Reefs at Risk in the Caribbean Threat Assessment Workshop Summary
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Produced by Lauretta Burke, Jon Maidens, and Stephen Menard, WRI.

The Reefs at Risk Caribbean project has two primary goals. This first is to improve the base of information available for examining threats to coral reefs from human activities across the Wider Caribbean. The second goal is to raise awareness about these threats and arm resource managers, policymakers, and coral reef advocates, in general, with high quality information and tools for making a strong argument for better protection and management of coral reefs.

The Reefs at Risk Caribbean project is lead by the World Resources Institute and is implemented in collaboration with many partner institutions, including UNEP Caribbean Environment Program. The project is a component of the International Coral Reef Action Network (ICRAN), and receives support from the United Nations Foundation and the United States Agency for International Development (USAID).

A project workshop was held in Miami Florida during October 22-24, which was attended by thirty-five participants. The workshop provided an opportunity to review the data and information assembled to date on coral reefs and threats to coral reefs across the region, evaluate the preliminary threat assessment approach and estimates of threats to coral reefs and identify better data sources for input to modeling and for calibration of results. The workshop also provided an opportunity to review maps of coral reef locations and data on the occurrence of coral disease and coral bleaching across the region and to discuss how to approach the analysis of these major threats. In addition, the workshop highlighted socioeconomic aspects of coral reefs, with sessions on evaluation of economic value of coral reefs and on the effectiveness of management of marine protected areas.

Enthusiastic participation by workshop attendees made the workshop a big success, with all workshop objectives achieved. The workshop had an intense three-day schedule, with a balance of presentation, discussion and review of preliminary results. Participants branded the project very broad and ambitious, acknowledged that there is a great need for this sort of comprehensive activity, and have widely endorsed what is regarded as a pragmatic approach.

Reefs at Risk uses an approach to estimating threat to coral reefs which relies upon the best available information for the region. As there are always limitations in the information that will be available, an innovative approach has developed which uses proxy indicators to estimate threat. Some scientists commented that they did not like the nature of the model, but did think that the preliminary results were pretty good. The bottom line is that we strive to produce the best estimates of threat to coral reefs possible using available, regionally consistent information. Workshop participants have helped us to further this approach.

During the workshop, participants made many constructive recommendations for improving the model, directed us to additional data sources, and provided detailed comments on the preliminary results.

This document serves as a brief summary of the workshop recommendations, proposed actions for improving the model, and next steps for the project. Although there was frequent and extensive discussion on a range of options for modifying the model, this summary is intended to highlight discussion conclusions and the modifications which can be implemented in light of data believed to be available at this time.

Conclusions from Individual Sessions:

Coral Reef Mapping for the Wider Caribbean (Ed Green, UNEP-WCMC)

The session provided an overview of UNEP-WCMC approach to improving the base map of coral reef locations for the Wider Caribbean, allowed for review of coral reef maps, and discussion of additional data sources.

Current data on coral reef locations have been compiled at UNEP-WCMC from a range of sources including hardcopy maps and charts, British Admiralty charts, and through interpretation of satellite imagery.

Conclusions from the session:

- The current mapping of coral reefs contains both errors of omission and commission, and many of these have been noted on the hardcopy maps.
- Several data sets, which improve upon current mapping, were provided to UNEP-WCMC by workshop participants.
- UNEP-WCMC will revise the current dataset based on these inputs from the workshop.
- A coral reef mapping activity currently underway at the University of South Florida could produce a more detailed mapping of coral reef locations for some parts of the region within the timeframe of this project.

Other possible enhancements:

- The current mapping of coral reefs does not distinguish shallow versus deep coral reefs. It might be useful to have such an attribute associated with the coral reef data. If a data set of suitable quality reflecting bathymetry for the region can be obtained or developed, it should be possible to differentiate shallow from deep coral reefs (perhaps using 10m as threshold).

Evaluating Threat to Coral Reefs from Coastal Development (Lauretta Burke, WRI)

This session allowed for presentation of a preliminary approach for evaluating threat from coastal development (including tourism), evaluation of preliminary model results, and discussion of completeness of data sources and possible approaches to capture current and future development threats.

