Economic Values of Coral Reefs, Mangroves, and Seagrasses

A Global Compilation

2008

CONSERVATION INTERNATIONAL

THE OCEAN FOUNDATION

ICRI

NOAA

WORLD RESOURCES INSTITUTE

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ICRI is a unique public-private partnership that brings together governments, international organizations, scientific entities, and non-governmental organizations committed to reversing the global degradation of coral reefs and related ecosystems, such as mangrove forests and seagrass meadows, by promoting the conservation and sustainable use of these resources for future generations.

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Suggested citation: Conservation International. 2008. *Economic Values of Coral Reefs, Mangroves, and Seagrasses: A Global Compilation.* Center for Applied Biodiversity Science, Conservation International, Arlington, VA, USA.

Photos:
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Valuation cases compiled by Sharon Khan and Cecilia Larrosa.

Foreword

TROPICAL MARINE AND CORAL REEF ECOSYSTEMS, including mangroves and seagrasses, are vulnerable environmental resources that provide significant economic goods and services and contribute to the livelihoods, food security and safety of millions of people around the world. The health of these resources is critical to human well-being. By accounting for coastal marine and coral reef ecosystem values in management decisions, we can sustain their flow of goods and services in the interest of current and future generations.

Recognizing the importance of economic valuations, in January 2008, the International Coral Reef Initiative (ICRI) established an Ad Hoc Committee on Economic Valuation of Coral Reef Ecosystems. The Committee is co-chaired by the Mexico-United States ICRI Secretariat and the World Resources Institute (WRI), and has as its primary responsibility the compilation of an inventory of studies, articles and publications to support ICRI members in coral reef valuation.

Toward this effort, Conservation International's Marine Management Area Science Program has produced "Coral Reefs, Mangroves and Seagrass Economic Values: A Global Compilation," in cooperation with The Ocean Foundation's Coastal Ocean Values Center, the WRI, and the United States National Oceanic and Atmospheric Administration (NOAA). The booklet compiles the results of a wide variety of economic valuation studies on coral reef and related ecosystems around the world, with a focus on the following ecosystem goods and services:

- **Tourism:** People the world over visit coral reefs to enjoy the recreational opportunities that these ecosystems provide, including SCUBA diving, snorkeling, and glass-bottom-boat viewing.

- **Fisheries:** Coral reefs and their surrounding ecosystems, including mangroves and seagrass beds, provide important fish habitat.

- **Coastal protection:** Coral reefs serve as natural barriers to storm surges that can cause great destruction to coastlines and communities.

- **Biodiversity:** The United Nations' *Atlas of the Oceans* describes coral reefs as among the most biologically rich ecosystems

on earth, with about 4,000 species of fish and 800 species of reef-building corals described to date.

- **Carbon sequestration:** Coral reefs remove carbon dioxide from the atmosphere and are thus important for the mitigation of global warming.

Section 1 of the booklet summarizes a sample of economic values for coral reef and surrounding ecosystems estimated at global, regional and site-specific levels. Section 2 provides a summary of values with a focus on tourism and recreation, fisheries, coastal protection, biodiversity, and carbon sequestration. Section 3 provides a sample of values for the degradation or loss of ecosystem services. References for these valuations are listed at the end of the booklet. The studies referenced have been peer-reviewed and published. However, their inclusion here is not an affirmation of the findings. It is also important to note that many of the values presented are not necessarily comparable across studies and sites. We encourage the readers to view the original sources for details on the contexts, methodologies and suitable uses of each result in this booklet.

We hope this global compilation will be a useful reference for marine area managers, policy makers, community stakeholders, and others interested in improving the conservation of coral reef and associated coastal ecosystems. The data presented in this booklet are highlighted in a global map available online at www.consvalmap.org. For more details, you can access many of the referenced technical papers and journal articles by joining the Coral Reef Economics Community of Practice; www.communities.coastalvalues.org/coralreef.

There are many efforts currently underway to value coral reefs, mangroves and seagrasses. The website will continue to be updated and we welcome additional statistics, which can be sent to www.consvalmap.org.

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Section 1: Global, Regional, and Site-Specific Values

This section contains a sample of values for coral reefs and surrounding ecosystems estimated at the global, regional and site-specific levels. Some of these summaries note values for ecosystem goods and services including tourism and recreation, fisheries, coastal protection, biodiversity, and carbon sequestration that are presented in Section 2.

Global Values

By one estimate, the total net benefit per year of the world's coral reefs is $29.8 billion. Tourism and recreation account for $9.6 billion of this amount, coastal protection for $9.0 billion, fisheries for $5.7 billion, and biodiversity for $5.5 billion (Cesar, Burke and Pet-Soede, 2003).

A 2006 meta-analysis of wetlands valuation studies around the world found that the average annual value is just over $2,800 per hectare (Brander, Florax and Vermaat, 2006).

A 2007 study found that the total value of ecosystem services and products provided by the world's coastal ecosystems, including natural (terrestrial and aquatic) and human-transformed ecosystems, added up to $25,783 billion per year (Martinez et al., 2007).

Regional Values

Southeast Asia

The total potential sustainable annual economic net benefits per km² of healthy coral reef in Southeast Asia is estimated to range from $23,100 to $270,000 arising from fisheries, shoreline protection, tourism, recreation, and aesthetic value (Burke, Selig and Spalding, 2002).

Caribbean

The annual net benefits provided by coral reefs through fisheries, dive tourism, and shoreline protection services were between $3.1 billion and $4.6 billion in 2000. The net benefits from dive tourism were the largest share of this total, at $2.1 billion, followed by shoreline protection services at $700 million to $2.2 billion, and fisheries at $300 million (Burke and Maidens, 2004).

Site-Specific Values

Citations are listed alphabetically by country.

Atlantic Ocean

The incremental benefits of the coral reefs and mangroves in **Jamaica's** Portland Bight Protected Area (PBPA) were estimated to be $52.6 million in present value terms for an optimistic tourism scenario, and $40.8 million in a pessimistic tourism case, calculated over a 25-year period and at a 10% discount rate. Fisheries accounted for about $19.0 million of the net present value, tourism for about $11.0 million, carbon sequestration for $4.0 million, coastal protection for $366,000, and biodiversity for $18.0 million. The incremental costs of the PBPA estimated in net present values terms amounted to $19.2 million (Cesar et al., 2000).

The net present value of **Jamaica's** Montego Bay reefs is approximately $400.0 million, with tourism and recreation, fisheries, and coastal protection accounting for $315.0 million, $1.3 million and $65.0 million, respectively. The biodiversity of Montego Bay reefs has a net present value of $13.6 million to tourists and $6.0 million to Jamaica residents (Ruitenbeek and Cartier, 1999).

The coral reefs in **Jamaica's** Montego Bay Marine Park were valued for tourism, fisheries, and coastal protection. The Net Present Value (NPV) in 1996 associated with tourism ranged from $210.0 million (using a 15% discount rate) to $630.0 million (using a 5% discount rate). The NPV in constant 1996 dollars associated with fishing ranged from $1.7 million to $7.5 million. The NPV of the total amount (250 acres) of land at risk of erosion was estimated to be $65.0 million (in constant 1996 dollars) (Gustavson, 1998).

