is likely to increase in importance with climate change and sea level rise, but we did not include it in our estimate of the total value generated per unit area of habitat due to a lack of data. Throughout the Caribbean, the estimated shoreline protection value of mangrove and coral habitats ranges from $0.52/ha/year to $2,574/ha/year (Rao *et al*. 2015). In Belize, St. Lucia, and Tobago, the estimated total value of shoreline protection provided by mangrove and coral reef habitats ranges from $22-199 million (Burke *et al*. 2008; Cooper *et al*. 2009). A detailed description of methods and data required to estimate the value of shoreline protection generated by coral reefs and mangroves is provided in Appendix D. Because we did not include some services like shoreline protection, the overall values that we present here are conservative estimates and do not represent the full economic value of Curaçao's coastal marine habitats.

Lastly, our method of reporting the average value per hectare for each habitat type obscures important spatial variation in the value generated by different habitats and may lead to the assumption that the value of a habitat type is homogenous throughout CuraÇao's waters. In reality, there is certainly variation in the value generated by different habitat types based on the specific location, human use patterns, and habitat quality. For example, a healthy coral reef with lots of colorful reef fish that is used frequently by divers and snorkelers creates more tourism value than a degraded reef that is not used by tourists. Thus, it is important to account for site-level variation in value when making policy decisions. In addition, ecosystem services such as shoreline protection are not always linearly related to habitat area; a decrease in the amount of mangrove habitat may have a disproportionately large impact on the shoreline protection provided by mangroves, depending on the relative spatial distribution of mangroves and high-value coastal properties (Barbier *et al*. 2008).

Ocean Zoning

Comprehensive ocean zoning, an ecosystem-based approach to resource management that designates different spatial areas for specific human uses, can yield economic benefits by reducing conflicts between ocean users, accelerating investment in new industries such as renewable energy and aquaculture, and enhancing marine ecotourism and fisheries yields (Kappel *et al*. 2009; European Commission 2011). By determining the economic value of various marine resources, managers and stakeholders can better understand the economic tradeoffs and impacts associated with restricting ocean areas for specific uses. For example, while designating a no-fishing area may result in a loss of fishery revenues, it may increase the revenue in the dive tourism industry. Similarly, establishing a no-diving zone may reduce economic losses to fishers caused by conflicts with divers. Incorporating the economic value of sectors relying on marine resources allows decision-makers to identify situations where trade-offs among ecosystem services are unavoidable, as well as situations where win-win outcomes are possible (Lester *et al.* 2013).

Land- and sea-based industries such as manufacturing, agriculture, coastal development, and shipping can have significant negative impacts on marine resource health. Given the potential for land-based industries and activities to impact the value of marine resources, it is important to incorporate regulation of land- and ocean-based industries into comprehensive ocean zoning:

- Increased sedimentation from coastal development and land use change can reduce live coral cover and damage seagrass beds (Orth *et al.* 2006; Bégin *et al.* 2016).
- Industrial and nutrient pollution from manufacturing, oil refining, shipping, and inadequate sewage treatment can also harm ocean health (Wetzel & Pulster 2010; Lapointe & Mallin 2011).
    - Chronic, long-term pollution from oil refineries can reduce the health of adjacent and downstream reefs, with decreases in the live coral cover and structural complexity of the reefs, as has been observed in Aruba (Bak 1987; Haapkyla *et al*. 2007).
    - Untreated wastewater can cause eutrophication, where high nutrient levels stimulate algal growth. This threatens the health of seagrass beds by reducing light levels (Burkholder *et al*. 2007) and reduces coral growth, reproduction, and recovery from bleaching events (Nagelkerken 2006; Wear & Thurber 2015). Eutrophication can also harm mangrove health (Lovelock *et al*. 2009; Reef *et al*. 2010).
    - Pollution from industry and inadequate sewage treatment also threatens the health of swimmers, including both local residents and tourists (Bernal *et al*. 2004).
- Pollution also has the potential to reduce the value of fisheries by decreasing ecosystem productivity and increasing the risk of harmful algal blooms and subsequent fish die-offs (Islam & Tanaka 2004). Furthermore, links between land-based trace metal pollution and the food safety of locally-caught fish are currently understudied but may also impact the value of local fisheries (Govers *et al*. 2014).

Potential Benefits of Ocean Zoning to Curaçao

Ocean zoning can yield economic benefits across a variety of sectors:

- **Fisheries**: Ocean zoning and marine protected areas can enhance local fishing yields through protection of important habitats, adult and larval spillover from marine reserves, and a reduction in conflict between user groups such as fishers and divers (Roberts *et al.* 2001; Nagelkerken & van der Velde 2002).
- **Marine tourism and recreation**: Dive tourists, who spend 60–80% more money than the average tourist to the Caribbean, prefer areas with healthy marine life and good water quality and are attracted to marine protected areas (Williams & Polunin 2000; Burke & Maidens 2004; Uyarra *et al.* 2005; Gill *et al.* 2015).
- **Shipping**: Designated shipping lanes can reduce conflicts between users, improve efficiency, and reduce the environmental impacts of shipping (Craig 2012).
- **Emerging ocean uses**: Zoning for new industries such as offshore renewable energy or aquaculture can prevent conflicts with existing activities and facilitate the development of new industries by providing certainty and predictability for prospective investors (Erbach 2013; Blau & Green 2015).

Comprehensive ocean zoning is a powerful strategy for preserving the marine resources that support Curaçao's economy while promoting further economic growth. By incorporating information about the economic value of Curaçao's marine resources into a national zoning plan, Curaçao can continue to "use the ocean without using it up."

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Appendices

Appendix A. Fisheries Valuation Methods

The WRI Fisheries Valuation Tool estimates the value of three components of the fishing industry: commercial fishing, local fishing, and fish processing. WRI defines local fishing as "any fishing conducted by locals on an informal basis that is not captured by official government statistics." Local fishing is further divided into three sub-components: fishing for sale, for consumption, and for enjoyment. Since there is no industrial-scale commercial fishing in Curaçao, we simply calculated the values of local fishing (for sale, consumption, and enjoyment) and fish processing. Although the WRI tool was originally intended to estimate the value of coral reef fisheries, we modified the tool to estimate the value of all fisheries in Curaçao's waters, because many fishers land both pelagic and coral reef species. We thus included pelagic, demersal, and coral reef fishery landings in the valuation. Table A1 presents all the input parameter values used in the calculation of the economic value of Curaçao's fisheries, as well as descriptions of how these parameters were derived.

Value of Local Fishing for Sale

Fisheries in Curaçao are artisanal. Five Spanish purse seining vessels are currently registered under Curaçao's flag and fish in the Eastern and Western Central Atlantic, but we did not include landings from these vessels because they fish exclusively in international waters. Curaçao does not currently have a fisheries monitoring or catch reporting system in place, but annual fishery landings, exports, and export value data have been reported to the FAO since 2011. To reflect the artisanal nature of Curaçao's fisheries, we combined the value of the WRI's 'commercial fishery' sector with the 'local fishing for sale' sector to estimate the value of a single local fishing for sale sector. This value included the estimated value of landings reported to the FAO (referred to as 'commercial fishing' in the WRI workbook) and the estimated value of unreported landings (referred to as 'local fishing for sale' in the WRI workbook).

We calculated the value of reported fisheries in the WRI workbook by determining the annual landings by species and multiplying this amount by the most recent market value for each species. From 2011 to 2013, Curaçao reported an average of 1,076.02 t of landings from the Western Central Atlantic per year to the FAO (FishStatJ 2016).

We assumed that the 15 full-time fishers in Curaçao were responsible for the FAO-reported portion of fisheries landings. Skipjack tuna (*Katsuwonus pelamis*), which we assumed were landed by the large purse seining boats registered under Curaçao's flag, accounted for 56% of the landings reported to the FAO (ICCAT 2006-2016). Curaçao exports large quantities of frozen skipjack tuna to the EU and US markets, where it receives a higher market value than it would if sold domestically (Lindop *et al.* 2015). We did not include the value of skipjack landings in our estimate because they were landed in international waters, rather than within Curaçao's EEZ (FishStatJ 2016).