The preliminary approach to estimating threat from coastal development is based on a coral reef's proximity to cities and towns (qualified by size), airports, mines, tourist sites, and the coastline. Coastal population growth was also factored into the analysis.

Conclusions from the session:

- Our current estimate of threat to coral reefs from coastal development is regarded as an underestimate of overall threat.
- There were several limitations noted and modifications proposed, which could make the estimate more accurate. These include:
  a) factoring poverty / economic development into the analysis;
  b) factoring coastal population density into the analysis, as many small islands lack "towns," but have more continuous development;
  c) including ports as a feature in the analysis, as these are important coastal development features;
  d) Data we use at present to represent tourism locations is regarded as limited, as it relies only on a data set on "dive centers" from UNEP-WCMC. These centers were thought to represent locations with substantial tourism activity, but upon review seem to miss many areas. As such, it is recommended that we try to include additional tourism information, such as the number of hotel rooms or visitors per year, or some sort of tourism intensity index. The discussion addressed the issue that most tourism information might only be available at the national level, and that this information might only be useful for the small island nations. Recommendations to address this include:

    - Obtaining data from the Caribbean Tourism Organization (CTO) or Caribbean Association for Sustainable Tourism (CAST), though these might only provide national level statistics;
    - The University of the West Indies (UWI) might be able to provide some time from a student based at CTO to develop some sub-national statistics on hotels and tourism;
    - Island Resources Foundation offered to explore some other sources of information on sub-national tourism statistics;
    - UNEP-WCMC has a more complete listing of dive centers than is portrayed on the preliminary maps, though many sites might have to be geo-referenced. These data will be provided to WRI.
    - Although the reliance of dive centers in the modeling is insufficient to capture "tourism pressure" on its own, including them does help to capture this threat, so they will be included in the model.
- WRI plans to explore and implement these recommendations – factoring in economic development, population density, the location of ports, and additional information on tourism development.
- There was some discussion of whether aquaculture sites could be included in the coastal development analysis. WRI will explore the availability of such data and the feasibility of including it in the analysis.
- There was also discussion of whether it would be appropriate to include land cover directly in the coastal development analysis. As landcover will now be included directly in the watershed-based analysis of pollution and sedimentation (see next session), this seems sufficient consideration of land cover.
- Participants reviewed the maps on coastal development features that serve as input to the modeling (cities, airports, mines, and dive centers) and noted some missing or erroneous features. These data will be edited based on comments.

Watershed-based Analysis of Pollution and Sedimentation (Lauretta, WRI)

This session included presentation of a preliminary approach to evaluating threat from land cover change and inland agricultural practices (performed at 1 km resolution), discussion of alternative approaches, improvements to the methodology, and higher resolution data sources, and allowed for review of preliminary results.

The preliminary analysis of watershed-based pollution and sedimentation threat was implemented for the region at 1 km resolution using regionally-consistent data sets. This rough-cut exploration used a simplified version of the Revised Universal Soil Loss Equation (RUSLE - USDA, 1989) in order to estimate relative erosions rates for each 1km resolution grid cell. These relative erosion estimates are summarized by watershed. (Watersheds were derived at WRI.) In addition, watershed flow during the peak rainfall month was estimated based on precipitation during that month, which serves as an indicator of relative river discharge. Relative sediment erosion rates and watershed flow were combined to estimate relative sediment delivery at each river mouth (pour point). From the pour point, sediment plumes can be estimated, though this has not been done yet. Model results should be calibrated at each stage of the analysis – relative erosion rates, river discharge and sediment delivery at the river mouth, and areas impacted by sediment. It should be noted that relative erosion rates and sediment delivery are being used as a proxy for both sediment and pollution delivery.

Conclusions from the session:
1) Scale of the analysis

- The scale of the analysis (1km resolution) is too coarse for many of the islands. We need to get more detailed elevation data (DEM) and landcover, particularly for the small island states.
- Watersheds delineated from the 1km DEM (with a 30sq km minimum) do not work for all areas. (There were no watersheds delineated on some of the small islands.) Therefore, we probably need to move to a different approach for the small islands – perhaps based only on land-cover type, or agricultural activities. Hence, not watershed based.
- There were accuracy issues with the landcover data in general. The landcover data set used is based on 1993 AVHRR satellite data and shows more land as natural landcover than is accurate. It would be

great if there were a more recent and higher resolution (500m or 250 m) product available. We can explore MODIS and LANDSAT sources.