A 2005 report found that coral reefs make a valuable contribution to the **Turks and Caicos Islands**, estimated at $47.3 million a year. Tourism and diving accounted for $18.2 million per year, fisheries $3.7 million per year, coastal protection $16.9 million per year, and biodiversity $4.7 million per year. Of this total, $17.7 million a year fed directly into the GDP, constituting 7.8% of the annual GDP for this small country (Carleton and Lawrence, 2005).

Indian Ocean

In 2002, a study evaluated the Total Economic Value (TEV) of the mangroves in **Egypt**, finding that it could be as high as $182,000 per year ($91,000/ha/yr) at Ras Mohammed Park and as high as $1.3 million per year ($24,000/ha/yr) at Nabq Protected Area (Spurgeon, 2004).

Using a dynamic simulation model, a study analyzed the Total Economic Value (TEV) of the Leuser National Park, **Indonesia**, from 2000–2030. With a 4% discount rate, the accumulated TEV for the ecosystem over the 30-year period was $7.0 billion under the 'deforestation scenario', $9.5 billion under the 'conservation scenario', and $9.1 billion under the 'selective utilization scenario'. Water supply, flood prevention, tourism and agriculture contributed the most in the conservation and selective utilization scenarios (Van Beukering, Cesar and Janssen, 2003).

A 2005 Total Economic Value (TEV) assessment of the Rekawa mangrove-lagoon ecosystem, **Sri Lanka**, found that it was $1,088/ha/year, or $217,600 per year, based on 200-ha of mangrove. Forestry net benefits accounted for $4,800 per year, lagoon fishery $53,600 per year, coastal fishery $98,600 per year, erosion control and buffer against damage from storms $60,000 per year, and existence, bequest and option values to local communities $520 per year (Gunawardena and Rowan, 2005).

In 1998, a study estimated the value of **Sri Lanka's** coral reefs to be between $140,000 and $7.5 million per km² over a period of 20 years (Berg et al., 1998).

A 2003 study estimated the monetary benefits of wetlands in Muthurajawela, **Sri Lanka**, finding an economic value of $8.1 million a year, or $2,700 per hectare. Flood attenuation accounted for $5.4 million; industrial wastewater treatment $1.8 million, support to downstream fisheries $220,000, firewood $88,000, fishing $70,000, leisure and recreation $60,000, domestic sewage treatment $48,000, freshwater supplies for local populations $42,000, and carbon sequestration $8,700. As is typical for urban wetlands, ecosystem services contributed most (90%) of this value, followed by fisheries (36% of total resource use values) (Emerton and Kekulandala, 2003).

A 1998 study found that converting the Surat Thani mangrove system in the south of **Thailand** to aquaculture did not make economic sense once external costs were included. The value of the original mangrove cover—from timber, charcoal, non-timber forest products, offshore fisheries, and storm protection—fell to almost zero following conversion. Summing all measured goods and services, the total economic value of intact mangroves was 3.6 times as high as that of shrimp farming

($60,400 compared to $16,700 Net Present Value, using a 6% discount rate over 30 years (Sathirathai, 1998 cited in Barbier, 2000).

Contingent valuation was used to estimate utility values associated with coral reef biodiversity at Phi Phi, **Thailand**. The mean Willingness To Pay (WTP) per visit was estimated at $7.17 for domestic visitors and $7.15 for international visitors, or $147,000 a year for domestic visitors and $1.2 million a year for international visitors. The study also calculated the mean WTP of vicarious domestic users at $15.85. The total value of the reefs was estimated to be $497.4 million per year, or $15,118 per hectare per year (Seenprachawong, 2004).

Pacific Ocean

The total value-added economic contribution of tourism, commercial fishing, and cultural and recreational activity to **Australia's** Great Barrier Reef Catchment Area was estimated at $3.7 billion per year (Access Economics, 2007).

The annual values of coral reefs of **American Samoa** were estimated at $5.1 million per year, and the Territory's mangroves at $750,000 per year. The added values account for 1.2% of the American Samoa GDP. A few of the most important benefits provided by coral reefs and mangroves included $755,000 per year from fisheries, $73,000 per year benefit resulting from recreational uses, $70,000 per year from bottom fishing, and $582,000 per year from benefits relating to shoreline protection (JacobsGIBB Ltd., 2004).

An economic analysis of Ream National Park, **Cambodia** (2000) surveyed households in local communities, looking at social, economic and ecological data, and the costs and benefits of three protected area management scenarios: (1) some protection is achieved, but fisheries eventually collapse; (2) the "ghost park" scenario, in which all timber and fish are harvested, destroying the area; and (3) the "dream park" scenario that allows subsistence activities, recreation, education and research. At a 10% discount rate, the dream park had the highest net present value ($11.9 million). This compared with $10.0 million for the ghost park and $9.8 million for partial protection scenario. The dream park scenario had the highest Net Present Value, exceeding the ghost park by nearly $2.0 million. However, protection scenarios allocated the bulk of the Park's benefits to local communities. The dream park conferred three times more benefit value to villagers compared with the ghost park; $2,729 per household versus $919 per household. The dream park

scenario confered a present value (before costs) of $12.6 million to local communities, compared with $7.3 million for the partially protected park, and $4.3 million for the ghost park. The Present Value (10%, 20 years) of fisheries for the partially protected park was $5.2 million; for the ghost park it was $3.6 million; for the dream park it was $7.9 million; and for recreation it was $21,390 to $699,636 (De Lopez, 2003).

The average yearly household value of the Veun Sean wetland, **Cambodia** was $3,200 in 2005, with $425 per household per year in fisheries value, or $650 per year to poorer households from income earned from selling fish, mainly used to purchase the food staple, rice (De Groot et al., 2006).

The Total Economic Value (TEV) of the reefs of **Commonwealth of the Northern Mariana Islands** was estimated at $61.2 million per year. The market values comprised 73% of the TEV, and the non-values comprised the rest. Tourism accounted for $42.3 million per year, fisheries for $1.3 million per year, coastal protection for $8.0 million per year, and diving and snorkeling $5.8 million per year (Van Beukering, 2006).

In 2007, the Total Economic Value for **Guam's** reefs was estimated at $127.3 million per year, with tourism accounting for approximately 75% of this value ($94.6 million per year), diving and snorkeling for $8.7 million per year, fisheries for $4.0 million per year, biodiversity for $2.0 million per year, and coastal protection for $8.4 million per year (Van Beukering et al., 2007).

The average annual value of the coral reef ecosystems of the main **Hawai'ian Islands** (Hawai'i, Maui, Oahu, Kauai, and Molokai) has been found to amount to $364.0 million. This leads to a Net Present Value of nearly $10.0 billion calculated over 50 years with a discount rate of 3% (Cesar and Van Beukering, 2004).