The FAO lists the remaining 44% of Curaçao's reported landings as "unidentified marine fish" (FishStatJ 2016). We assumed that this portion of the catch was a mix of demersal, pelagic, and reef species landed by the smaller (< 20 m length) vessels participating in Curaçao's artisanal fishery and sold in local markets. We used the average local market value of pelagic, demersal, and reef species from previous reports (Dilrosun 2004; Johnson 2010) to calculate the value of this portion of Curaçao's local for-sale fishery landings.

Curaçao also reported landing 26 t of conch annually from 2011-2013. However, both the literature and expert knowledge suggest that there is currently no substantial conch fishery in Curaçao (Theile 2001; van Buurt 2001; F. Dilrosun, pers. comm.). It is likely that these reported conch landings were caught off other islands, so these data were not included in the valuation.

We estimated the value of the unreported portion of Curaçao's for-sale landings by determining the total number of part-time fishers (assuming that part-time fishers did not contribute to the landings reported to the FAO). We multiplied the number of part-fishers by the average number of days spent fishing per year, the average catch per trip, and the average sale price per unit of catch. Details on the derivation of these parameters are presented in Table A1.

Value of Fish Processing, Cleaning, Sales, and Distribution

We calculated the value of fish processing and cleaning by determining the portion of local for-sale landings that are cleaned or processed and multiplying that portion of the catch by the value added by cleaning (Table A1). Forty-three percent of 128 fishers interviewed in 2009 reported selling their catch to middlemen (Johnson 2011). We used information from Dilrosun (2004) to determine the value added to catch through local cleaning, processing, sales and distribution, and applied this value to 43% of the reported catch.

Value of Fishing for Consumption and Enjoyment

We estimated the value of fishing for consumption by multiplying the number of fishers that fish for consumption by the number of days fishing, average catch per trip, and average value of landings. We calculated the value of local fishing for enjoyment as a product of the number of residents fishing for enjoyment each year, the average number of days they spent fishing, and the average wage of the local population. We present all parameters used to estimate the value of Curaçao's fisheries in Table A1.

Table A1. Inputs used to estimate the economic value of Curaçao's fisheries through the WRI Fisheries Valuation Tool.

Parameter		*Estimated Value*	*Description of Estimation Method or Source*
General	Number of full-time fishers	15	Personal communication with F. Dilrosun.
	Number of part-time fishers	229	There are a total of 214 fishers listed in LVV's 2009 Fishermen Overview. F. Dilrosun clarified that there were at least 30 additional bigeye scad (*Selar*

			crumenophthalmus) fishers not included in that list, raising our estimate of total fishers to 244. Approximately 15 of these are full-time, leaving 229 part-time fishers.
	Number of small boats (< 5 meters)	9	Vessels in LVV's 2006 harbor registration database that were marked as active, part-time, or full-time and had a length of less than 5 m.
	Number of large boats (> 5 meters)	86	Vessels in LVV's 2006 harbor registration database that were marked as active, part-time, or full-time and had a length greater than 5 m.
	Number of landing sites	26	LVV's 2006 fishery database lists 26 fishery landing sites.
	Number of fish processing facilities	24	Estimate of the number of 'fish peddlers' (middlemen between fishers and consumers) from Dilrosun 2004.
	Average price of fish sold to consumers (US$/kg)	8.26*	Average value of the unit prices of all species (pelagic, demersal, and reef) sold to consumers (Dilrosun 2004; Johnson 2010).
Local Fishing for Sale (Reported) ["Commercial" in WRI Workbook]	Labor costs in for-sale fishing (as a percentage of revenue)	25	No local information available; used WRI's Caribbean-wide default value.
	Non-labor operating costs in for-sale fishing (as a percentage of revenue)	10	No local information available; used WRI's Caribbean-wide default value.
	Labor costs in fish processing (as a percentage of revenue)	25	No local information available; used WRI's Caribbean-wide default value.
	Non-labor operating costs in fish processing (as a percentage of revenue)	10	No local information available; used WRI's Caribbean-wide default value.
	Average annual reported FAO	480	Curaçao's average annual landings in

	landings (t)		the Western Central Atlantic from 2011-2013, as reported to the FAO (excluding conch and skipjack landings).
	Value of for-sale fisheries (US$/t)	4,510*	The same average value (in $/kg) of pelagic and reef fish sold locally (as previously described) was assumed for the "other marine fish" category.
Local Fishing for Sale (Unreported) ["Local Fishing for Sale" in WRI Workbook]	Percentage of population engaged in unreported fishing for sale	0.2	Estimated as the number of full-time fishers subtracted from the total number of fishers, divided by the total population. Full-time fishers were not included in this value because their portion of the catch was assumed to be represented by the FAO data.
	Average catch per trip (unreported fishing for sale) (kg)	16	Average catch per trip reported by fishers interviewed in 2009 (Johnson 2010) and observed in fishing trips monitored in 2005-2006 (LVV 2006).
	Average sale price/unit (unreported fishing for sale) (US$/kg)	8.26*	Average local market value for pelagic, demersal, and reef species (Dilrosun 2004; Johnson 2010).
	Average annual days in activity (unreported fishing for sale)	200	Full-time artisanal reef and trolling fishers are active 200 days a year (LVV 2003).
Cleaning and Processing	Percentage of for-sale catch that is locally cleaned or processed	43	Forty three percent of 128 fishers interviewed in 2009 reported selling their catch to middlemen for cleaning, processing, and distribution.

	Value added by processing/cleaning and distribution/sales (US$/kg)	$2.23*	We calculated the average value added per kilogram as the difference between the price of fish sold to middlemen by fishers and the price of fish sold to consumers by middlemen (Dilrosun 2004). We then applied this value to the 'other marine fish' landings that were assumed to be sold locally.
Fishing for Consumption	Percentage of population fishing for consumption	0.7	We assumed that 1 out of every 190 people in the population fishes recreationally, as suggested in Lindop *et al*. 2015 (previously published in Zaneveld 1962). Most commercial fishers also take home a portion of their catch for consumption, so we assumed that both recreational and for-sale fishers consume some of their catch. Based on interviews with fishers, we assumed that on average, 3% of the landings were retained for consumption (Johnson 2011).
	Average catch per trip (fishing for consumption) (kg)	0.5	This value represents the catch per trip of fish that are caught for personal consumption. Lindop *et al*. (2015) use this value based on methods developed by Pauly *et al*. (2015) for Aruba.
	Value of average unit of catch (fishing for consumption) (US$/kg)	8.26*	We assume that the species composition in landings of artisanal fishers is the same regardless of whether they catch fish to sell or for personal consumption because most fishers consume a portion of their catch (Lindop *et al*. 2015). The value per unit of catch is thus the same as in the unreported for-sale sector.
	Average annual days in activity (fishing for consumption)	200	Most fishers consume some portion of their catch (Johnson 2010), so this

			value is the same for both local fishing for sale and for consumption (LVV 2003).
Fishing for Enjoyment	Percentage of population fishing for enjoyment	0.5	We assumed that 1 out of every 190 people in the population fishes recreationally, as suggested in Lindop *et al*. 2015 (previously published in Zaneveld 1962).
	Average hours per day spent fishing for enjoyment	7.1	Average length of fishing trip, from interviews with fishers (Johnson 2011).
	Average annual days in activity (fishing for enjoyment)	11	Recreational fishermen on average spend fewer than 12 days per year fishing (LVV 2003).
	Average hourly wage of people engaged in fishing for enjoyment (US$)	8.28*	The average annual income in Curaçao is $14,000 (InvestCuraçao 2006). We estimated the hourly wage based on 2080 working hours in a year.

*Values adjusted for inflation to 2015 US dollars.