- Our indicator, "percent altered landcover" by watershed was not very useful due to errors in the base data, so we will not use this indicator.
- As areas discharging into the wider Caribbean include large watersheds on continents, medium sized watersheds in Central America and on some of the larger islands, and small watersheds on many of the smaller islands, we will try to move to a sub-regional analysis. In this case, we would try to identify data sets of consistent quality across a sub-region, implement the modeling for that extent, and then try to harmonize results to create a region-wide picture of threat. The possible sub-regions are: Lesser Antilles, Greater Antilles, Bahamas, USA, Central America, and South America.

2) Modeling of Erosion and Pollution:

- WRI's adaptation of the Revised Universal Soil Loss Equation called "Relative Erosion Potential" (REP) seems an appropriate and adequate model for approximating sediment in most large watersheds. The current weighting of factors in the model might over-emphasize slope and under-represent the importance of land cover.
- A qualifier to the above endorsement is that the current model does not capture nutrient delivery in flat, agricultural areas. We need an additional indicator to flag these areas with large amounts of land in agriculture.
    - The simplest statistic could be agricultural land within the watershed
    - The indicator could be improved on if we had data on type of agriculture, or fertilizer application rates. We will explore FAO and CIAT as possible sources for this information.
- Precipitation is an input to the calculation of REP. Participants were pretty happy with the use of mean precipitation during the peak rainfall month as the precipitation variable, so we will continue to use this.
- Some participants encouraged the inclusion of hurricanes (extreme events) into the REP analysis. We will explore this possibility.
- Two possible indicators of sediment delivery by watershed were compared. One was mean REP for the watershed. The second indicator combines mean REP by watershed with the sum of precipitation by watershed. From review of maps, mean REP by watershed seems the better indicator of sediment risk at the river mouth.

3) Watersheds:

- There was not much comment on our watershed delineations at the workshop. Phil Krammer and WWF have provided a data set on river locations along the Central America that can be used to evaluate watershed delineations.

4) Calibration of the model:

- Liana McManus offered data from the Land Ocean Interaction in the Coastal Zone (LOICZ) project and another source (Svitsky and Milliman??) to evaluate sediment delivery estimates for the larger watersheds.

Data from Sea Wifs that has been processed to look at sediment in coastal areas might be available from Chuanmin Hu (University of South Florida).

Marine-based Sources of Pollution

A session on marine-based sources of pollution allowed for discussion of whether this should be maintained in the analysis as a separate threat category, review of preliminary model results, and discussion of additional data sources.

The preliminary approach to estimating threat from marine-based sources of pollution was based on a coral reef's proximity to ports (qualified by size), and to oil wells and other infrastructure. Due to lack of data, shipping lanes were not included in the preliminary analysis.

Conclusions from the session:

- Participants feel that we should evaluate marine-based sources of pollution as a separate threat in the analysis.
- Participants agree that this is an important threat, which is fairly widespread across the region. In addition to the pollution-related threat, there is a threat from invasive species and red tides associated with ballast water discharge.
- It is important to include shipping lanes within the model. UNEP-WCMC has shipping lane data from ITOPF (focused on tanker routes.)
- It would also be good to include information on cruise ships. Michelle Page of the Florida Cruise Ship Association was suggested as a contact.
- Information on reef access points (such as marinas, harbors, and boat ramps) would help to identify areas of high use and possible degradation. Some possible data sources were suggested, including GARMIN GPS, and the Marnier's Guide to Sailing the Caribbean.
- WRI will follow-up on these potential data sources and will make improvements to the model depending on the data available.

Evaluation of Relative Overfishing Pressure across the Wider Caribbean (Phil Krammer, AGRRA, Jon Maidens, WRI,)

This session provided an overview of the current approach to evaluating overfishing pressure, which integrates information from REEF surveys, AGRRA assessments, and coastal population density to develop a preliminary indicator of overfishing pressure. The session also allowed for discussion of methodology and review of preliminary results.