Potential sustainable economic net benefits per year from coral reefs in **Indonesia**—from fisheries, shoreline protection, tourism, and aesthetic value—have been estimated at $1.6 billion per year (Burke, Selig and Spalding, 2002).

The Total Economic Value of coral reefs in **Indonesia's** Wakatobi National Park in Southeast Sulawesi was estimated to be $308,000 or $12,100/km². The Net Present Value over 20 years with a 10% discount rate is estimated at $2.6 million. Fisheries produced an average of $10,340 per km²

annually and had a present value (PV) of over $2.2 million, calculated over 20 years with a 10% discount rate. Eco-tourist revenues provided almost $1,320 per km² in 2004 and an expected PV of $286,000. The indirect benefit of coastal protection was estimated to be worth $1,320 annually or $473/km² (Hargreaves-Allen, 2004).

The quantifiable net benefits of managing Taka Bone Rate Marine Protected Area (MPA), **Indonesia**, as a protected area were estimated to be between $3.5 and $5.0 million in Net Present Value terms, at a 10% discount rate over 25 years. The creation of MPAs allowed fish stocks and yields to recover, and stopped destructive fishing practices (Cesar, 2002).

A 2002 study analyzed the costs and benefits of coral mining in Lombok, **Indonesia**, looking at the societal costs of coral mining associated with losses to typical reef function. The economic valuation presented two scenarios, one with limited tourism potential and little coastal construction (scenario 'LOW'), and the other with high tourism potential and coastal infrastructure (scenario 'HIGH'). All costs were calculated in Net Present Value terms for a 30-year time horizon. Combining the net profits from mining with the societal costs, the economic loss of mining to society was found to be $33,000 per km² for a 'LOW' value scenario, and $762,000 per km² in the 'HIGH' scenario. For both scenarios, therefore, coral mining constituted a significant, long-term loss to society. The net loss of the fishery function was valued at $74,900 in both scenarios; loss of the tourism $2,900 for the 'LOW' scenario and $481,900 for the 'HIGH' scenario; and loss of coastal protection $12,000 for the 'LOW' scenario and $260,000 for the 'HIGH' scenario (Cesar, 2002).

The coral reefs, seagrass, mangroves, beaches, intertidal areas, and marine waters of the Bohol Marine Triangle (BMT) in the **Philippines** provide ecosystem goods and services from fisheries, gleaning, seaweed farming, tourism, research, and education. Over a 10-year period and using a 10% discount rate, the BMT provided $11.5 million in total net benefits. Tourism and the municipal fisheries accounted for 44% and 39% of the total net benefits. Coral reefs provided $1.3 million in annual revenues, beach and intertidal area provided $1.1 million, marine waters $646,501, mangroves $239,561, and seagrass $105,990 (Samonte-Tan et al., 2007).

The Net Present Value (NPV) of benefits of coral reefs in the South China Sea basin in the **Philippines** was estimated to be Philippine pesos (PhP) 24,700 million, or $449 million, calculated over 20 years with a discount rate of 10%. This NPV translated into approximately PhP 5.3 million per km², or $266,112 per km² per year (Samonte-Tan and Armedilla, 2004).

The potential sustainable economic net benefits per year from coral reefs in the **Philippines** was estimated at $1.1 billion, arising from fisheries, shoreline protection, tourism, and aesthetic value (Burke, Selig and Spalding, 2002).

Based on a pilot survey of divers' Willingness To Pay to enter marine parks in the **Philippines**, annual potential revenues were found to range from $850,000 to $1.0 million on Mactan Island, from $95,000 to $116,000 in Anilao, and from $3,500 to $5,300 on Alona Beach (Arin and Kramer, 2002).

Coral reefs, seagrass, mangroves, and mudflats around Olango Island in the **Philippines** provide goods and services from fisheries, seaweed farming, bird habitat, tourism (SCUBA diving and snorkeling), and wood harvest. Annual net revenue was estimated to be $38,300 to $63,400 per km², or $1.5 to $2.5 million for the entire 40 km² reef area. Another $389,000 was added when wetlands were considered. The costs of managing Olango Island coral reefs and wetland habitats for improved net revenues and conservation would amount to less than $100,000 per year (White, Ross and Flores, 2000).

The 27,000 km² of **Philippines** coral reefs, in their current degraded condition, contribute at least $1.4 billion to the economy each year. In the Apo Island case study, an investment of $75,000 to protect 1 km² of coral reefs was found to return between $31,900 and $113,000 annually in increased fish production and local dive tourism (White, Vogt and Arin, 2000).

In Hon Mun Marine Protected Area in **Vietnam**, the total value-added from the support function of coral reefs was estimated at $2 million for the local fishing and aquaculture industries. Total recreational benefits from the reef-related recreation industry was estimated at $4.2 million. Domestic visitors' Willingness To Pay (WTP) per visit was $3.10 and that for international visitors' was $3.90. Given visitation patterns, the total conservation value of Hon Mun's coral reefs was estimated to be approximately $128,245 for domestic visitors and $114,945 for foreign visitors (Khan Nam et al., 2005).

Section 2: Ecosystem Goods and Services Values

This section presents values for tourism and recreation, fisheries, coastal protection, biodiversity, and carbon sequestration.

Tourism and Recreation

Global

By one account, tourism and recreation account for $9.6 billion of the total $29.8 billion global net benefit of coral reefs (Cesar, Burke and Pet-Soede, 2003).

In 2007, a study estimated that the average global value of coral reef recreation is $184 per visit, in 2000 prices (Brander, Van Beukering and Cesar, 2007).

Atlantic Ocean

Coral reefs, mangroves and seagrasses help to provide safe nesting grounds for endangered marine turtle species. Turtle tourism in **Barbados**, started in 2003 as an "add-on" activity for tourists. That year 1,400 visitors with an average $20–$100 spending per visitor generated $108,000 to dive operators, tour guides, the Barbados Sea Turtle Project, and local business owners (Troëng and Drews, 2004).

In 2004, a study found that **Brazil's** marine turtle conservation program (TAMAR Project) value increased 30% annually from 1998–2002, and was a major income source for local communities, generating $2.6 million in 2001 from sales of turtle t-shirts, hats, etc. (Troëng and Drews, 2004).

In 2003, 300 visitors to **Cape Verde** chose to see nesting loggerhead turtles as one of many activities, with an average spending of $11.50. Estimated gross revenue from this activity was $3,451 annually from 1998 to 2003; a small but locally-important sustainable source of income (Troëng and Drews, 2004).

In the **Caribbean**, the annual net benefits provided by coral reefs from dive tourism were estimated to be $2.1 billion in 2000 (Burke and Maidens, 2004).

An estimated (2003) 15 million dives take place near Florida, **USA**, each year, half of them inside Marine Protected Areas (MPAs). Only 25% of MPAs with coral reefs charge divers an entry or user fee, usually $2–$3 levied per dive or per diver. The revenue generated by these fees is estimated at $1.0 to $2.0 million annually. Protected area agencies in the **Caribbean** have an average financial shortfall of $30 per hectare. This survey suggested that 3.75 million divers visited the region annually, and if user fees of $25 per person were collected, this would raise $93.0 million, or 78% of the $120.0 million shortfall. While oversimplistic, the study demonstrated that major contributions to MPA management in the Caribbean could be made by properly pricing and collecting user fees (Green and Donnelly, 2003).