Table A2 provides a breakdown of our estimates of the value of the different components of Curaçao's fishing industry. We estimated the value of Curaçao's fisheries using the best available information, relying on the assumptions detailed in Table A1. Nevertheless, we were able to assess the accuracy of our estimates by comparing them with independent sources. For example, the combined agriculture and fisheries sector in Curaçao accounts for 0.7% of the total national GDP, which was $3.128 billion in 2014 (CIA World Factbook 2013-14). Agriculture and fisheries thus contribute approximately $21 million to the economy. If fisheries accounted for approximately half of that value (0.35% of GDP), then our estimate of $12 million would be reasonable.

Table A2. Value of Curaçao's fisheries sectors.

Fishery Sector	**Estimated Value (US$)**
Local fishing for sale (total)	$10.2 million
Reported landings	*$1.9 million*
Unreported landings	*$8.3 million*
Local fishing for consumption	$900,000
Local fishing for enjoyment	$480,000

Fish processing/cleaning	$460,000
Total	$12.0 million

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Appendix B. Marine Tourism and Recreation Valuation Methods

We estimated the value of marine tourism using three methods: the WRI Tourism and Recreation Valuation Tool for general marine-related tourism, including diving and snorkeling; a separate method for sport fishing due to data constraints; and an additional method for the value of cruise tourism. We did not include the cruise tourism value in our overall estimate of the value of marine tourism because many cruise tourists do not choose individual destinations for their trips, meaning that the quality of Curaçao's natural resources would not necessarily influence their decision to visit, and we did not have information on the numbers of cruise tourists that visit Curaçao's coral reefs or other marine and coastal ecosystems. We also did not calculate the value of yacht tourism due to data constraints, although Curaçao does have a significant amount of yacht tourism, with 661 yachts visiting the island in 2006 (Girigori 2007). Yacht visitation contributes to island economies via expenditures in tourist activities, boat maintenance and repairs, yacht club fees, and other expenses (Henry 2013); the government of Curaçao has expressed interest in investing in yacht infrastructure in order to increase visitation (DEZ, n.d.). However, we did not have sufficient data on yachting-derived revenues in Curaçao, and furthermore, we expect that many yacht tourists do not choose to come to Curaçao based on the quality of coastal marine habitats, but rather use it as a refuge during hurricane season (Girigori 2007).

WRI Tourism and Recreation Valuation Tool

The WRI Tourism and Recreation Valuation Tool provides several options for conducting valuations, depending on data availability. In the following sections, we outline the primary methodological choices, assumptions, and data values used in our analysis.

The WRI valuation methodology relies on estimates of the percent of visitors using the reef, either through recreation (diving, snorkeling, etc.) or by visiting white sand beaches, which are of coralline origin. In 2014, Curaçao had approximately 452,000 stay-over tourists, of whom 77% reported going to beaches, while 45% went snorkeling, 13% went diving, and 2.5% went sport fishing (Croes *et al.* 2015). For our valuation of marine-associated revenue in the accommodation sector, we used 77% as our estimate of the percentage of marine-related stay-over tourists, assuming that tourists who went diving, snorkeling, or sport fishing were included within the percentage that reported visiting beaches. This may be a conservative estimate: if some of the tourists who went diving or snorkeling did not report visiting beaches during their stay, then 77% is an underestimate.

Gross revenue in the accommodation sector is based on the percentage of tourists that visited coralline beaches, the number of hotels in Curaçao and their occupancy rates, the average number of rooms per hotel, and the average room rate (Table B1). To calculate the net revenue, we subtracted costs associated with wages, non-labor operating costs, and losses due to leakages from foreign-owned rooms. The total direct value of marine-associated accommodation is approximately $173.8 million. A key assumption in the calculation of the secondary value of this spending was the application of an accommodation multiplier, which reflects the ripple effect of money spent in the hotel sector. We applied a multiplier of 1.92 (from Croes *et al*. 2015) to the gross revenue of the accommodation sector ($178.9 million) to yield an estimated indirect impact of $164.6 million. This total represents the value generated by the transfer of direct expenditures through backward-linked industries (Waite *et al.* 2014).

Recreation-associated revenue consists of expenditures in diving and snorkeling and is estimated through a similar method (Table B1). We used the WRI calculation method based on the total number of divers and snorkelers, together with the average number of dives and snorkel trips in the study area, using data from Croes *et al*. (2015) and the total number of stay-over tourists in 2014 reported by the Curaçao Tourist Board (CTB). Responses to our survey of dive and snorkel operators, along with personal communication with Dr. Mark Vermeij, provided estimates of additional input parameters such as trip prices, gear rentals, certification costs, and operating costs. In 2014, 13.2% of tourists (58,767) went scuba diving, while 44.5% (201,163) went snorkeling (Croes *et al*. 2015). Our results are extrapolated from a low number of survey responses (*n*=6 of 14), but our response rate was 43% and the respondents provided fairly consistent answers. The results indicate the total value of the diving sector to be $15.3 million and snorkeling to be $18.0 million.

Table B1. Data inputs for the WRI Tourism and Recreation Valuation Tool.

Parameter		*Value*	*Description of Estimation Method or Source*
Accommodation	Number of stay-over tourists	452,042	CBS 2014
	Average length of stay (number of nights)	9.65	Croes *et al*. 2015
	Percent of visitors using the reef, either through reef recreation (diving, snorkeling, etc.) or by visiting white sand beaches of coralline origin	77	Croes *et al*. 2015
	Average hourly hotel wage (US$)	8.28*	The average annual income in Curaçao is $14,000 (InvestCuraçao 2006). We estimated the hourly wage based on 2080 working hours in a year.
	Average hours worked per week by hotel employees	48	CAIPA 2012
	Persons employed per room	1.5	No local information available; used WRI's Caribbean-wide default value
	Non-labor operating costs in accommodation sector (as a % of base revenue)	25	No local information available; used WRI's Caribbean-wide default value
	Tax rate (accommodation sector) (%)	7	CTB 2016a
	Service charge rate (accommodation sector) (%)	12	CHTA 2013
	Percent of rooms that are foreign owned (%)	31	Leakage factor used by Croes *et al*. 2015

	Average room rate (price per night in US$, excluding taxes and service charges)	142.30*	2014 data (CHATA 2016)
	Hotel occupancy rate (%)	70	2014 data (CHATA 2016)
	Average number of rooms per hotel	45	Divided the 6404 rooms listed by the CTB divided by number of accommodations listed on Curaçao.com (CTB 2016b).
	Number of accommodations	142	Number of listings on Curaçao.com (CTB 2016b).
	Accommodation multiplier	1.92	Croes *et al*. 2015
Diving	Tax rate (diving) (%)	9	M. Vermeij, personal communication
	Service charge rate (diving) (%)	12	M. Vermeij, personal communication
	Total annual number of divers	59,670	13.2% of 452,042 total tourists (Croes *et al*. 2015)
	Average number of dives per diver	4	Survey
	Proportion of dives taken at all-inclusive resorts (%)	2	Survey; M. Vermeij, personal communication
	Annual number of dive certifications issued	9040	Average number of certifications per shop reported in survey, multiplied by the number of shops
	Average price of a single tank dive (US$)	50.00	Survey
	Average price of dive certification (US$)	450.00	Survey
	Average price of dive equipment rental (US$)	40.00	Survey
	Proportion of dives with equipment rental (%)	28	Survey
	Labor costs in dive operations, as a percentage of revenue	40	Survey
	Other costs in dive operations, as a percentage of revenue	40	Survey
Snorkeling	Tax rate (snorkeling) (%)	9	M. Vermeij, personal communication
	Service charge rate (snorkeling) (%)	19	M. Vermeij, personal communication
	Total annual number of snorkelers	201,159	44.5% of 452,042 total tourists (Croes *et al*. 2015)
	Average number of trips per snorkeler	2	Survey
	Percentage of snorkeling trips	2	Survey; M. Vermeij, personal

	taken at all-inclusive resorts		communication
	Average price per snorkel trip (US$)	40.00	Survey
	Average price snorkeling equipment rental (U$S)	14.00	Survey
	Percentage of snorkelers that rent equipment	55	Survey
	Percentage of snorkeling trips charging for equipment rental	20	M. Vermeij, personal communication
	Number of independent snorkel rentals per year	20,000	Survey
	Labor costs in snorkel and boating operations, as a percentage of revenue	20	Survey
	Other costs in snorkel and boating operations, as a percentage of revenue	20	Survey

*Values adjusted for inflation to 2015 US dollars.