For the preliminary analysis of overfishing pressure, we looked both at coastal population density and at some data from coral reef fish surveys. We identified populations within 10 km of the coastline from modeled 1km resolution LANDSCAN data set (USDOE, 1998). We then produced a surface reflecting the total population within 40 km of a given location and overlaid this with coral reef locations to produce an indicator of population within 40 km of each coral reef. The second part of the analysis was developed to validate the population density approach. The abundance of ten target reef finfish species was calculated with data from the REEF roving diver surveys. This data set is region wide and has about 2500 sites. Data from AGRRA was not included in this initial analysis, but will be in the future. AGRRA provides fish size attribute, which the REEF survey data does not capture.

The participants commented that the results of the analysis reflected in general what is known about the threats to the reef fish populations, but the analysis methodology requires some development.

Conclusions from the sessions:

- Population density based analysis
  - Coastal population density should be weighted by shelf area.
  - Population density should be clipped by EEZs. This would limit the pressure indicator to pressure that is national in origin as illegal fishing is not such a problem in the Caribbean.
  - Participants would like to see the proportion of fishermen within the population to be used and if possible the numbers that are actually fishing the reefs (no sources for the region were suggested though).
  - The assumption that a fishermen will travel 40km too is too great a distance. Participants suggested that 10 to 20km would be more realistic, but fishermen will travel as far as needed. The distance should also be lineally revamped so that the farther offshore areas have lower threat. (Also suggested was a tiered buffering system as fishermen will travel as afar as needed to be profitable – and will travel to the closest reefs first.)
  - Adjust this pressure indicator by national GDP. Tier the distance evaluated based on the GDP
    - Countries with larger GDP are evaluated for a greater distance
    - Countries with lower GDP – more localized

- REEF/AGRRA diver survey analysis
  - Increase the coverage of the REEF sites (there are more available)

- Resample the REEF sites to remove bias for sites that have higher survey effort
- More than 10 target fish species are necessary for a valid analysis – the list should include more species at lower trophic levels
- Introduce the AGRRA survey data into the model – size of fish is important
- Biogeographic distribution is also important and should not be overlooked in the analysis – replacing zero values with null values, where the species isn't found.

- Participants strongly endorsed the use of lobster and conch data, which can be used as a proxy for fishing effort. These two highly valuable commercial stocks have good regional data available from recent studies (CITES, WCAFC Lobster Working Group).

- Being able to capture the perception of fishermen was also felt to be important, because of the historical traditions of fishing and the fact that fishing has been going on so long that no-one remembers how good the fish stocks used to be – a potential method for highlighting the creeping baseline effect in the Caribbean.

- Protection is very important to capture, but the regulations of the reserves need to be accounted for as many allow trap fishing, thus offering little protection to the reef fish population.
  - Also it was suggested that there could be enough information to be able to rank the management effectiveness of the fishing authorities. Need to factor into the model the capability of the fishery management authority in evaluating the threats.

- Scale of the analysis – There is a great deal of historic and biogoegraphic differences across the region. As such, regional analysis is difficult. We will examine overfishing pressure at the country and sub-country level.

For the population density analysis, WRI will rerun the updated model with the above changes, probably producing a range of alternatives for the second round of reviews. This analysis is dependent on acquiring quality bathymetry data.

More coverage is available for the REEF data which will be requested. WRI will work with Phil Kramer to increase the number of target fish and develop the fish population approach further. Biogeographic distribution of fish species will be obtained.

WRI will pursue further the collection of qualitative information to go towards the country summaries. WRI will also acquire the lobster and conch data to explore its use as a proxy for fishing effort in the Caribbean.

Coral Bleaching – Evaluating Relative Resistance (Mark Spalding, Independent, Phil Krammer, AGRRA)

Presentation of preliminary approach to analysis of the relative resistance of different coral reef locations to coral bleaching; discussion of background (input) data sets for pilot analysis; discussion of relative importance of different factors; feasibility of analysis.

In examining coral bleaching under *Reefs at Risk in Southeast Asia,* we were not able to examine any spatial differences in susceptibility to coral bleaching. As a result of several recent workshops on the topic and hypotheses developed over the past few years, we are interested in exploring the possibility of implementing a pilot analysis of the differential susceptibility of coral reefs to bleaching across the wider Caribbean.