Tourism to see green turtle nesting in Tortuguero National Park, **Costa Rica**, was found to have an estimated gross revenue of $6.7 million locally. Tourism visitation increased at a rate of 16% per year between 1988 and 2002. In 2002, 50,339 visitors, with an estimated spending of $255 per visitor, entered the park, and turtle nesting had increased by 417% since 1971 (Troëng and Drews, 2004).

Tourism accounted for about $11.0 million out of the optimistic $52.6 million Net Present Value of the incremental benefits of the coral reefs and mangroves in **Jamaica's** Portland Bight Protected Area. The net present value was calculated over a 25-year period and at a 10% discount rate (Cesar et al., 2000).

Tourism accounted for $315.0 million of the approximately $400.0 million Net Present Value of **Jamaica's** Montego Bay reefs (Ruitenbeek and Cartier, 1999).

In a 1998 study, the coral reefs in **Jamaica's** Montego Bay Marine Park were valued for tourism, fisheries, and coastal protection. In 1996, the net present value associated with tourism ranged from $210.0 million (using a 15% discount rate) to $630.0 million (using a 5% discount rate) (Gustavson, 1998).

The total annual Consumer Surplus (CS) benefits of cruise ship and air travelers to **Jamaica's** Montego Bay National Park were estimated at $189.0 and $993.0 million, respectively. The adjusted CS per person is estimated at $586 and the CS per person per trip was $739. The benefit or economic utility that they experience is above and beyond the amount that tourists spend to get to Montego Bay (Reid-Grant and Bhat, 2008).

In an experiment used to value visibility, percent coral cover, and diversity of species in the **Netherlands Antilles'** Bonaire National Marine Park, researchers found that a decline in quality from the current level to 'good' gave an average per person loss of about $45. The decline to 'medium-quality' was about $142 per person and to 'poor-quality' was about $192 per person. Using a discount rate of 3% and assuming a population of users that is steady around 28,000, the corresponding total asset value of the loss at each level was about $42.0 million, $132.0 million, and $179.0 million. If the number of divers grew at 2% annually, these asset values would jump to $126.0 million, $398.0 million, and $538.0 million (Parsons and Thur, 2007).

The net economic value of dive tourism in the **Netherlands Antilles'** Bonaire Marine Park was estimated to be approximately $19.0 million annually. Over a twenty-year period and at a discount rate of 10%, the net present value (in 1993) of benefits to dive tourists was calculated to be $180.0 million. In 1991, the net annual benefits of dive-related tourism were approximately $7.0 million to $8.0 million. The net present value (in 1993) of local net expenditures by tourists would be $74.0 million (Pendleton, 1995).

Direct spending by coral reef-associated tourists contributed an estimated $91.6 million to the economy of **St. Lucia** in 2006—approximately 11% of the GDP. Additional indirect economic impacts from coral-reef associated tourism totaled an estimated $68–$102 million for the same year (Burke et al., 2008).

The Matura Protected Area coastline in **Trinidad and Tobago** has the third largest leatherback nesting population in the world. In 2001, a total of 10,693 visitors paid to participate in marine turtle tours. Spending per visitor was estimated to be between $21 and $390, and the estimated gross revenue for 2001 was $559,014 (Troëng and Drews, 2004).

Diving on coral reefs in the **Turks and Caicos Islands** was worth an estimated $8.3 million per year in 2005 ($7.5 million per year in Gross Value Added and $0.9 million per year consumer surplus). Reefs also support other forms of tourism, worth at least $9.8 million per year ($6.2 million per year in Gross Value Added and $3.7 million per year consumer surplus) (Carleton and Lawrence, 2005).

A 2001 study estimated the recreational value of Buccoo Reef Marine Park in **Tobago**, West Indies. Benefits derived from total annual visitor expenditure in estimates of Net Present Value (NPV) ranged from $9.1 to $18.7 million over a 10-year period for different scenarios. Recreational user benefits were estimated as the total Willingness To Pay of visitors to southwest Tobago, both users and non-users of the park. The mean Willingness To Pay by all respondents, including those not willing to pay, ranged from $3.70 to $9.30. The resulting estimates showed an equivalent surplus of $600,000 to $2.5 million in NPV depending on the resulting environmental quality implied by the scenarios (Brown et al., 2001).

Direct spending by coral reef-associated tourists contributed an estimated $43.5 million to the economy of **Tobago**, West Indies in 2006—approximately 15% of GDP. Additional indirect economic impacts, driven by the need for goods to support tourism (such as boats, towels and beverages) contributed another $58–$86 million to the national economy of Trinidad and Tobago (Burke et al., 2008).

Over a five-year study period, an average visitor made an estimated 6.31 trips to the Florida Keys, **USA**, for the purposes of diving, snorkeling or glass-bottom-boat viewing. The per trip user value was estimated to be $463. However, it was estimated that the establishment of a marine reserve would lead to improvements of 200% in fish abundance, 100% in water visibility, and 100% in coral quality; 4.99, 3.88 and 2.70 more trips by the average visitor, respectively (Bhat, 2003).

In 2007, tourism to Morrocoy National Park on the west coast of **Venezuela** averaged 1.5 million visitors annually; up from 1.15 million visitors in 2001, when a study found that each visitor spent $135, generating $22.4 million that year (Cartaya, 2007 cited in Pabon-Zamora et al., 2008).

Indian Ocean

In **Israel's** Eilat Coral Beach Nature Reserve divers are willing to pay an extra 11.86 New Israeli Shekels (NIS) ($2.60) per dive over the current diving fee of 20 NIS, for each additional unit increase in a biological index that comprises coral and fish abundance and genus richness. They would also pay an extra 5.46 NIS ($1.20) per dive for an additional meter of visibility. Environmental improvements that would lead to attribute levels similar to those on the higher quality Sinai reefs were valued at 13.2 million NIS ($2.3 million) per year (Wielgus et al., 2003).

The average Willingness To Pay for coral reef conservation and tourism (beach going, snorkeling, SCUBA diving, glass-bottom-boat rides) in the **Seychelles'** Marine National Parks was $12.20 (61 Rupees) in 2000. This exceeds the $10.00 (R50) marine park entrance fee instituted in 1997. Given that 40,000 tourists visited the parks in 1997, total consumer surplus was estimated to be $88,000 (440,000 Rupees) (Mathieu, Langford and Kenyon, 2000).

A 2003 study estimated the economic value of wetland benefits of Muthurajawela, **Sri Lanka**, finding that the wetland had a high direct and indirect economic value of $8.1 million a year, or $2,700 per hectare. Leisure and recreation accounted for $60,000 per year (Emerton and Kekulandala, 2003).

In the mid-1990s, coastal tourism contributed about $20.0 million per year to the national economy of **Sri Lanka** (Berg et al., 1998).

