Economic Valuation Methodology

by Lauretta Burke and Jonathan Maidens, World Resources Institute, 2004

This paper provides additional background notes on the economic valuation of Caribbean coral reefs presented in Chapter 5 of the *Reefs at Risk in the Caribbean* report.

Fisheries

The economic value of fisheries associated with both healthy and degraded coral reefs was assessed through an "effect on production" approach.

Fisheries Production

Previous studies of the productivity of coral reef fisheries in the Caribbean[1] and in Southeast Asia[2] provided guidelines for determining productivity declines on degraded coral reefs. Fisheries productivity on Caribbean coral reefs overall ranged between 0.5 and 5.0 mt/km^2/yr. Degraded coral reefs produced much less, averaging between 17 percent and 44 percent of the productivity of healthy reefs. For our estimate, we used the following productivity coefficients:

- For coral reefs regarded as healthy or classified as being under low threat, productivity of 4 mt/km^2/yr was used.
- For reefs under medium threat, productivity was assumed to decline to between 2.3 mt and 2.9 mt/km^2/yr.
- For reefs classified as under high threat, productivity of 0.7 and 1.7 mt/km^2/yr was used.

Degradation scenarios are for 2015. The *Reefs at Risk* Threat Index was used to estimate coral reef area in each threat category. By multiplying, we derived coral reef fisheries–related production for both the "healthy" and "degraded" categories (see Table 1).

Table 1. Threatened Reefs, by Category

Fisheries Production Scenario	Assumed Maximum Sustainable Fisheries Production (mt/km^2/yr)	Reef Area (km^2)	Fisheries Production for the Caribbean (mt/yr)	Gross Revenues (US$ million)	Net Revenues (US$ million)
Healthy reefs (in 2000)	4	26,000	104,000	624	312
Reef degradation by 2015 (using Reefs at Risk Threat Index values)					
Reefs under low threat	*4*	*9,400*	*37,400*		
Reefs under medium threat	*2.3–2.9*	*5,400*	*12,700–15,600*		
Reefs under high threat	*0.7–1.7*	*11,200*	*7,400–19,200*		
Total (in 2015)		26,000	57,500–72,200	346–434	173–217
Decline/Loss			**31,700–46,400**	**190–278**	**95–139**

Fisheries Revenue

Current market prices for reef-related fish average about $6/kilogram (kg).[3] This average was used for all calculations of gross revenue. Although declines in productivity (and associated harvest) could reduce supply and serve to increase price, overfishing of reefs will also result in catches of smaller and less valuable fish, and so could offset price increases. Fishing costs

– vessels, fuel, gear etc. – vary widely between the United States and developing countries within the region, ranging between 20 and 90 percent.[4] We have chosen 50 percent net return of gross revenues as an average for the region.

Tourism and Recreation

Analysis of the economic value of tourism and recreation related to coral reefs used a "financial revenue" approach and focused on the gross revenue and net benefits associated with dive tourism.

Number of Divers and Gross Revenue from Dive Tourism

The estimate of numbers of divers in the region and associated gross revenue is based on integration and cross-tabulation of several data sources. Two market survey reports by the Cline Group provided detailed information on divers from the United States:

- Cline Group. 1995. "Diving Manufacturer and Travel Industry Retailer Study" and Cline Group. 1997. "Diving Industry Consumer Study". Both online at http://www.clinegroup.net/diving.

These data were supplemented with information from:

- Personal communication with William R. Cline (November, 2003).
- Caribbean Tourism Organization (CTO), *Caribbean Tourism Statistical Report: 2000-2001* (Barbados: CTO, 2002).
- P. Pattullo, *Last Resorts - the Cost of Tourism in the Caribbean* (London, UK: Cassell, 1996), 220pp.
- E. Green and R. Donnelly. 2003. "Recreational Scuba Diving in the Caribbean Marine Protected Areas: Do the users pay?" *Ambio* 32 (2): 140-144
- G.M. Johns et al., *Socioeconomic Study of Reefs in Southeast Florida: Final Report* (Hazen and Sawyer, Florida State University and National Oceanic and Atmospheric Administration, 2001). Online at http://marineeconomics.noaa.gov