The thinking:

- Bleaching is a stress response, which can be caused by a number of factors. Not all locations, however, have the same susceptibility to coral bleaching. Different locations could have
  a) differing resistance to coral bleaching, or

b) differing resilience (ability to recover rapidly)

The main factors that affect these are:

- Temperature and Water Exchanges - proximity to deep water; upwellings; wind-driven mixing; high wave energy; fast currents and high tidal ranges; topographic features which cause fast water movements (such as channels); and areas which seem less subject to high temperatures.
- Light - cloud cover; turbidity; reefs on steep slopes; island shadows; reef structural complexity; and polar facing reefs
- Intrinsic factors and adaptation - reefs naturally exposed to large temperature availability; emergence at low tide; Zooxanthellae genotypes.
- Factors affecting recovery (affecting resilience only) - high connectivity by currents; size and distribution of adjacent reef areas; high coral cover prior to bleaching; wider ecological factors; protection from other impacts.

Data are not available for all of these data sets, and data which are available are often coarse scale or of limited quality. A review of available data lead us to believe that there are likely to be data available reflecting depth (bathymetry), water mixing (wind, waves and currents), and cloud cover.

The main question is whether it would be sensible and possible to develop a single data layer reflecting relative resistance of locations to coral bleaching.

Conclusions from the session:

- Coral bleaching is an important threat in the region, and we are encouraged to pursue this pilot analysis of relative resistance to bleaching, but, we should not include it in the threat model per se. It should be a separate layer for discussion.
- We should focus on the months where bleaching is most likely to occur – July through September, rather than using annual averages.
- It should be noted that in the Caribbean, bleaching does not always result in mortality. Many reef recover.
- We should examine hypothesized factors during actually bleaching events (if historical data area available) to test some of these relationships.
- We are also encouraged to examine data on SST anomalies during the five big bleaching events, and look for relationships with other factors and the observations of bleaching.
- Burt and Lucy Williams of the University of Puerto Rico were noted as having these sorts of data.

Thoughts on the pilot analysis:

- The most important layers remain depth of water near the reef and water movement in the area.
    a) Proximity to deep water is an important factor. It was also suggested that proximity to a large mass of shallow water could be an important factor. Our present depth data is of too course resolution to be useful for this analysis. We should purchase the C-map data product and develop a bathymetry grid. We can probably improve on this in shallow areas by combining it with SeaWifs.
        - We could look at 30, 50, 100, or 200 m contour for depth of deep water. We will make this decision based on the resolution of the data.
    b) Phil Krammer, Johnathan Kool and others at RSMAS are working on water movement data sets. These will integrate (if possible) currents, wind and wave energy at about 9 km resolution. The focus will be on the months with the greatest risk of bleaching – July to September.
        i) Currents – available from RSMAS's MICON model (roughly 8 km resolution) are not very good close to shore.
        ii) Wind data – capture large scale patterns well (about 13 km res.)
        iii) Wave height data – observations are available from a Navy atlas from 1940 to 1990.
        iv) Reef exposure is also important.– Phil is going to try to test classifying exposure based on whether an area is windward or leeward of the 100 m contour.
    c) Cloud cover – We will explore the availability of data on cloud cover during July to September.

- Within the report, we would likely present two maps – one on observations of coral bleaching, the other on "Estimated relative resistance of different locations to coral bleaching."
- We should explore whether there are other organizations already working on coral bleaching (WWF, TNC or CI) that might want to partner on this.

Coral Disease in the Wider Caribbean (Ed Green, UNEP-WCMC)

Presentation on data available on coral disease across the Wider Caribbean; discussion of appropriate approaches for analysis of coral disease within the Reefs at Risk project; review of maps of observations of coral disease; discussion of other data sources.

UNEP-WCMC have compiled a database on observations of coral disease from a variety of sources including AGRRA, NOAA, and the University of Puerto Rico.

Discussion and Conclusions:

- Participants agree that we should not attempt any sort of vulnerability analysis regarding coral disease. Rather, we should clearly address the issue within the *Reefs at Risk* report, and present a mapping of observations of the most important diseases.
- We should focus on the most important diseases – Black Band, White Band and White Plague.
- We should note that there is a relationship between stress and the observations of a disease. A stressed reef is more likely to get sick.
- Several participants noted that disease seems to increase after coral bleaching. If the data allow, we will try to examine this.
- Participants reviewed maps showing UNEP-WCMC's data on observations of coral disease (compiled from many sources.) UNEP-WCMC will be revising the data based on these inputs.