Pacific Ocean

The recreational use value of **Australia's** Great Barrier Reef ranges from $700.0 million to $1.6 billion per year (Carr and Mendelsohn, 2003).

In 2004, the annual values of coral reefs of **American Samoa** were estimated at $5.1 million per year, and the Territory's mangroves at $750,000 per year; $73,000 per year resulted from recreational uses (JacobsGIBB Ltd., 2004).

An economic analysis of Ream National Park, **Cambodia** (2000), surveyed households in local communities, looking at social, economic and ecological data, and the costs and benefits of three protected area management scenarios: (1) some protection is achieved, but fisheries eventually collapse; (2) the "ghost park" scenario, where all timber and fish are harvested, destroying the area; and (3) the "dream park" scenario, allowing subsistence activities, recreation, education and research. Present value (10%, 20 years) of fisheries for partially protected park, $5,207,267; ghost park $3,576,067; dream park $7,867,328; and for recreation $21,390 to $699,636 (De Lopez 2003).

In 2006, the Total Economic Value (TEV) of the reefs of the **Commonwealth of the Northern Mariana Islands** was estimated at $61.2 million per year. The market values comprised 73% of the TEV, and the non-market values comprised the rest. Tourism accounted for $42.3 million per year, and diving and snorkeling for $5.8 millon per year (Van Beukering, 2006).

Ostional Wildlife Refuge in **Costa Rica** is one of the world's largest marine olive ridley turtle nesting areas. It has high community participation and equitable profit-sharing from the legal sale of turtle eggs. In 2001, 208 residents collected 4,137,000 olive ridley eggs with a revenue of $1.0 million benefiting villagers, intermediaries and market salesmen (Troëng and Drews, 2004).

From 1998 to 2000, it was estimated that key biodiversity marine areas, including coral reefs and mangroves in the Galapagos, **Ecuador**, were worth over $2.7 million annually due to tourism (non-use value), compared to $220,000 benefits received by local fishermen, whose actions can negatively affect tourism (Wilen et al., 2000).

In 2007, the total economic value of **Guam's** reefs was estimated at $127.3 million per year, with tourism accounting for approximately 75% ($94.6 million per year) and diving and snorkeling for $8.7 million per year (Van Beukering et al., 2007).

A 2001 study in Hanauma Bay, **Hawai'i**, showed that visitors were willing to pay $7.00 more for their experience than they were currently paying, and that the net benefits of the Hanauma Bay Educational Program—set up to improve the marine awareness of visitors—were around $100 million; greatly exceeding the cost of the program (around $23.0 million) over time (Van Beukering and Cesar, 2004).

The Pulau Weh Marine Protected Area (MPA) on Weh Island, **Indonesia**, contributed more than 60% to the regional GDP, or about $230,000 in entrance fees per year. Residents were willing to pay $13.60 per household per year to preserve this marine park. It was also estimated that people involved in nature-based tourism near the MPA had an annual per capita income of $216 compared to $150 for those working in other sectors (Iqbal, 2006 cited in Pabon-Zamora et al., 2006).

In its first year, between March and December 2001, 15,055 visitors, including 5,183 foreigners, visited Bunaken National Park, **Indonesia**, paying $42,000 in entry fees. In 2002, the entrance fee was doubled, and $110,000 was collected from 25,697 visitors (Emerton, Bishop and Thomas, 2005).

A 2002 study analyzed the costs and benefits of coral mining in Lombok, **Indonesia**, looking at the societal costs of this activity associated with losses to typical reef functions. The economic valuation presented two scenarios: one with limited tourism potential and little coastal construction (scenario 'LOW'), and the other with high tourism potential and considerable coastal infrastructure (scenario 'HIGH'). All costs were calculated in net present value terms (the discounted sum of annual costs) for a 30-year time horizon. The net loss of the tourism function was valued at $2,900 for the 'LOW' scenario and $481,900 for the 'HIGH' scenario (Cesar, 2002).

Eco-tourist revenues generated by the coral reefs in **Indonesia's** Wakatobi National Park in Southeast Sulawesi provided almost $1,320 per km² in 2004 and an expected present value of $286,000 (Hargreaves-Allen, 2004).

The Willingness To Pay (WTP) to access the Pulau Payar Marine Park, **Malaysia**, was elicited in 1998. The study found that 91% of respondents would accept an entrance fee. The average WTP was estimated at $4.20. In terms of the tourist numbers recorded during the year of the study, this estimate reflected a potential recreational value of the reefs in the park of $390,000 per year (Yeo, 2004).

A study estimated that the economic value of recreational resources of Pulau Redang Marine Park, **Malaysia**, based on willingness to pay per visit responses, ranged from $3.00 to $4.40. If collected, this would have contributed between $373,900 and $545,100 in park management funds in 2005 (Mohd Parid, Lim and Woon, 2005).

A 2007 contingent valuation study found that ecotourism to see whale sharks in the Bahia de los Ángeles, **Mexico**, could be an important source of income (between $78,030 and $111,843 per year) for the 700 residents living around the bay (Low-Pfeng, de la Cuera and Enríquez, 2005).

Tourism accounted for 44% of the total net benefits of the $11.5 million provided by the Bohol Marine Triangle in the **Philippines** (Samonte-Tan et al., 2007).

Using the travel cost method, a study evaluated recreational benefits of coral reefs along the Lingayen Gulf, Bolinao, **Philippines**. Empirical results generated consumer surplus valued at (Philippine peso) PhP10,463 ($223) per person per annum or potential net annual revenues

to the local economy worth PhP220.2 million ($4.7 million) from an estimated 21,042 visitors to Bolinao in 2000 (Ahmed et al., 2007).

A 2005 study in the Hon Mun Marine Protected Area in **Vietnam** estimated that total recreational benefits from the reef-related recreation industry was $4.2 million. Domestic visitors' Willingness To Pay (WTP) per visit was $3.10 and international visitors' WTP was $3.90. Given visitation patterns, the total annual conservation value of Hon Mun's coral reefs was estimated to be approximately $128,245 for domestic visitors and $114,945 for foreign visitors (Khan Nam et al., 2005).

Fisheries

Global

By one estimate, fisheries account for $5.7 billion of the total $29.8 billion global net benefit of coral reefs per year (Cesar, Burke and Pet-Soede, 2003).

In the Millennium Ecosystem Assessment, the market value of seafood from mangroves has been put at $7,500 to $167,500/km²/year (Millennium Ecosystem Assessment, 2005 cited in UNEP-WCMC, 2006).

In 1997, annual commercial fish harvests from mangroves were valued $6,200 per km² in the United States to $60,000 per km² in Indonesia (Bann, 1997).

Atlantic Ocean

Reef fisheries of the Meso-American Barrier Reef of **Belize**, **Honduras** and **Mexico** are potentially worth $15,000–$150,000 per km² a year, based on catch values of $1.00–$10.00 per kg (Talbot and Wilkinson, 2001 cited in UNEP-WCMC, 2006).