<u>Sport Fishing Valuation</u>

Sport fishing is another tourist attraction in Curaçao, and although only 2.5% of tourists participate (Croes *et al*. 2015), sport fishing is an expensive activity, with trips ranging from approximately $600-$1,000 for half and full day trips, respectively, although participants share the cost of a fishing trip.

We calculated the economic value of sport fishing (*SFE*) to Curaçao with the following formula:

$$SFE = (SF / FPB) * ACT,$$

where *SF* is the number of tourists who go sport fishing, *FPB* is the average number of fishers per boat trip, and *ACT* is the average cost per trip. We estimated the number of tourists who went fishing (*SF*) in 2014 to be 11,301 individuals, representing the 2.5% of 452,042 stay-over tourists who go sport fishing (Croes *et al*. 2015). Fishing trips last either 4 hours (half-day) or 8 hours (full-day) but the relative proportion of these trips in Curaçao is unknown, as is the average number of fishers per trip. These values are important as they can each greatly influence total sport fishing expenditures. In the absence of reliable estimates for Curaçao, we assumed an average of five fishers per trip (*FPB*) following the results of a study in the British Virgin Islands (Gillet *et al*. 2005). We also assumed an even ratio of half- and full-day trips and thus used an average trip cost (*ACT*) of $800. The subsequent estimate of total expenditures by tourists attributed to sport fishing is approximately $1.8 million. See Table B2 for a breakdown of the values used in the calculation.

Table B2. Values used in the estimation of the economic value of sport fishing.

Parameter	*Estimated Value*	*Description of Estimation Method or Source*
Percentage of stay-over tourists who go sport fishing	2.5	Croes *et al*. 2015
Total stay-over tourists in 2014	452,042	CBS 2014
Total number of sport fishing tourists in 2014	11,301	2.5% of 452,052 tourists
Average number of fishers per boat	5	Based on results of a recreational sport fishing study in the British Virgin Islands (Gillet *et al*. 2005).
Average cost per trip	\$800	Trip prices range from \$600-\$1,000 for half-day and full-day trips. We assumed an even proportion of these trips and adopted the midpoint of the price range, \$800.

Cruise Ship Valuation

We calculated the total cruise expenditures (*TCE*) for Curaçao in 2014 using the following equation:

$$TCE = PE + CE + CLE,$$

where *PE* is the total onshore expenditures by cruise ship passengers, *CE* is the total onshore expenditures by crew members, and *CLE* is the total expenditure by the cruise line on local supplies, services, and port fees and taxes (from BREA 2012).

To estimate *PE* in 2014, we multiplied the average onshore expenditure per passenger derived from passenger surveys (Croes *et al*. 2015) by the number of cruise ship passengers who went ashore in 2014. To estimate the number of cruise ship passengers that went ashore in Curaçao in 2014, we assumed that the same percentage of passengers went ashore in 2014 as in 2011/2012 (BREA 2012). We estimated *PE* to be approximately \$41 million. See Table B3 for a breakdown of the values used in the calculation.

Table B3. Values used in the estimation of total onshore expenditures by cruise ship passengers.

Parameter	*Estimated Value*	*Description of Estimation Method or Source*
Number of 2014 passenger arrivals	629,145	CBS 2015
Percentage of passengers who went ashore	91.9	Assumed to be the same as in 2011-2012 (value calculated from BREA 2012 data)
Number of passengers who went ashore in 2014	578,206	Estimated based on number of passenger arrivals and the percentage that went ashore in 2011-2012
Average onshore expenditure per passenger (US$)	70.86*	Croes *et al*. 2015

* Values adjusted for inflation to 2015 US dollars.

To estimate *CE* in 2014, we multiplied the average onshore expenditure per crew member derived from surveys (Croes *et al*. 2015) by the number of cruise ship crew members who went ashore in 2014. To estimate the total number of crew members arriving in Curaçao in 2014, we assumed that the ratio of passengers to crew members remained the same from 2011-2012 to 2014. We also assumed that the percentage of crew members who went ashore was constant over time (BREA 2012). We estimated *CE* to be approximately $9.7 million. See Table B4 for a breakdown of the values used in the calculation.

Table B4. Values used in the estimation of total onshore expenditures by cruise ship crew members.

Parameter	*Estimated Value*	*Description of Estimation Method or Source*
Ratio of passengers to crew members	2.5	Assumed to be the same as in 2011/2012 (value calculated from BREA 2012 data)
Number of crew member arrivals in 2014	251,573	Estimated from number of passenger arrivals in 2014 from CBS, assuming passenger to crew member ratio of 2.5.
Percentage of crew members who went ashore (%)	38.5	Assumed to be the same as in 2011-2012 (value calculated from BREA 2012 data)
Number of crew members who went ashore in 2014	96,770	Estimated based on estimate of crew member arrivals and the percentage that went ashore in 2011-2012

Average onshore expenditure per crew member (US$)	99.88*	Croes *et al*. 2015

* Values adjusted for inflation to 2015 US dollars.

To estimate *CLE* in 2014, we assumed that the cruise lines' expenditures per passenger remained the same from 2011-2012 to 2014. In 2011-2012, cruise lines spent a total of $5.2 million on local supplies, services, and port fees and taxes, for an average of $11.94 per passenger (BREA 2012). Based on this expenditure per passenger and the increased number of passengers in 2014, we estimated a total cruise line expenditure of $6.9 million in 2014.

Table B5 provides a breakdown of our estimates of the value of the different components of Curaçao's marine-associated tourism industry.

Table B5. Estimated value of Curaçao's marine-associated tourism.

Marine-Associated Tourism Sector	**Estimated Value (US$)**
Total Direct Value of Marine-Associated Accommodation	$173.8 million
Gross revenue	*$178.9 million*
Net revenue (gross revenue, minus wages and costs)	*-$18.4 million*
Net revenue, minus foreign leakage	*-$12.7 million*
Transfers to the economy via taxes, wages, etc.	*$186.5 million*
Total Indirect Value of Marine-Related Accommodation	$164.6 million
Total Value of Diving Industry	$15.3 million
Gross revenue	*$18.9 million*
Net revenue	*$3.8 million*
Transfers to the economy via taxes,	*$11.5 million*

wages, etc.	
Total Value of Snorkeling	$18.0 million
Gross revenue	*$16.7 million*
Net revenue	*$10.0 million*
Transfers to the economy via taxes, wages, etc.	*$8.0 million*
Total Value of Sport Fishing Tourism	$1.8 million
Total Economic Value of Marine-Associated Tourism	**$373.5 million**
Additional Value Derived from Cruise Tourism	**$57.5 million**

Alternative Methods for Estimation of the Value of Marine Tourism and Recreation

Other methods for estimating the value of coastal and marine resources to tourism and marine recreation require more data than the methods we employed. These alternate methods include hedonic pricing, travel cost, contingent valuation, and choice modeling (Waite *et al*. 2014). For example, Wolfs Company used interviews with tourists in Bonaire to estimate their actual expenditures on the island, as well as their willingness to pay an additional fee for environmental management (Schep *et al*. 2013). Tourists' willingness to pay for environmental preservation is sometimes incorporated into calculations of the potential value of natural resources, but there are issues in relating people's stated willingness to pay, in response to hypothetical questions, to actual economic values.