Marine Protected Areas and Management Effectiveness (Ed Green, UNEP-WCMC)

Presentation on UNEP-WCMC's efforts to date to develop a comprehensive mapping of MPAs across the region and integration of data on MPA characteristics from a range of sources; review of results; development of a rating of MPA effectiveness; development of plan for improving the MPA database.

UNEP-WCMC have compiled information on MPAs from a variety of sources including the World Database on Protected Areas (WDPA), CANARI, CAMPAM (a product of UNEP Regional Seas), and others. The objective is to assemble both spatial information (location and extent) and attribute information (characteristics of the MPA). Ultimately the R*eefs at Risk* project would like to have information on management effectiveness for all MPAs. Workshop participants had the opportunity to review maps of MPA locations and a table, which offered the opportunity to comment on management effectiveness.

Discussion and next steps:

- Review of the maps and data revealed some errors:
    - Some MPAs are missing from the database, while some terrestrial protected areas (without a coastal or marine component) seem to be included.
    - Internationally-designated MPAs seem to be missing from this list.
    - For many MPAs, there is only a point location (no polygon extent). This can be improved for some MPAs.
    - For MPAs that only have points, we would buffer the point based on the MPA area. But, at present, 110 of the 390 polygonless points lack any sort of area estimate.
- Participants rated management effectiveness of MPAs they are familiar with on sheets provided. We agreed to use a four-point rating scheme similar to what was used by CANARI/MRAG – High, Moderate, Low and None. At the workshop 198 of the 646 listed MPAs were rated for management effectiveness.
- There are other sources of information on MPAs that should be approached and included. These include:
    - CANARI – which have additional data on the web;

- Rich Appledorn (of U of PR) who seems to have data for many areas;
- Kali DeMeyer / CORAL- who should have information for some MPAs.
- an MPA workshop hosted by TNC

Further work to be done:
WCMC will work to improve the base dataset of coverage. We need to be confident that we have the definitive list of MPAs for the Caribbean. WRI and WCMC will work at acquiring polygon coverage for as many sites as possible, and an accurate size attribute where there is a point location only. WCMC will provide a dataset of internationally designated MPAs.

WRI will research and approach alternative sources for information.

WRI and WCMC will coordinate the effort for assessing management effectiveness. WCMC will continue with the application of the CANARI method to other MPAs derived from its' compilation of MPA attribute information. A strategy for assessing the management effectiveness of remaining MPAs will be developed, possibly through the project partners.

Natural Vulnerability of Coral Reefs to Pollution, Sedimentation, and Hurricanes (Lauretta, WRI)

Discussion of the use of an "adjustment" to the threat modeling which addresses the differential vulnerability of different locations to pollution and sedimentation and the differential threat of storm impacts; discussion of data available for this analysis.

Adjustment – Natural Vulnerability

- Participants encouraged the development of an indicator of natural vulnerability to pollution and sedimentation. This data layer would be developed through an approach similar to what was done for *Reefs at Risk in Southeast Asia*. This data layer would be based on:
    i) Depth of nearby water
    ii) Fetch, or another indicator of water movement
    iii) Currents, if available (MYCOM is the likely source)
    iv) Leeward versus windward shore, if available.

Hurricanes

- There was considerable discussion on the effect of hurricanes on coral reefs. There can be both positive and negative impacts. It depends on many different variables, including the current state of the coral reef. A hurricane can help to rejuvenate a reef, though if a reef is already degraded, a hurricane can impede recovery.
- It was noted that it is not always a direct hit of a hurricane that does the most damage. For example, Mitch hit Honduras directly, but did more damage in other areas. Hurricanes pass near Jamaica and cause sufficient rainfall for floods and damage.
- We should not include the hurricane layer as an aspect of vulnerability, but should try to include it in the watershed based analysis of sediment delivery. (This will be done if a data set of sufficient quality on hurricanes can be obtained or developed.)
- We should include a text box (or some sort of section) on hurricane impacts on coral reefs, and possibly some more general mention of other climate-related changes and impacts. Carolyn Rogers offered to help on this section.
- We made an initial attempt to develop a "hurricane probability layer." The results were not convincing, as we show Jamaica, for example, as a very low activity area, while in fact, this should be high. We should first look to see if there is an existing data set (or even an image) we could use. Some possible sources would be the National Hurricane Center in Miami, or the World Bank Disaster Preparedness project.
- But, in case we need to work with our data on hurricane occurrence, we would:
    a) Widen the buffer beyond 50km,
    b) Include all storms (down to tropical depressions)