In the **Caribbean**, the annual net benefits provided by coral reefs in terms of fisheries were estimated to be about $300.0 million (Burke and Maidens, 2004).

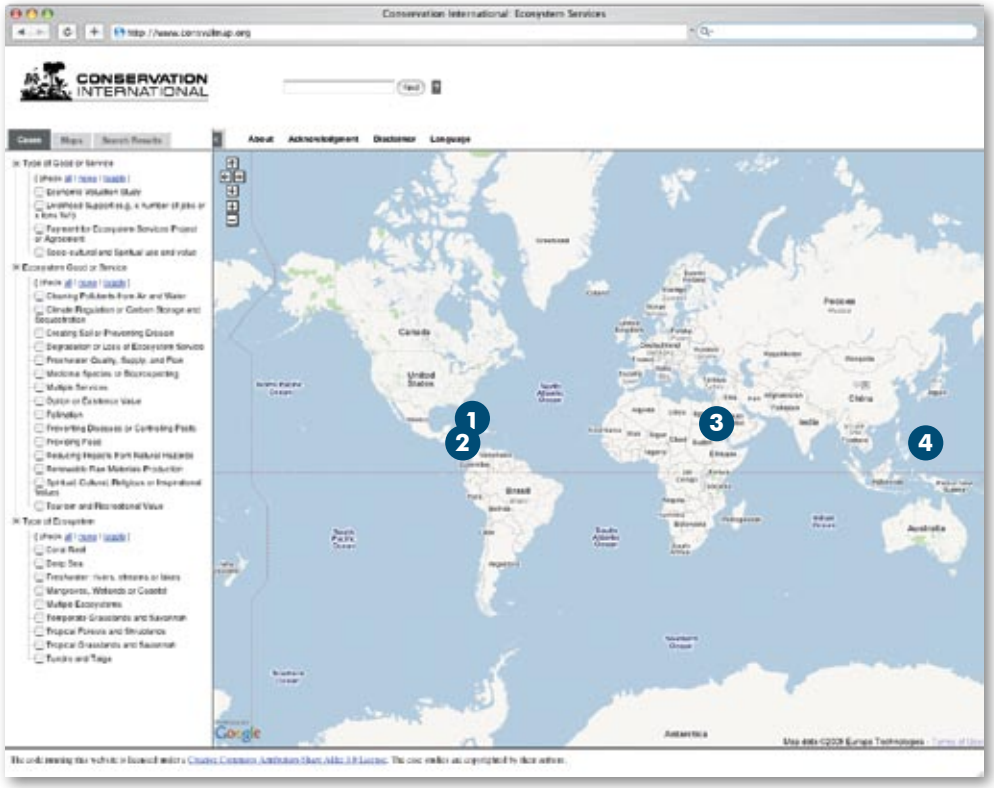
Fisheries accounted for about $19.0 million of the Net Present Value of the $40.8 million to $52.6 million in incremental benefits of the coral reefs and mangroves in **Jamaica's** Portland Bight Protected Area. The Net Present Values were calculated over a 25-year period and at a 10% discount rate (Cesar et al., 2000).

All values in this booklet are located at www.consvalmap.org, which is continuously updated.

1 Caribbean

In 2000, coral reefs in the Caribbean region provided annual net benefits in terms of fisheries, dive tourism, and shoreline protection services with an estimated value of $3.1 billion to $4.6 billion. The net benefits from dive tourism were the largest share of this total ($2.1 billion), followed by shoreline protection services ($0.7 to 2.2 billion), and fisheries (about $300 million).

Burke, L. and Maidens, J. 2004. Reefs at Risk in the Caribbean. World Resources Institute, Washington, DC.



2 Bonaire Marine Park, Antilles

The net economic value to visitors (measured as consumer surplus) to the Bonaire Marine Park (from May 1993 to May 1994) was estimated to be approximately $19 million annually. Over a twenty year period, the net present value of benefits to tourists would be $180 million (assuming 1993 levels of consumer surplus).

Pendleton, L.H. 1995. Valuing Coral Reef Protection. Ocean & Coastal Management, 26(2): 119–131.

3 Red Sea

The marginal prices for coral and fish diversity and water visibility in the Coral Beach Nature Reserve near Eilat, Israel, were estimated to be $2.60 and $1.20 per dive, respectively. From the standpoint of recreational diving welfare, the annual social costs of activities contributing to coral reef degradation are approximately $2.86 million.

Wielgus, J., Chadwick-Furman, N.E., Zeitouni, N., and Shechter, M. 2003. Effects of Coral Reef Attribute Damage on Recreational Welfare. Marine Resource Economics, 18: 225–237.

4 Bohol Marine Triangle, Philippines

With 10% discount rate, the total accumulated net benefits for the Bohol Marine Triangle resources in the Central Visayas of the Philippine archipelago, over a 10-year period was found to be $11.54 million. Tourism and the municipal fisheries accounted for 44% and 39% of the total net benefits, respectively. Annual revenues attributed to coral reefs were $1.26 million.

Samonte-Tan, G.P.B., White, A.T., Tercero, M.A., Diviva, J., Tabara, E. and Caballes, C. 2007. Economic Valuation of Coastal and Marine Resources: Bohol Marine Triangle, Philippines. Coastal Management 35(2): 319–333.

Fisheries accounted for $1.3 million of the $400.0 million Net Present Value of **Jamaica's** Montego Bay reefs (Ruitenbeek and Cartier, 1999).

The Net Present Value (in constant 1996 dollars) of coral reefs in **Jamaica's** Montego Bay Marine Park associated with fishing was found to range from $1.7 million to $7.5 million (Gustavson, 1998).

Coral reef fisheries in the **Turks and Caicos Islands** have been valued at $3.7 million per year in Gross Value Added (Carleton and Lawrence, 2005).

Indian Ocean

In 2001, coastal fisheries and aquaculture in and around Leuser, **Indonesia**, exceeded $171.0 million. The average share of the fishery sector dependent on Leuser was estimated at 2% for the maritime fishery; 9% for brackish water fishery; and 100% for brackish and freshwater aquaculture (Van Beukering, Cesar and Janssen, 2003).

A 2005 Total Economic Value assessment (TEV) of the Rekawa mangrove-lagoon ecosystem, **Sri Lanka**, showed that it was $1,088/ha/year, or $217,600 per year, based on 200-ha of mangrove. Lagoon fishery accounted for $268/ha/year or $53,600 per year, and coastal fishery for $493/ha/year or $98,600 per year. TEV for fisheries was $152,200 per year (Gunawardena and Rowan, 2005).

A 2003 study estimated the monetary worth of wetland benefits of Muthurajawela, **Sri Lanka**, finding that it has a high direct and indirect economic value of $8.1 million a year, or $2,700 per hectare. Support to downstream fisheries accounted for $220,000 per year and fishing for $70,000 per year (Emerton and Kekulandala, 2003).

Pacific Ocean

In 2004, the annual values of coral reefs of **American Samoa** were estimated at $5.1 million per year, and the Territory's mangroves at $750,000 per year: $755,000 per year from fisheries and $70,000 per year from bottom fishing (JacobsGIBB Ltd., 2004).