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Appendix C. Marine Recreation Survey

To gather the data on scuba diving and snorkeling needed for the WRI Tourism and Recreation Valuation Tool, we administered an online survey to the members of the CHATA Dive Task Force. The text of the survey is below:

Survey of Curaçao's Dive Shops

We are researchers at the University of California, Santa Barbara (http://sfg.msi.ucsb.edu/). We are working with the Waitt Institute's Blue Halo Initiative in Curaçao (http://Curaçao.waittinstitute.org/) to assess the economic value of marine resources in Curaçao, including the contribution of dive tourism to the economy.

To do this analysis, we are looking for some information about the dive industry in Curaçao. Your answers to the following questions will be very helpful for our analysis. Please answer this as soon as you can, preferably by March 15th. Feel free to forward it to other dive shops that you know of. Don't worry if you don't have an exact number for some of the answers: an estimate or best guess is also helpful!

There are two sections to this survey: one on information about the dive industry in Curaçao as a whole and one on your specific dive shop. This second section is spread over two pages: the first is about dive customers and dive trips, and the second is about snorkeling customers.

Your answers will be kept private and no identifying information will be released. If you are unable to answer all of the questions, please just answer the ones that you can and leave the others blank.

If you have any questions, feel free to contact us at katherinesiegel@ucsb.edu or tyler_clavelle@ucsb.edu. Thank you!

Section 1

1. Which dive shop are you affiliated with? Note: this information will only be used to determine how many unique dive shops we have information from.

2. Is your dive shop part of an all-inclusive resort?
   - ☐ Yes
   - ☐ No

3. How many dive shops do you know of in Curaçao?

4. What is your estimate of the total number of dives that occur in Curaçao each year?

5. Of all the dives that occur in Curaçao throughout the year, what percentage are led by dive shops?

6. What is your best estimate of the percentage of local residents of Curaçao who go diving each year?

7. What is your best estimate of the percentage of foreign tourists in Curaçao who go diving each year?

8. Of all the snorkeling trips that occur in Curaçao throughout the year, what percentage are led by dive shops?

9. What is your best estimate of the percentage of local residents of Curaçao who go snorkeling each year?

10. What is your best estimate of the percentage of foreign tourists in Curaçao who go snorkeling each year?

11. Please list the top five most popular dive spots in Curaçao.

Section 2: Questions Specific to Your Dive Shop: Dive Customers
Please answer these questions with estimates from the dive shop with which you are affiliated.

12. How many dive customers did your shop have in 2015?

13. Of your dive customers in 2015, what percentage were foreign tourists (not residents of Curaçao)?

14. How many dives did your shop lead in 2015?

15. How many dives does the average customer go on with your dive shop?

16. Please list the top five most frequent dive spots for your dive shop.

17. How many dives does your shop lead per year in the Curaçao Underwater Park?

18. How much does your dive shop charge for a single tank shore dive, in NAf? If your shop does not offer shore dives, please enter "Not Applicable." If you offer diving packages (for example, 10 dives for NAf 450), please provide the cost per dive.

19. How much does your dive shop charge for a single tank boat dive, in NAf? If your shop does not offer diving trips from boats, please enter "Not Applicable." If you offer diving packages (for example, 10 dives for NAf 450), please provide the cost per dive.

20. Does your shop offer dive certifications?
    - ☐ Yes
    - ☐ No

    If yes, how many dive certifications do you issue in an average year?

21. What is the cost of a dive certification at your shop?

22. What percentage of your dive customers rent equipment from your shop?

23. How much does your dive shop charge for equipment rental, in NAf per day?

24. What percentage of your revenue from dive trips and rentals goes to labor costs?
    - ☐ Less than 20%
    - ☐ 20-40%
    - ☐ 40-60%
    - ☐ 60-80%
    - ☐ More than 80%

25. What percentage of your revenue from dive trips and rentals goes to other operational costs?
    - ☐ Less than 20%
    - ☐ 20-40%
    - ☐ 40-60%
    - ☐ 60-80%
    - ☐ More than 80%

Section 3: Questions Specific to Your Dive Shop: Snorkeling Customers
Please answer these questions with estimates from the dive shop with which you are affiliated.

26. How many snorkel customers did your shop have in 2015?

27. Of your snorkeling customers in 2015, what percentage were foreign tourists (not residents of Curaçao)?

28. How many snorkeling trips did your shop lead in 2015?

29. How many snorkeling trips does the average customer go on with your dive shop?

30. How much does your shop charge for a snorkel trip from the shore, in NAf? If your shop does not offer shore-based snorkel trips, please enter "Not Applicable."

31. How much does your shop charge for a snorkel trip from a boat, in NAf? If your shop does not offer boat-based snorkel trips, please enter "Not Applicable."

32. What percentage of your snorkeling customers rent equipment?

33. How much does your dive shop charge for snorkel equipment rental, in NAf per day?

34. Does your dive shop also rent snorkel equipment to independent snorkelers (customers who are planning to snorkel on their own, rather than with a guide from your dive shop)?
    - ☐ Yes
    - ☐ No

If yes, how many independent snorkelers do you rent to per year?

35. What percentage of your revenue from snorkel trips and rentals goes to labor costs?
    - ☐ Less than 20%
    - ☐ 20-40%
    - ☐ 40-60%
    - ☐ 60-80%
    - ☐ More than 80%

36. What percentage of your revenue from snorkel trips and rentals goes to other operational costs?
    - ☐ Less than 20%
    - ☐ 20-40%
    - ☐ 40-60%
    - ☐ 60-80%
    - ☐ More than 80%

Thank you for your help!

Appendix D. Habitat Valuations

Marine and coastal ecosystems provide a range of benefits, or ecosystem services, to people. These ecosystem services include regulating services such as shoreline protection and erosion control; provisioning services such as fisheries and building materials; cultural services such as recreation and aesthetics; and supporting services such as water filtration and nursery habitats for fish (Millennium Ecosystem Assessment 2005). Curaçao's mangroves, coral reefs, and seagrass beds provide essential ecosystem services that benefit the health and well-being of Curaçao's residents and economy. Curaçao has approximately 55 hectares of mangroves, primarily distributed along the eastern and northeastern coastlines and in many of the inland bays, with a large mangrove system in Spanish Water Bay (de Freitas, pers. comm.; FAO 2005). Coral reefs surround Curaçao's coastline in a fringing reef, covering an area of about 785 hectares (Vermeij 2012), while seagrass beds cover about 8 hectares of Curaçao's inland bays (Green & Short 2003).

To estimate the economic value of each ecosystem on a per hectare basis, we first identified a list of direct and indirect use values that are relevant to Curaçao, drawing from the literature on ecosystem services (Orth *et al*. 2006; UNEP-WCMC 2006; Nakaoka *et al*. 2014; Table D1).

Table D1. Ecosystem values generated by coral reef, mangrove, and seagrass habitats. Checks (✓) indicate ecosystem goods and services for which we estimated values; an "○" indicates a service that currently produces value in Curaçao but whose value we did not estimate due to a lack of data; and an "✗" indicates goods and services that can potentially be generated by the habitat, based on the scientific literature, but are not currently utilized in Curaçao.

Ecosystem Goods and Services	Coral Reefs	Mangroves	Seagrass
Consumptive Use Values			
Fisheries (direct extraction)	✓	✗	✗
Pharmaceutical products	✗	✗	✗
Non-Consumptive Use Values			
Direct Non-Consumptive Use			
Research	✓	✓	✓
Diving and snorkeling tourism	✓	✗	✗
Local and informal recreation	○	○	○
Aesthetics	○	○	○
Indirect Non-Consumptive Use			
Habitat support for fisheries target species	✓	✓	✓
Habitat support for species valued by diving and snorkeling industry	✓	✓	✓
Shoreline protection and sediment stabilization	○	○	○
Carbon sequestration and climate regulation	✓	✓	✓
Water quality, waste assimilation, and nutrient cycling	○	○	○
Non-Use Values			
Species protection and biodiversity	○	○	○
Cultural heritage and spiritual values	○	○	○

We then estimated the value of each ecosystem good or service for each habitat type using one of three methods:

1. Our sector analyses, in the case of Fisheries and Tourism (Diving and Snorkeling)
2. Expert estimations, in the case of Research
3. Benefit transfers using values published in the literature for other locations, for all other values

Fisheries (Direct Extraction and Habitat Support)

In estimating the value that each habitat type provides to fisheries, we considered both the value of direct harvest of fishery resources from the habitat (consumptive use), and the value of the supporting role that each habitat plays in the life cycles of target species (indirect, non-consumptive use). Throughout the tropics, there is a strong, positive correlation between fisheries productivity and the availability of high quality nursery habitat (Manson *et al*. 2005; Shinnaka *et al*. 2007). In Curaçao, seagrass meadows and mangrove habitats serve as essential nursery habitat for many fish, including species exploited by local fishers (Tuya *et al*. 2014). In the Caribbean, densities of certain commercially-exploited reef fish in coral reef habitats are a function of the presence of nearby mangrove and seagrass habitats (Nagelkerken *et al*. 2002). At the same time, some targeted species utilize coral reef habitats throughout their juvenile and adult life stages (Nagelkerken *et al*. 2002).