c) Use more recent data (1944 forward)
d) Compare results where we do and don't weight by storm size;
e) Do a plot of frequency by year (bar chart)

Economic Valuation of Coral Reefs (Chiew Chong and Mahfuz Ahmed, ICLARM)

Presentation on objectives of economic valuation component of Reefs at Risk; presentation of proposed method for valuation analysis and information needs; discussion of methodology and data sources.

ICLARM will be implementing the economic valuation analysis, with input from WRI. Chiew presented two possible approaches to the analysis:

1) First, a metadata analysis which would be based on past research. This would involve creating a database summarizing results of valuation studies and then use regression techniques to determine the relationship between independent variables (reef area, length of coastline, number of tourists, etc) and estimated value of coral reef (direct and indirect use values.)
2) The second method involves using existing data to estimate fisheries production and income, tourism income, etc, using the actual values.

Discussion:

- Participants encouraged trying to implement the first method as the primary approach, but supplement it with the second, where needed.
- ICLARM will need additional data to conduct this analysis, including additional references, and data on coral reef condition, reef areas, and visitation information.
- WRI can provide reef area estimates and other socioeconomic data to ICLARM.
- WRI can also suggest some "subregions" for grouping countries as to reduce the number of geographic units in the analysis.

Other Modeling Approaches, Use of Data for Calibration

Open discussion of modeling approaches presented over the first three days; discussion of data available for calibration of the threat estimates.

Discussion:

- Within individual sessions, participants helped to identify data sources for calibration of the components (such as the use of data from SeaWifs or LOICZ for sediment delivery.)
- It is the Integrated Reefs at Risk Threat Indexthat can be calibrated against condition information. Here, the integrated index summarizes threat from a range of human activities, and factors "natural vulnerability" into the analysis. Although this is a "pressure indicator," it would be worthwhile to compare this to available data on coral reef condition. We can use data from AGRRA, CARICOMP, and data from Billy Causey for the Keys.

Revisiting of Unfinished Topics

An opportunity to review maps and come to closure on any outstanding modeling issues.

Key Comments

- Key Disclaimer – As we present our analysis, we need to be clear about the difference between realized and potential threats. Also, about reefs that already might be gone.
- Policy Comments - Participants questioned how far WRI should go with policy recommendations within the report, and whether there would be a hierarchy of recommendations for addressing global, regional and local threats. In general, WRI provides a brief summary of policy recommendations within a Reefs at Risk report, and will strive to make clear the options (and importance of actions) at different levels. It was also noted that WRI provides tools and information through the Reefs at Risk project, and hopes that project partners, NGOs and national governments will use the information generated through a Reefs at Risk project to address threats to coral reefs.

- Extent of region - Hector Guzman felt strongly that we should not include Pacific reefs as they have not been reviewed through this process. It should be noted that only a limited portion of Pacific reefs are included within our rectangular maps. We agree with Hector's point. WRI plans to go ahead and assemble data for both coasts (such as elevation and land cover) and perform the watershed modeling for both drainage directions (for future use.) However, we will not include Pacific coral reefs in this analysis.

Products / Next Steps / Review (Lauretta, WRI)

Discussion of appropriate products for the Reefs at Risk Caribbean project (reports, data CD, poster, web site, others); agreement on next steps; development of plan for review of results of revised model.