The average household value from fisheries of the Veun Sean wetland, **Cambodia**, was $425 per year of a total wetland value of about $3,200/household/year. Fisheries are worth about $650 per year to poorer households from income earned from selling fish, and mainly used to purchase the food staple, rice (De Groot, 2006).

An economic analysis of Ream National Park, **Cambodia** in 2000 surveyed households in local communities, looking at social, economic and ecological data, and the costs and benefits of three protected area management scenarios: (1) some protection is achieved, but fisheries eventually collapse; (2) the "ghost park" scenario, where all timber and fish are harvested, destroying the area; and (3) the "dream park" scenario, allowing subsistence activities, recreation, education and research. Present value (10%, 20 years) of fisheries: some protection $5.2 million; ghost park $3.6 million; dream park $7.9 million (De Lopez, 2003).

The Total Economic Value (TEV) of the reefs of the **Commonwealth of the Northern Mariana Islands** was estimated at $61.2 million per year. The market values comprised 73% of the TEV, and the non-market values comprised the rest. Fisheries accounted for $1.3 million per year (Van Beukering, 2006).

The Terraba-Sierpe wetlands and fisheries in **Costa Rica** provided fish and shellfish worth $6.0 million to local families (Reyes et al., 2004).

In 2007, the total economic value for **Guam's** reefs was estimated at $127.3 million per year, with fisheries accounting for approximately $4.0 million per year (Van Beukering et al., 2007).

Fisheries supported by the coral reefs in **Indonesia's** Wakatobi National Park in Southeast Sulawesi produce an average of $10,340 per km² annually and have a present value of over $2.2 million, calculated over 20 years with a 10% discount rate (Hargreaves-Allen, 2004).

In Matang, west **Malaysia**, a 2006 study estimated that with fish catches averaging 1.3–8.8 kg an hour, a 400-km² managed mangrove forest supported a fishery worth $100.0 million a year ($250,000/km²/year) (UNEP-WCMC, 2006).

A 2005 study found that mangroves in the Mexcaltitán Island, **Mexico**, protect and act as nurseries for fish and shrimp, providing residents with direct fishing benefits of more than $1.0 million annually (Sanjurjo, Cadena and Erbstoesser, 2005).

A 2001 study in the Gulf of **Panama** estimated that each kilometer of coastline generated an estimated $95,000 in shrimp and fish annually (Talbot and Wilkinson, 2001 cited in UNEP-WCMC, 2006).

Fisheries accounted for 39% of the total net benefits of the $11.5 million over 10 years provided by the Bohol Marine Triangle in the **Philippines** (Samonte-Tan et al., 2007).

The sustainable fisheries benefit for all of **Southeast Asia** is estimated to be $2.4 billion per year (Burke, Selig and Spalding, 2002).

In 2005, the total value-added from the support function of coral reefs in Hon Mun Marine Protected Area, **Vietnam**, was estimated at $2 million for the local fishing and aquaculture industries (Khan Nam et al., 2005).

Coastal Protection

Global

By one estimate, coastal protection accounts for $9.0 billion of the total $29.8 billion global net benefit of coral reefs (Cesar, Burke and Pet-Soede, 2003).

Atlantic Ocean

In the **Caribbean**, the annual net benefits provided by coral reefs through shoreline protection services were estimated to be $700,000 to $2.2 billion (Burke and Maidens, 2004).

Coastal protection accounted for $366,000 of the $40.8–$52.6 million Net Present Value of the incremental benefits of the coral reefs and mangroves in **Jamaica's** Portland Bight Protected Area. The Net Present Values were calculated over a 25-year period and at a 10% discount rate (Cesar et al., 2000).

Coastal protection accounted for $65.0 million of the $400.0 million Net Present Value of **Jamaica's** Montego Bay reefs (Ruitenbeek and Cartier, 1999).

The Net Present Value of the total amount of land (250 acres) at risk of erosion if not protected by the coral reefs in **Jamaica's** Montego Bay Marine Park was estimated to be $65.0 million (in constant 1996 dollars) (Gustavson, 1998).

The annual value of shoreline protection services provided by coral reefs (in potentially avoided damages) is estimated to be between $28 and $50 million for **St. Lucia**. Coral reefs contribute to the protection of over 40 percent of the shoreline of the island (Burke et al., 2008).

The annual value of shoreline protection services provided by coral reefs (in potentially avoided damages) is estimated to be between $18 and $33 million for **Tobago**, West Indies. Coral reefs contribute to the protection of nearly 50 percent of the shoreline of the island (Burke et al., 2008).

Reefs' contribution to coastal protection in the **Turks and Caicos Islands** has been valued at $16.9 million per year, taking into account both coastal erosion and storm/hurricane damage (Carleton and Lawrence, 2005).

Indian Ocean

A 2005 assessment of the Rekawa mangrove-lagoon ecosystem, **Sri Lanka**, found that the Total Economic Value was about $1,088/ha/year, or $217,600/year based on 200-ha of mangrove. Erosion control and buffer against storm damage accounted for $300/ha/year or $60,000 per year (Gunawardena and Rowan, 2005).

A 2003 study estimated the monetary worth of wetland benefits of Muthurajawela, **Sri Lanka**, and found that wetland has an economic value of $8.1 million per year, or $2,700 per hectare, with flood attenuation accounting for $5.4 million per year (Emerton and Kekulandala, 2003).

Pacific Ocean

The annual values of coral reefs of **American Samoa** were estimated at $5.1 million per year, and the Territory's mangroves at $750,000 per year, of which $582,000 per year related to shoreline protection (JacobsGIBB Ltd., 2004).

The Total Economic Value (TEV) of the reefs of **Commonwealth of the Northern Mariana Islands** was estimated at $61.2 million per year. The market values comprised 73% of the TEV, and the non-market values comprised the rest. Coastal protection accounted for $8.0 million per year (Van Beukering, 2006).

In 2007, the total economic value for **Guam's** reefs was estimated at $127.3 million per year, with coastal protection accounting for approximately $8.4 million per year (Van Beukering et al., 2007).

The indirect benefit of 'coastal' protection from coral reefs in **Indonesia's** Wakatobi National Park in Southeast Sulawesi was estimated to be worth $1,320 annually or $473/km² (Hargreaves-Allen, 2004).

A 2002 study analyzed the costs and benefits of coral mining in Lombok, **Indonesia**, looking at the societal costs of coral mining associated with losses to typical reef functions. The economic valuation presented two scenarios, one with limited tourism potential and little coastal construction (scenario 'LOW'), and the other with high tourism potential and considerable coastal infrastructure (scenario 'HIGH'). All costs were calculated in net present value terms (the discounted sum of annual costs) for a 30-year time horizon. The net loss of the coastal protection function was $12,000 for the 'LOW' scenario and $260,000 for the 'HIGH' scenario (Cesar, 2002).