We used our estimate of the total value of Curaçao's fisheries sector ($12 million, with methods described in Appendix A) to calculate the contribution of each hectare of mangrove, coral reef, and seagrass habitat to the value of fisheries in Curaçao. Because coral reefs provide habitat for adult and juvenile fisheries species, we assumed coral reef habitats contribute to the value of fisheries in two ways: 1) by serving as the location of direct extraction of fishery resources (a consumptive use value), and 2) by providing nursery habitat for juvenile fish, helping to sustain local fisheries (an indirect, non-consumptive use value). Because there is no evidence that fishers in Curaçao target mangrove or seagrass habitats for direct fisheries extraction, we assumed that mangroves and seagrass habitats contributed only indirect, non-consumptive use values to Curaçao's fisheries by providing nursery habitat. We thus divided the total value of Curaçao's fisheries into four separate values:

1. The consumptive use value provided by coral reefs
2. The indirect, non-consumptive use value provided by coral reefs as a nursery habitat
3. The indirect, non-consumptive use value provided by mangroves as a nursery habitat
4. The indirect, non-consumptive use value provided by seagrass beds as a nursery habitat

To account for the two roles of coral reefs in generating fisheries value, we assumed that coral reef habitats contributed twice as much overall value per unit area as seagrass or mangrove habitats. We used the following equation to calculate the value per unit of area:

$$V = F/(M + S + 2*C),$$

where V is the base value per unit of habitat ($/ha), F is the total value of the fisheries sector ($), M is the total area (ha) of mangroves, S is the total area (ha) of seagrass, and C is the total area (ha) of coral reef habitat in Curaçao. The indirect, non-consumptive use value per unit of area of mangrove and seagrass beds associated with fisheries is equal to *V*. The total value per unit of area of coral reefs (V_C) was calculated as twice the base value per unit of area:

$$V_C = 2*V,$$

with half of this value stemming from the direct consumptive use of coral reefs as the location of fisheries extraction and the other half from the indirect non-consumptive use value of coral reefs' nursery role.

<u>Diving and Snorkeling (Direct Use and Habitat Support)</u>

To estimate the contribution of each unit of area of mangrove, coral reef, and seagrass bed to the value of marine tourism in Curaçao, we used the values of the diving and snorkeling sectors calculated in the WRI Tourism Valuation workbook with the two modifications. We did not include the value of sport fishing, since Curaçao's sport fishing sector targets pelagic species that are not dependent on the health of mangroves, coral reefs, or seagrass beds. We also did not include the value of accommodation associated with marine recreation in the habitat valuations.

The majority of snorkeling and diving in Curaçao takes place within coral reefs. Nevertheless, as discussed above, reef fish species use various habitats at different life stages: coral reefs, mangroves, and seagrass beds serve as nurseries and juvenile feeding grounds for reef fish species (Nagelkerken *et al*. 2000; Nagelkerken *et al*. 2001; Nagelkerken *et al*. 2002; Nagelkerken & van der Velde 2002). For this reason, coral reefs provide a direct, non-consumptive use value as the location in which diving and snorkeling takes place, while all three habitats provide indirect, non-consumptive use values through their ecological roles in supporting the different life stages of reef fish. For this reason, we divided the total value of Curaçao's diving and snorkeling tourism into four separate values:

1. The consumptive use value provided by coral reefs
2. The indirect, non-consumptive use value provided by coral reefs as a nursery habitat
3. The indirect, non-consumptive use value provided by mangroves as a nursery habitat
4. The indirect, non-consumptive use value provided by seagrass beds as a nursery habitat

To account for the two roles of coral reefs in generating diving and snorkeling value, we assumed that coral reef habitats contributed twice as much overall value per unit area as seagrass or mangrove habitats. We used the following equation to calculate the value per unit of area:

$$V = DS/(M + S + 2*C),$$

where *V* is the base value per unit of habitat ($/ha), *DS* is the value of diving and snorkeling tourism ($), *M* is the total area (ha) of mangroves, *S* is the total area (ha) of seagrass, and *C* is the total area (ha) of coral reef habitat in Curaçao. The indirect, non-consumptive use value per unit of area of mangrove and seagrass beds associated with fisheries is equal to V. The total value per unit of area of coral reefs (V_C) was calculated as twice the base value per unit of area:

$$V_C = 2*V,$$

with half of this value stemming from the direct non-consumptive use of coral reefs as the location of diving and snorkeling and the other half from the indirect non-consumptive use value of coral reefs' nursery role.

Research

Coral reefs, mangroves, and seagrass beds also contribute direct, non-consumptive value to Curaçao's economy through scientific research opportunities (Barbier *et al*. 2011). Scientists come to Curaçao from around the world to work on applied and basic scientific research questions in coastal and marine systems. CARMABI hosts approximately 225 marine scientists and students per year. Their expenditures for rent, on-island transportation, supplies for experiments, dive equipment, and laboratory and boat fees sum to a total of about $230,000 per year. Additional sources of value include film teams shooting underwater footage on Curaçao and the expertise provided by external universities. The value of this expertise is calculated as the avoided cost, or what Curaçao would have to spend to generate the knowledge on-island. Combined with the expenditures from individual scientists and students, CARMABI's research value in 2011 was about $497,000[5] (Vermeij, personal communication). This value is based on the assumption that about 90% of CARMABI's research is marine, while only 10% is terrestrial (Vermeij, pers. comm.).

Over the last ten years, about 85% of the marine research at CARMABI has focused on coral reef ecosystems, with an additional 10% focused on seagrasses and the remaining 5% on mangroves (Vermeij, pers. comm.). We attributed the value of CARMABI's marine research according to this breakdown of research focus, allocating 85% of the value to coral reefs, 10% to seagrasses, and 5% to mangroves.

Beyond CARMABI, marine research takes place at the Curaçao Sea Aquarium and the Substation. However, we were unable to obtain data on the economic value of these research activities. Our estimates for the research value of Curaçao's resources reflect only the value of CARMABI's work and thus represent the lower bound of the total value.

Carbon Sequestration and Climate Regulation

Marine and coastal ecosystems, particularly seagrass beds and mangrove forests, play an important role in sequestering carbon (Mcleod *et al*. 2011). Carbon sequestration plays a role in regulating the global climate and represents an indirect, non-consumptive value (Table 2). Mangrove and seagrass ecosystems sequester carbon at rates 2-4 times higher than tropical forests. Unlike terrestrial soils, the sediments associated with seagrass beds and mangrove forests accrete vertically in response to rising

[5] Value converted to 2015 US$.

sea level and do not become saturated with carbon, allowing for the storage of large quantities of carbon (Murray *et al*. 2011). Although mangroves and seagrass areas occupy < 0.1 % of all coastal habitats, they account for 14% of carbon sequestration by the ocean on a global scale (Alongi 2014).

