Appendix B. DATA SOURCES USED IN THE REEFS AT RISK IN THE CARIBBEAN THREAT ANALYSIS

Data used in the Reefs at Risk threat analysis, model results, and metadata are available on CD. Model results, accompanied by metadata, are available online at http://reefsatrisk.wri.org.

COASTAL DEVELOPMENT

- Cities and towns—Environmental Systems Research Institute (ESRI), "World Cities" and "U.S. Cities," 2002 and http://www.world-gazetteer.com.
- Ports—National Imagery and Mapping Agency (NIMA), "World Port Index," 2002.
- Airports—NIMA, "VMAP," 1997.
- Dive tourism centers—United Nations Environment Programme - World Conservation Monitoring Centre (UNEP-WCMC), "Caribbean Dive Centers," 2002 and M.D. Spalding, *Guide to the Coral Reefs of the Caribbean* (Berkeley, USA: University of California Press, 2004).
- Population density—U.S. Dept. of Energy (DOE), "LandScan," 2001.
- Population growth (by administrative district)—ESRI, "Administrative Districts", 2002 and http://www.ciat.cgiar.org.
- Annual tourism growth (by country)—Caribbean Tourism Organization (CTO), *Caribbean Tourism Statistical Report 2001–2002,* 2002.

WATERSHED-BASED SOURCES OF SEDIMENT AND POLLUTION*

- Watershed boundaries—Delineated at WRI from U.S. Geological Survey (USGS), "HYDRO1K" digital elevation model, 2000 (1-km resolution for the entire Caribbean region), and U.S. National Aeronautics and Space Administration (NASA), "Shuttle Radar Topography Mission" (SRTM) provisional data set, 2003 (90-m resolution for the Eastern Caribbean).
- Elevation and slope—USGS, "HYDRO1K", 2000 (1-km resolution for the entire Caribbean region), and NASA "SRTM," 2003 (90-m resolution for the Eastern Caribbean).
- Land cover—USGS, "Global Land Cover Characteristics Database," 2000 (1-km resolution for the Wider Caribbean); University of Maryland, "Global Percent Tree Cover at a Spatial Resolution of 500 Meters: First Results of the MODIS Vegetation Continuous Fields Algorithm," 2003 (500-m resolution for the Eastern Caribbean); Landsat data classified in 2003 by Jennifer Gebelein, Florida International University (30-m resolution for select islands in the Eastern Caribbean).
- Soil porosity—UN Food and Agriculture Organization (FAO), "World Soil Database," 1995.
- Precipitation—U.S. Army CERL and Center for Remote Sensing and Spatial Analysis (CRSSA), Cook College, Rutgers University, "Global ARC" CD, 1996.

MARINE-BASED THREATS

- Ports—NIMA, "World Port Index," 2002.
- Oil and gas extraction, processing, and pipeline locations—NIMA, "VMAP," 1997.
- Cruise ships (intensity of visitation)—Information for this data set was derived from the "Choosing Cruising" website http://www.choosingcruising.co.uk, and georeferenced at WRI, 2003.

OVERFISHING

- Population density—U.S. DOE, "LandScan," 2001.
- Shelf area—Developed at WRI based on data from the Danish Hydrological Institute (DHI), "MIKE C-MAP" depth points and data on coastline location—NASA, "SeaWiFS" and NIMA, "VMAP," 1997.
- Coral reef fish abundance—Reef Environmental Education Foundation (REEF) website http://www.reef.org (accessed 10 February 2003).

CORAL REEF LOCATIONS

Maps of coral reefs in vector format (ESRI ArcINFO line and polygon files) are the basis for the coral reef map for the region. These data were of multiple scales, generally ranging from approximately 1:30,000 to 1:1,000,000, and from multiple sources (listed below). To standardize these data, WRI converted them to raster format (ESRI ArcINFO GRID) at 500-m resolution for use in the analysis. Sources:

- University of South Florida, Institute for Marine Remote Sensing (IMaRS), "Millennium Coral Reef Mapping Project," 2004 (30 m Landsat data classified and converted to shapefile) for the Lesser Antilles (British Virgin Islands through Barbados), the Turks and Caicos Islands, Southern Bahamas, Dominican Republic, Haiti, Jamaica, Nicaragua, and Panama).**

* The watershed-based analysis of sediment and pollution was implemented at 1-km resolution for the entire Caribbean region and at 250-m resolution for the islands of the Eastern Caribbean. This finer scale of analysis provides better detail for the relatively small watersheds of the Eastern Caribbean islands.