Biodiversity

Global

By one estimate, biodiversity value accounts for $5.5 billion of the total $29.8 billion annual global net benefit of coral reefs (Cesar, Burke and Pet-Soede, 2003).

Atlantic Ocean

Biodiversity accounted for $18 million of the $40.8 million to $52.6 million Net Present Value of the incremental benefits of the coral reefs and mangroves in **Jamaica's** Portland Bight Protected Area (calculated over a 25-year period and at a 10% discount rate) (Cesar et al., 2000).

The biodiversity of **Jamaica's** Montego Bay reefs has a Net Present Value of $13.6 million to tourists and $6.0 million to Jamaica residents (Ruitenbeek and Cartier, 1999).

Pacific Ocean

In 2007, the Total Economic Value for **Guam's** reefs was estimated at $127.3 million per year, with biodiversity accounting for approximately $2.0 million per year (Van Beukering et al., 2007).

The value of biodiversity on coral reefs in the **Turks and Caicos Islands** has been estimated at $4.7 million per year (Carleton and Lawrence, 2005), based on estimates in Cesar, Burke and Pet-Soede (2003).

Carbon Sequestration

Atlantic Ocean

Carbon sequestration accounted for $4.0 million of the $40.8 million to $52.6 million Net Present Value of the incremental benefits of the coral reefs and mangroves in **Jamaica's** Portland Bight Protected Area (Cesar et al., 2000).

Indian Ocean

A 2003 study estimated that the monetary benefits of wetlands in Muthurajawela, **Sri Lanka**, have an economic value of $8.1 million a year, or $2,700 per hectare. Carbon sequestration accounted for $8,700 per year (Emerton and Kekulandala, 2003).

Section 3: Degradation or Loss of Ecosystem Services Values

This section presents values for the costs of degradation or loss of ecosystem services.

Global

The global costs of coral bleaching are calculated to range from $20.0 billion (a moderate bleaching scenario) to over $84.0 billion (a severe bleaching scenario) in Net Present Value (over a 50-year time horizon with a 3% discount rate). The tourism cost is highest with $10.0 billion to nearly $40.0 billion losses, followed by fisheries ($7.0 billion to $23.0 billion) and biodiversity ($6.0 billion to $22.0 billion) (Cesar, Burke and Pet-Soede, 2003).

Atlantic Ocean

One estimate of the total cost of severe coral bleaching over a 50-year time horizon with a 3% discount rate for the **Caribbean** (excluding tropical marine waters of the United States) is $5.7 billion in Net Present Value, and $7.6 billion for the **USA** (Cesar, Burke and Pet-Soede, 2003).

A 2004 study indicated that the degradation of Caribbean coral reefs could result in annual losses of $95.0 to $140.0 million in net revenues from coral reef-associated fisheries and $100.0 to $300.0 million in reduced tourism revenue by 2015. In addition, degradation of reefs could lead to annual losses of $140.0 to $420.0 million from reduced coastal protection within the next 50 years (Burke and Maidens, 2004).

Pacific Ocean

The total cost of severe coral bleaching in the **Pacific** (excluding Hawai'i) is $7.6 billion in Net Present Value, calculated over a 50-year time horizon with a 3% discount rate (Cesar, Burke and Pet-Soede, 2003).

The total cost of severe coral bleaching in **Australia** is $28.4 billion in Net Present Value (calculated over a 50-year time horizon with a 3% discount rate) (Cesar, Burke and Pet-Soede, 2003).

In 2004, the estimated economic costs to **Australia** from a degraded Great Barrier Reef as a result of global warming ranged from $2.5 billion to $6.0 billion over 19 years (Hoegh-Guldberg and Hoegh-Guldberg, 2004 cited in UNEP-WCMC, 2006).

A 2004 study on the Kihei coast, Maui, **Hawai'i** concluded that the problem of algae blooms causes large losses of real estate value and hotel business, and that mitigation could result in benefits of $30.0 million over time (Van Beukering and Cesar, 2004).

In 2002, more than 32,000 km² of reefs were overfished in **Indonesia**, resulting in massive societal losses, estimated at $1.9 billion over 20 years (Burke, Selig and Spalding, 2002).

In 2002, financial damage from the overfishing of more than 21,000 km² of reefs in the **Philippines** was estimated at $1.2 billion over 20 years (Burke, Selig and Spalding, 2002).

The total cost of severe coral bleaching for **Southeast Asia** (excluding Japan) is $38.3 billion in Net Present Value (calculated over a 50-year time horizon with a 3% discount rate), and $7.0 billion for **Japan** (Cesar, Burke and Pet-Soede, 2003).

Indian Ocean

One estimate for the **Indian Ocean** (including the Red Sea), found that the total cost of severe coral bleaching is $13.0 billion in Net Present Value (calculated over a 50-year time horizon with a 3% discount rate) (Cesar, Burke and Pet-Soede, 2003).

The value of the welfare impacts of mangrove deforestation on coastal, mangrove-dependent fisheries in Surat Thani Province on the Gulf of **Thailand** was estimated at $33–$110 per hectare deforested, depending on whether the fisheries were open access or managed. Given deforestation rates in the early 1990s, the economic losses were around $100,000 per year, if these fisheries were optimally managed. Under open access conditions, this economic loss ranged from $40,000 to $132,000 depending on demand elasticities (Sathirathai, 1998 cited in Barbier, 2000).

The welfare losses from ecological damage to Zanzibar's coral reefs in **Tanzania** was estimated using the cost of the trip as a payment vehicle, before and after the actual change in quality occurred. The annual loss from coral bleaching was estimated to be $22.0–$154.0 million, imply-

ing $254 to $1,780 per visitor (prices and costs deflated to 1997 USD) (Andersson, 2007).

In **Sri Lanka**, damage to coral reefs generated erosion on the south and west coasts, which in 1998 was estimated to average 40-cm a year. Some $30.0 million had already been spent on constructions to curtail this, and it has been estimated that the cost of replacing the coastal protection provided by these reefs would be $246,000 to $836,000 per km (Berg et al., 1998).

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Conservation International

Marine Management Area Science Program (MMAS)
www.conservation.org/MMAS

Ecosystem Service Value Statistics Database and Map
www.consvalmap.org

International Coral Reef Initiative (ICRI)

www.icriforum.org

The Ocean Foundation

Coastal Ocean Values Center
www.coastalvalues.org

Coral Reef Economics Community of Practice
www.communities.coastalvalues.org/coralreef

United States National Oceanic and Atmospheric Administration (NOAA)

Coral Reef Conservation Program
www.coralreef.noaa.gov

World Resources Institute (WRI)

Economic Valuation of Coral Reefs in the Caribbean
www.wri.org/project/valuation-caribbean-reefs

Reefs at Risk
www.wri.org/project/reefs-at-risk

Tropical marine and coral reef ecosystems are vulnerable environmental resources that provide significant economic goods and services. The health of these ecosystems is critical to human well-being; they contribute to the livelihoods, food security and health of millions of people. By accounting for marine ecosystem values in management decisions, we can sustain their flow of goods and services in the interest of current and future generations.