To calculate the value that Curaçao's marine ecosystems contribute to carbon sequestration (*CSV*), we derived the rates of carbon sequestration (*CR*) for mangroves and seagrass from valuation studies in the literature from similar, tropical regions (*n*=3) and used the US Environmental Protection Agency's 2016 estimate of the social cost of carbon (*SCC*) of $64.01 per megagram (Mg) (EPA 2015). We calculated the potential annual value of carbon sequestration (*CSV*) in Curaçao for mangrove and seagrass habitat as:

$$CSV_{M,S} = SCC * CR_{M,S}.$$

To estimate the value that coral reefs contribute to carbon sequestration in Curaçao, we used the average value for climate regulation from coral reef habitats found in the TEEB (Economics of Ecosystems and Biodiversity) database (Emerton 1998; Emerton & Asrat 1998; Mohd-Shahwahid & McNally 2001; Charles 2005). However, the estimated value for carbon sequestration by coral reefs should be treated with caution as it is more speculative than the values estimated for seagrass and mangroves. This is because coral reefs act as both sources and sinks for carbon: coral reefs sequester carbon through the precipitation of calcium carbonate, but the precipitation of calcium carbonate also causes a shift in the acidity of ocean water that causes the release of CO_2 on a global scale (Ware *et al*. 1991). Calculating the local rate at which coral reefs sequester carbon can be problematic: at a local scale, a reef may be a net carbon sink, but at the global scale, reefs may be a source of atmospheric carbon dioxide (Charles 2005).

Shoreline Protection

Mangrove habitats and nearshore coral reefs protect coastal developments from flooding and storm surges (Rao *et al*. 2015). In the Caribbean, over 20% of all coastlines are protected by coral reefs (Burke 2010). Regardless of the exact dollar value of this ecosystem service, these habitats protect otherwise vulnerable coastal communities from damaging storm surges and flooding. Man-made protection structures are costly and may come with their own negative environmental impacts, so there is a growing appreciation for relying on natural habitats to protect coastal developments (Moberg & Rönnbäck 2003). Shoreline protection from coral and mangrove habitats is an indirect, non-consumptive ecosystem value. The World Resources Institute has developed a methodology for calculating the value of benefits associated with shoreline protection (WRI 2009). This method uses the avoided costs method, determining the value of properties and developments in areas identified as at risk of flooding but currently protected by mangroves or coral reefs. To estimate this value, WRI defines at-risk coastline as land that is lower than 5 km of elevation and within 1 km of the coast, and then considers all at-risk areas that are within 100 m of fringing reef or mangrove habitats (WRI 2009).

We were unable to conduct a valuation of shoreline protection in Curaçao following the WRI approach described above because we did not have spatially-explicit data on the value of coastal properties or the distribution of coastal marine habitats. However, shoreline protection is certainly an important value in

Curaçao, especially in the Willemstad UNESCO World Heritage Site. The range of shoreline protection values estimated for Belize, St. Lucia, and Tobago using WRI's method are presented in Table D2. The variation in values is driven by differences in the length of coastline protected by mangroves or coral reefs, exposure to storms and wave action, and property values. The total value of shoreline protection in Curaçao likely falls within this range of magnitudes.

Table D2. Range of values estimated for shoreline protection of other sites in the Caribbean using WRI's methodology. All values are in 2015 US$.

Site	*Estimated Value of Shoreline Protection (Lower Bound)*	*Estimated Value of Shoreline Protection (Upper Bound)*	*Reference*
Belize	$133 million	$199 million	Cooper *et al*. 2009
St. Lucia	$32 million	$55 million	Burke *et al*. 2008
Tobago	$20 million	$36 million	Burke *et al*. 2008

An alternate method for estimating the value of shoreline protection was proposed by Rao *et al*. (2015). They used a meta-analysis of economic valuations to develop a multivariate regression function to estimate the value of shoreline protection provided per unit area of coral reef and mangrove ecosystems around the world. Variables that were significant in predicting the value of coastal protection included the area of the habitat providing coastal protection, the level of development, storm frequency, wind speed, the valuation method used, and per capita gross domestic product (GDP). The authors used a benefit transfer function to extrapolate the value of shoreline protection to unstudied sites. We did not have the spatial or environmental data required to estimate the value of shoreline protection in Curaçao from their model, but the range of values for other locations in the Caribbean was $0.52-2,574/ha/year (in 2015 US$). The level of development was the most important factor in driving variation in values (Figure D1). Development was measured by the relative intensity of existing coastal infrastructure and the general development pressure as determined using the $GLOBIO_3$ model, a model developed to assess human-induced changes in biodiversity (Alkemade 2009). Given the level of development in Curaçao, it is likely that the per-hectare value of shoreline protection falls at the higher end of the range of values reported by Rao *et al*.

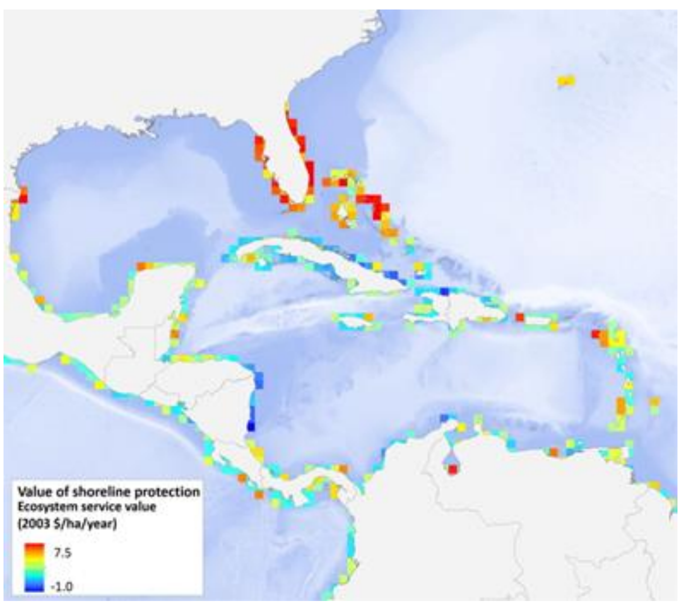

Figure D1. Estimates of the value of shoreline protection across the Caribbean (Rao *et al*. 2015, Figure 5). Values in the legend are presented as the natural log of the true value. No data were available to provide estimates for Curaçao.

Limitations and Caveats

Despite the proliferation of coastal marine ecosystem valuation studies over the past two decades, there are no consistent methodologies for estimating the economic value of many ecosystem goods and services. As a result, results vary widely from study to study (Barbier *et al*. 2011; Clifton *et al*. 2014). This means that decisions about which study to apply to a given location can have a significant impact on the subsequent estimate of economic value. Transferring benefits across international borders poses additional challenges, since different incomes across countries can impact the value of ecosystem goods and services, as can different cultural values and institutional structures (Ready & Navrud 2006).

Furthermore, our method of reporting the average value per hectare for each habitat type may obscure important variation in the amount of value generated by different areas of habitat and lead to assumptions that all areas are equally valuable. In fact, there is likely to be high spatial variability in habitat value. For example, a coral reef that is used frequently by dive operators, such as Marie Pampoen or Tugboat, will generate far more value for the tourist industry than a patch of reef that is never used for snorkeling or diving. A degraded reef is also likely to generate less value than a healthy reef, as a reef with reduced coral cover and fish abundance is less likely to be utilized by dive shops or fishers. Similarly, healthy corals with high levels of structural complexity play a greater role in shoreline protection than reefs that have lost their large, branching corals (Graham & Nash 2013). Our reported values represent averages for coral reef, mangrove and seagrass habitat in Curaçao, but when using these values for policy decisions, it is essential to take smaller-scale variation into account.

In addition to these important caveats, there are several ecosystem services which are either unassessed or unutilized in Curaçao. We describe these additional sources of value in the following sections (“Unassessed Habitat Values” and “Potential Additional Values”).

Unassessed Habitat Values

There are several important habitat values that we were unable to assess due to a lack of both local data and appropriate studies for benefit transfers. These values, not included in our summaries of the total value provided by each habitat type, may contribute substantially to Curaçao’s economy and the health and well-being of the island’s residents.