** The Millennium Coral Reef Mapping Project developed a geomorphologic classification of coral reefs. To make data comparable to other map sources, the Reefs at Risk project selected a subset of 30 categories from the overall mapping effort. Categories with high probability of being living coral—such as forereef, intertidal reef flat, barrier reef pinnacle, and shallow terrace—were included, while categories such as drowned bank and undetermined envelope were excluded. Full details are available online at http://reefsatrisk.wri.org.

- US National Oceanographic and Atmospheric Administration (NOAA), "Benthic Habitats of Puerto Rico and the U.S. Virgin Islands," 2001, from high-resolution aerial photography.
- Coastal Zone Management Institute of Belize, 1999. (30-m Landsat data classified and converted to shapefile, for Belize).
- For other areas, UNEP-WCMC "Coral Reef Maps," 2002. Data have been acquired or digitized from a variety of sources. Scales typically range from 1:60,000 to 1:1,000,000.
- In addition, WRI edited and digitized maps for some areas based on input from project partners.

MODEL CALIBRATION AND VALIDATION

Data from a range of monitoring and assessment programs were used to explore patterns of degradation, calibrate the threat analysis, and validate the results:

- Caribbean Coastal Productivity Program (CARICOMP)—Coral reef habitat parameters for 27 reef locations across 20 countries (1993 – 2001).
- Atlantic and Gulf Rapid Reef Assessment (AGRRA)—This assessment protocol has been applied at over 730 reef locations in 17 countries across the region between 1997 and 2001, providing a (one-time) snapshot of many indicators of reef condition.
- Reef Check—Volunteer survey program. The protocol has collected social, physical, and biological parameters at 186 sites in 16 countries within the region since 1997.
- The Reef Environmental Education Foundation (REEF) Fish Survey—Data on coral reef fish populations from more than 2,500 locations across the region.

Model Calibration

Reefs at Risk project partners have provided valuable guidance on threat model development and review of model results. This expert opinion, coupled with observations of threats to reefs from Reef Check, was used to calibrate the estimates of threat from coastal development and watershed-based sediment and pollution. Data on coral reef fish populations from REEF were used to calibrate the estimate of threat from fishing pressure. Due to limited data of sufficient detail, expert opinion during the Reefs at Risk in the Caribbean workshop was the main source for calibration of the estimate of marine-based threat.

Threat Analysis Validation and Exploration of Relationships with Indictors from Assessment and Monitoring Programs

Using results from the 22 CARICOMP sites that have trend information (multiple years of data between 1993 and 2001) the study finds:

- Sites identified as threatened by sediment and pollution from inland sources had substantially higher average levels of decline in hard coral cover (loss of 9 percent in high-threat areas versus loss of 1 percent in low-threat areas).
- Sites identified as threatened (medium or high threat) from coastal development or marine-based pollution had a much larger average increases in extent of algal cover than sites rated as low threat. (Increase was about twice as large on threatened sites.)
- Few CARICOMP sites were identified as under low threat from overfishing. Sites identified as under high threat from overfishing pressure had larger average loss of hard coral cover and larger gains in algae cover as compared with medium threat sites.

Several coral condition indicators were developed for the 432 AGRRA assessment sites. These include coral density, ratios of different coral species, extent of hard coral cover, recent and old mortality, and a macroalgal index. Of these indictors, the macroalgal index, old mortality, and hard coral cover had the only statistically significant (95%) relationships with the threat indictors. The three pollution-related threats (coastal development, marine-based threats, and pollution and sediment from inland sources) were combined for this analysis. The findings:

- Average extent of old mortality was higher on sites identified as threatened by pollution. (29 percent on high versus 26 percent on low threat sites.)
- Average hard coral cover was slightly higher on sites identified as under low threat from pollution (8.2 percent) than on high threat sites (7.3 percent).
- The average macroalgal index was higher on sites identified as threatened by pollution (150 on high versus 123 on low threat sites.)
- In addition, the average macroalgal index was higher on sites identified as threatened by overfishing (170 on high versus 100 on low threat sites.)