Net Benefits from Dive Tourism

The study estimated net benefits to the local economy by adjusting these estimated gross expenditures for costs such as transportation, fuel, boat expenses, etc. (assumed to be 65 percent of total expenditure) and then accounting for a multiplier effect due to expenditures rippling through the local economy (assumed to be 25 percent).[5]

Losses of Revenue due to Degradation

To estimate potential losses in tourism revenue due to projected trends in coral reef degradation, the Reefs at Risk Threat Index was used as a proxy for future reef condition. It assumed a percentage decline in dive tourism (ranging between 1 and 10 percent) and associated lost revenue for reefs at medium or high threat. These percentage declines were conservative best estimates, based on a synthesis of expert opinion. Reefs under low threat retain 100 percent of revenue in the future; medium-threat reefs retain between 95 and 99 percent, while high-threat reefs retain between 90 and 99 percent of gross tourism receipts. These were summarized by country and then for the region, resulting in losses estimated at between 2 percent and 5 percent of the total.

Future gross revenue under a "no degradation" scenario was based on assumed continued growth of dive tourism at 7 percent per year. The "degradation scenario" assumes that degradation reduces tourism by 2015 and applies the percentage reductions described above (totaling 2 to 5 percent) to the revenues that might have accrued by 2015 from a base that was increasing at 7 percent annually.

Shoreline Protection

To analyze the economic contribution of shoreline protection services provided by Caribbean coral reefs, the study estimated the extent of the region's shoreline protected by coral reefs, the value of the shoreline protection services provided by these reefs (based on costs required to replace them by artificial means), and potential losses in the annual benefits of shoreline protection services due to reef degradation.

Extent of Shoreline Protected by Coral Reefs

Using data on shoreline and coral reef location, and identifying coastline within 2 km of a mapped coral reef as "protected" by the reef, the study estimated that coral reefs protect about 21 percent of the coastline of the Caribbean region (about 18,000 km in length). When we exclude the US coastline, our estimate increases to 29% of the coastline being protected by coral reefs.

Data Sources:

- Shorelines—World Vector Shoreline (E.A. Soluri and V.A. Woodson. 1990. "World Vector Shoreline". *International Hydrographic Review*, LXVII(1)) and NIMA. 1997. "VMAP National boundaries". Land areas of 100 hectares minimum were identified, and the associated shoreline was converted into a GRID for the analysis
- Coral Reefs—Data set developed under the *Reefs at Risk Caribbean* project. See Appendix B of L. Burke and J.Maidens *Reefs at Risk in the Caribbean* (Washington, DC: World Resources Institute, 2004) for full list of compiled data sources.

Value of Coastal Protection

To estimate the economic value of the shoreline protection services provided along these coastlines, we relied on earlier studies[6] and estimates of past expenditures for artificial replacement of this protection.[7] These estimates ranged from about US$50,000 to US$800,000 or more for each kilometer of coastline protected by coral reefs. The value of the coastal protection service varies with the level of development along the shoreline, population density, and presence of a tourism industry. Values used in this study ranged from US$2,000 to US$1,000,000 per kilometer of coastline protected by coral reef, as follows:

- Low development areas (fewer than 100 people within a 5-km radius) used a value range of US$2,000 to US$20,000 per kilometer of coastline.
- Medium development areas (100 to 600 people within a 5-km radius or located within 5 km of a dive center) had values ranging between $30,000 and $60,000 per kilometer of coastline.
- High development areas (more than 600 people within a 5-km radius) used a range of US$100,000 to US$1,000,000 per kilometer of shoreline.

Of shoreline in the region "protected by" coral reef, 29 percent was in low development areas, 27 percent in medium development areas, and 44 percent in high development areas.

We combined these shoreline development classifications with the values (ranges) to estimate the value of shoreline protection service provided by healthy coral reefs. Because only a few shoreline segments are likely to be at the high extreme of value, we developed our ranges as follows: Low end = 100 percent of shoreline is at low end of value range; High = 75 percent at low end of and 25 percent at high end of range. Using this approach, we arrive at a total value of $750 million to $2.2 billion.

Losses in Coastal Protection

Using threat estimates from this study as a proxy for future coral reef condition, we estimated associated declines in the coastal protection function on the basis of the threat level of the nearest coral reef. According to our calculations, 84 percent of the shoreline areas currently protected by coral reefs will eventually experience some reduction in this service (67 percent are near highly threatened reefs, and 18 percent are near reefs identified as being under medium threat.) Table 2 shows our cross-tabulation.