Local and Informal Recreation

Our estimates of the value of marine recreation (Appendix B) only account for foreign tourists’ expenditures in diving and snorkeling. Informal marine recreation by local residents may not directly add money to Curaçao’s economy, but it may still be an important source of value. Studies in other islands in the Dutch Caribbean using in-depth surveys have found that local residents would be willing to pay annual fees to maintain access to high-quality marine recreation activities (Dekker *et al*. 2014; van der Lely *et al*. 2014).

Water Quality, Waste Assimilation, and Nutrient Cycling

The interconnected systems of coral reefs, mangroves, and seagrass beds play important roles in maintaining water quality, assimilating waste, and cycling nutrients. Coral reefs exposed to increased nutrient inputs, siltation, and turbidity suffer increased mortality, decreased recruitment and biodiversity, and phase shifts to algal-dominated systems (Fabricius 2005; Fabricius *et al*. 2005). Mangroves and seagrass beds reduce siltation and pollution on reefs by taking up nutrients and decreasing the concentration of suspended particles in the water column (Koch *et al*. 2006; Duke & Wolanski 2001). Mangroves have been used successfully to treat wastewater in China, removing dissolved organic carbon, nitrogen, ammonia, and polycyclic aromatic hydrocarbons (Chen *et al*. 2009). Finally, coral reefs host nitrogen-fixing organisms that help transfer excess nitrogen, enhancing pelagic productivity (Moberg & Folke 1999).

We did not estimate the value of these ecosystem functions in Curaçao because these values have not been reliably estimated for seagrasses or coral reefs, even in other comparable locations (Barbier *et al*. 2011). A global meta-analysis of mangrove ecosystem services found that the value of water quality maintenance, waste assimilation, and nutrient cycling in mangroves is approximately $4,900/ha/year (Salem & Mercer 2012). We expect the value of this ecosystem service to be particularly high in Curaçao because of the lack of adequate wastewater treatment on the island.

Seagrass Sediment Stabilization

By reducing wave height, current velocities, and sediment resuspension, seagrass meadows protect shorelines from erosion and reduce the turbidity of coastal marine ecosystems (Terrados & Borum 2004). This is an indirect, non-consumptive value. While there are no reliable, direct estimates of the value generated by seagrass habitats' role in sediment stabilization (Barbier *et al*. 2011), the costs of replanting seagrasses to control erosion in the US and Australia are $25,000-50,000/ha/year (Rönnbäck *et al*. 2007). Replacing natural seagrass habitat may be more economically optimal than building structures to control erosion. For example, estimated initial construction costs for artificial seawalls to mitigate erosion begin at $3 million per km of shoreline. These artificial structures have a limited lifespan, and continual maintenance can be costly (Moberg & Rönnbäck 2003).

Aesthetics, Cultural Heritage, and Spiritual Value

The Millennium Ecosystem Assessment identified aesthetic, cultural heritage, and spiritual values as important services provided by healthy ecosystems (Hassan *et al*. 2005). However, these benefits are largely intangible and thus difficult to express in terms of economic value (Chan *et al*. 2012). We did not attempt to assign an economic value to these ecosystem services in Curaçao but acknowledge the importance of these non-consumptive and non-use values.

Species Protection and Biodiversity

Like cultural heritage and spiritual values, species protection and biodiversity are non-use values that are largely intangible. This value, often termed "existence value," reflects the utility that people derive from the knowledge that biological diversity exists (Nunes *et al*. 2001). Methods for assigning an economic value to this ecosystem service include willingness-to-pay studies and analyses of charitable contributions to conservation organizations (Turpie 2003). As in the case of aesthetic, cultural, and spiritual values, we did not attempt to assign a value to this ecosystem service in Curaçao.

Potential Additional Values

There are also several ecosystem goods and services that are not currently generating value in Curaçao but could do so in the future, if industries are developed to exploit their value.

Pharmaceutical Products

Coral reefs harbor high levels of biodiversity and have already proved themselves to be fertile ground for the extraction of potential pharmaceutical products (Adey 2000). Researchers from the US's National Cancer Institute have worked at the Curaçao Sea Aquarium, studying the bioactive compounds in corals, sponges, algae, and other marine organisms in search of potential biomedical and pharmaceutical products (Curaçao Sea Aquarium 2016). The discovery and development of biomedical products in Curaçao's coral reefs represents a large potential value: a study of the potential value of bioprospecting in Montego Bay, Jamaica found the potential pharmaceutical value of the reef to range from $72,500/ha to $698,000/ha (Ruitenbeek & Cartier 1999). This value is not directly transferable to Curaçao because of the age of the study and the high dependence on local factors such as the species richness, site-specific costs of prospecting, and royalty rates and revenue sharing agreements. The value also depends on the probability of developing a marketable drug from a given sample, the expected future value of the drug, and the costs and length of the research and development period (Ruitenbeek & Cartier 1999). Nevertheless, given the National Cancer Institute's current interest in Curaçao, it is likely that the island's reefs represent an untapped resource.

Comparatively less research has been conducted on the pharmaceutical potential of compounds derived from organisms in mangrove and seagrass habitats. Nevertheless, mangroves yield many compounds used in traditional medicine (Bandaranayake 1998) and bioactive compounds with a range of useful properties, including anti-viral and anticancer properties, have been extracted from mangroves (Kathiresan *et al*. 2013; Das *et al*. 2015). Extracts from seagrasses and associated actinobacteria have similarly been found to have a variety of potential pharmaceutical uses, including anticancer, antiparasitic, and anti-HIV properties, as well as uses as mosquito larvicides (Ali *et al*. 2012; Subhashini *et al*. 2013; Valliappan *et al*. 2014). As in the case of coral reefs, the potential economic value from these biological compounds depends on local factors such as the presence of useful species, the costs of finding and extracting relevant compounds, and royalty rates and revenue sharing agreements.

Mangrove and Seagrass Tourism

Ecotourism is an increasingly popular subsector of the tourist industry in some areas in the Caribbean, as an alternative to the typical focus on sea, sand, and sun (Scleupner 2008). Mangrove forests are a common destination for ecotours, offering a unique setting for bird watching, kayaking, or forest walks (Walton *et al*. 2006). Seagrass habitats have also been utilized by ecotourism operations in Belize for snorkeling and educational purposes (Kangas *et al*. 1995) and for the viewing of sea turtle feeding grounds in Queensland, Australia (Tisdale & Wilson 2000). Although mangrove- and seagrass-focused ecotourism is not currently promoted in Curaçao, it is a potential option for generating additional revenue in the tourism sector, increasing the direct, non-consumptive value of these habitats.

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Appendix E. Additional Resources for Economic Valuation

Case Studies of Marine and Coastal Resource Valuation

Burke L, S Greenhalgh, D Prager, & E Cooper. 2008. Coastal capital: economic valuation of coral reefs in Tobago and St. Lucia. Washington, DC: World Resources Institute. 66pp.

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Tools for Estimating the Value of Ecosystem Services

World Resources Institute Coastal Capital Valuation Tools:
http://www.wri.org/our-work/project/coastal-capital-economic-valuation-coastal-ecosystems-caribbean/coastal-capital

- Tourism & Recreation Valuation Tool
- Fisheries Valuation Tool
- Marine Protected Area Economic Impact Tool

Integrated Valuation of Environmental Services and Tradeoffs (InVEST):
www.naturalcapitalproject.org/InVEST.html

- Guerry AD, MH Ruckelshaus, KK Arkema, JR Bernhardt, G Guannel *et al*. 2012. Modelling benefits from nature: using ecosystem services to inform coastal and marine spatial planning. *International Journal of Biodiversity Science, Ecosystem Services and Management*, 8(1-2), 107-121.

Descriptions of Methods for Valuing Natural Resources and Ecosystem Services

The US Department of Agriculture's Natural Resources Conservation Service and the National Oceanographic and Atmospheric Administration describe the purpose of ecosystem valuation and outline various methods: http://www.ecosystemvaluation.org/.