Products

- We should focus our efforts on the report, the data CD and the Web site.
- The printed report (in English and Spanish) would provide a fairly concise summary, while lots of additional information would be made available over the web (such as the country by country summary.)
- People also like the idea of a poster, but found the poster for Southeast Asia to be much too wordy.
- Some participants encouraged the development of a large map or poster, folded as an insert in the back of the report.
- Alessandra would also like a summary pamphlet (in 3 languages.)
- On the data CD, in addition to the GIS data sets, technical notes and high resolution maps, we are encouraged to provide a PowerPoint presentation which can be used for (or by) policy-makers.
- WRI is not planning on asking people to write "reef stories" about particular reefs around the region.

Review and Next Steps

- WRI hopes to have the next version of the modeling ready for review by late winter or early spring. We can make these draft results available for review over a password protected portion of the ReefBase site.
- The draft report should be ready for internal review at WRI by late June, and for external review in late August or September.

Thanks much for all of your support at the workshop.
We look forward to working with you further on this project.

Warm Regards,
Lauretta Burke (lauretta@wri.org)
Jon Maidens (jmaidens@wri.org)
Stephen Menard (smenard@wri.org)

Reefs at Risk Caribbean Threat Assessment Workshop
Participant List
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Name	Organization	Email
Mahfuz Ahmed	ICLARM	m.ahmed@cgiar.org
Oscar Alvarez Gil	National Commission of Protected Areas	oalverez@conanp.gob.mx
Serge Andréfouët	University of South Florida	serge@seas.marine.usf.edu
Lauretta Burke	World Resources Institute	lauretta@wri.org
Georgina Bustamante	The Nature Conservancy	gbustamante@tnc.org
Billy Causey	NOAA, NOS, Florida Keys National Marine Sanctuary (FKNMS)	billy.causey@noaa.gov
Chiew Kieok Chong	ICLARM	c.chong@cgiar.org
Richard Curry	Biscayne National Park	richard_curry@nps.gov
Cara Dickman	NCORE	cdickman@rsmas.miami.edu
Jaime Garzon-Ferreira	Instituto De Investigaciones Marinas Y Costeras (INVEMAR)	jgarzon@invemar.org.co
Bob Ginsburg	University of Miami	rginsburg@rsmas.miami.edu
Ed Green	UNEP - WCMC	ed.green@unep-wcmc.org
Hector Guzmann	Smithsonian Tropical Research Institute	guzmanh@naos.si.edu
Milton Haughton	CARICOM Fisheries Unit (CFU)	haughton@caricom-fisheries.com
Noel Jacobs	Mesoamerican Barrier Reef System Project (MBRS)	ndjacobs@mbrs.org.bz
Johnathan Kool	NCORE	jkool@rsmas.miami.edu
Philip Kramer	University of Miami	pkramer@rsmas.miami.edu
Michelle Libby	The Nature Conservancy	mlibby@tnc.org
Dulcie Linton	University of the Wrest Indies	dmlinton@uwimona.edu.jm
Brian Luckhurst	Dept of Environmental Protection	bluckhurst@gov.bm
Jon Maidens	World Resources Institute	jmaidens@wri.org
Melanie McField	WWF Mesoamerica Reef Conservation Program	mcfield@btl.net or mcfield@wwfca.org
John McManus	NCORE	jmcmanus@rsmas.miami.edu
Liana McManus	University of Miami	lmcmanus@rsmas.miami.edu
Stephen Menard	World Resources Institute	smenard@wri.org
Peter Murray	OECS Natural Resources Management Unit	pamurray@oecsesdu.org
Jamie Oliver	ICLARM -- The World Fish Center	j.oliver@cgiar.org
Hazel Oxenford	University of West Indies, Barbados	hoxenford@uwichill.edu.bb
Bruce Potter	Island Resources	bpotter@irf.org
Caroline Rogers	US Geological Survey	caroline_rogers@usgs.gov
Mark Spalding	University of Cambridge	mark@mdspalding.co.uk
Luc St-Pierre	UNEP-CAR/RCU	lsp.uneprcuja@cwjamaica.com
Kathleen Sullivan Sealey	University of Miami	ksealey@miami.edu
Elizabeth Taylor	CORALINA	elizabetht@coralina.org
Alessandra Vanzella-Khouri	UNEP-CAR/RCU	avk.uneprcuja@cwjamaica.com
Ernesto Weil	University of Puerto Rico	eweil@caribe.net ; reefpal@yahoo.com