Table 2. Shoreline Classified by Closest Coral Reef's Development and Threat Levels (percent)

		Threat Level of Nearest Reef			TOTAL
		Low	Medium	High	
Development Level of Shoreline	Low	14	9	6	**29**
	Med	2	7	18	**27**
	High	0	1	42	**44**
TOTAL		**16**	**18**	**67**	**100**

To estimate the loss in coastal protection function, we assumed that shorelines adjacent to reefs under low threat retain 100 percent of their current coastal protection service; shoreline's near reefs under medium threat retain 90 percent of their current coastal protection function; and shorelines near reefs under high threat retain 80 percent of current service. Since data on this topic are limited, these estimates were developed by the Reefs at Risk project, in collaboration with project partners. Loss of this service will be much slower to manifest itself than other ecosystem function losses, because of the time required for erosion and reef loss to occur, but could be expected within the next 50 years.

[1] J.L. Munro. 1974. "The biology, ecology, exploitation and management of Caribbean reef fishes. Part VI. Assessment of the potential productivity of Jamaican fisheries." *Research Reports from the Zoology Department of the University of the West Indies* 3 (VI): 1-55; R. Mahon. 1993. "Lesser Antilles," in *Marine Fishery Resources of the Antilles: Lesser Antilles, Puerto Rico and Hispaniola, Jamaica, Cuba.* FAO Fish. Tech. Pap., No. 326, pp. 1-98.; Sary, J.L.Munro and J.D. Woodley. "Status report on a Jamaican fishery: Current value and the costs of non-management," in Proceedings of the Fifty-fourth Annual Gulf and Caribbean Fisheries Institute. L. Creswell, ed. (Fort Pierce, Florida: GCFI, 2003).

[2] D.E. McAllister. 1988. "Environmental, economic and social costs of coral reef destruction in the Philippines." *Galaxea* 7:161-178 estimated coral reef fisheries productivity at 18 mt/km^2/yr on reefs in excellent condition; 13 mt/km^2/yr on reefs in good condition, and 8 mt/km^2/yr on reefs in fair condition, and 3 mt/km^2/yr on reefs in poor condition. Reefs in Southeast Asia have higher productivity than Caribbean reefs, but overall proportions are informative.

[3] Z. Sary, J.L.Munro, and J.D. Woodley. "Status Report on a Jamaican Fishery: Current Value and the Costs of Non-Management," in *Proceedings of the Fifty-fourth Annual Gulf and Caribbean Fisheries Institute.* L. Creswell, ed. (Fort Pierce, Florida: GCFI, 2003).

[4] Kearney and Centaur. 1984. "Economic Impact of the Commercial Fishing Industry in the Gulf of Mexico and South Atlantic Regions." *Final Report 8318 to the Gulf and South Atlantic Fisheries Development Foundation, Inc* suggest returns in United States fisheries ranging between 11 and 36 percent. Pomeroy (*Economic Analysis for the Siting of Marine Protected Areas: A Case Study in the British Virgin Islands*, unpublished) found returns of about 80 percent in the British Virgin Islands.

[5] Net benefits from tourism and the multiplier used were adapted from H. Cesar, P. Beukering and G. Berdt Romilly, *Mainstreaming Economic Valuation in Decision Making: Coral Reef Examples in Selected CARICOM-Countries* (Arnhem, The Netherlands: World Bank and ARCADIS Euroconsult, 2003) Their analysis used "value added of direct expenditures" of 25-40 percent and a multiplier of 25 percent.

[6] H. Cesar, ed., *Collected Essays on the Economics of Coral Reefs* (Kalmar, Sweden: CORDIO, 2000); H. Cesar, L. Burke and L. Pet-Soede, *The Economics of Worldwide Coral Reef Degradation* (Zeist, The Netherlands: WWF Netherlands, 2003).

[7] H. Berg, et al.. 1998. "Environmental Economics of Coral Reef Destruction in Sri Lanka," in *Ambio* 27 (8): 627-634; S.J. Williams, K. Dodd, and K.K. Gohn. 1995. "Coast in Crisis." *US Geological Survey Circular* 1075; Herman Cesar, personal communication.