Belize Coastal Threat Atlas

DRAFT, May 2005

A collaborative data product coordinated by the World Resources Institute

WORLD RESOURCES INSTITUTE

The Reefs at Risk in Belize project is implemented by the World Resources Institute in collaboration with many partners in Belize, and has received generous support from the Oak Foundation. Analysis of threats along the Mesoamerican Reef is supported by the US Agency for International Development and the United Nations Foundation through the ICRAN partnership.

Belize Audubon Society (BAS)
Belize Biological Diversity / Belize Tropical Forest Studies
Belize Fisheries Department
Belize Forest Department
Belize Meteorlogical Department
Coastal Zone Management Authority and Institute (CZMAI)
Friends of Nature (FoN)
Green Reef
Hol Chan Marine Reserve
International Coral Reef Action Network
- Mesoamerican Reef Project (ICRAN-MAR)
Land Information Center (LIC)
The Nature Conservancy (TNC)
Toledo Institute for Development and Environment (TIDE)
Toledo Association for Sustainable Tourism and Empowerment (TASTE)
University of Belize
Wildlife Conservation Society (WCS)
World Resources Institute (WRI)
World Wildlife Fund (WWF) Belize
World Bank/GEF Mesoamerican Barrier Reef Systems Project

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Photo credits: Turtle by Krishna Desai;
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Ship by Wolcott Henry; River plume from NASA.

Belize Coastal Threat Atlas

The *Belize Coastal Threat Atlas* and the *Belize Coastal Data CD* are products of the *Reefs at Risk in Belize* project.

The *Reefs at Risk in Belize* project is implemented by the World Resources Institute (WRI) in collaboration with many partner organizations in Belize. A list of collaborating organizations is included on the back cover.

Acknowledgments

The *Belize Coastal Threat Atlas* would not have been possible without the encouragement and financial support provided by the Oak Foundation through the *Reefs at Risk Belize* project. Financial support for the analysis of threats along the Mesoamerican reef was provided by the US Agency for International Development (USAID) and the United Nations Foundation through the International Coral Reef Action Network (ICRAN) Mesoamerican Reef (MAR) project.

The World Resources Institute (WRI) gratefully acknowledges the many partner organizations and colleagues who contributed to this project - Belize Audubon Society, Belize Biological Diversity / Belize Tropical Forest Studies (BTFS), Belize Fisheries Department, Belize Forest Department, Belize Meteorological Department, Coastal Zone Management Authority and Institute (CZMAI), Friends of Nature, Green Reef, Hol Chan Marine Reserve, ICRAN Mesoamerican Reef Project, Land Information Center, The Nature Conservancy, Toledo Institute for Development and Environment, Toledo Association for Sustainable Tourism and Empowerment, University of Belize, Wildlife Conservation Society (WCS), World Wildlife Fund (WWF), and World Bank/GEF Mesoamerican Barrier Reef Systems Project.

WRI would like to give special thanks to the following colleagues in Belize: Melanie McField (WWF) and Janet Gibson (WCS) for their contribution to the concept and design of the data CD and Atlas; Sergio Hoare (WCS) for editing all the datasets from the threat mapping workshops; Shalini Cawich (WWF) for work on the hotel and tourism data, and for helping to organize the coastal GIS workshop in Belize City; Jan Meerman (BTFS) for the generous provision of many datasets; and Emil Cherrington (CZMAI) for organizing and providing a wealth of base datasets for Belize.

Lauretta Burke, Jon Maidens
World Resources Institute

Reefs at Risk in Belize: Improving the information base for better management of coral reefs

Coastal ecosystems of Belize are threatened by both local threats (coastal development, pollution, sediments, overfishing) and broader scale threats (transboundary sediment and pollution, coral bleaching, coral disease). Pressure on the reefs will continue to grow as development increases, but better management can help reduce the threat and protect these valuable ecosystems in order to maintain their sustainable use.

The *Reefs at Risk in Belize* project was developed to improve access to information on coral reefs in Belize in support of better management of coastal resources.

Information available on threats to and condition of coral reefs in Belize is limited and uneven, but is improving. Several Belizean NGOs have done assessments of resources within selected marine protected areas, and have detailed information for these areas. During 2004, the Wildlife Conservation Society, Belize Audubon Society, Coastal Zone Management Authority and Institute and World Wildlife Fund held a series of threat assessment and mapping workshops where coastal resource users (stakeholders) and scientists mapped known threats to coral reefs in Belize. One workshop was held for each of the four major reef systems – the Belize Barrier Reef, Glover's Reef, Lighthouse Reef, and Turneffe Atoll.

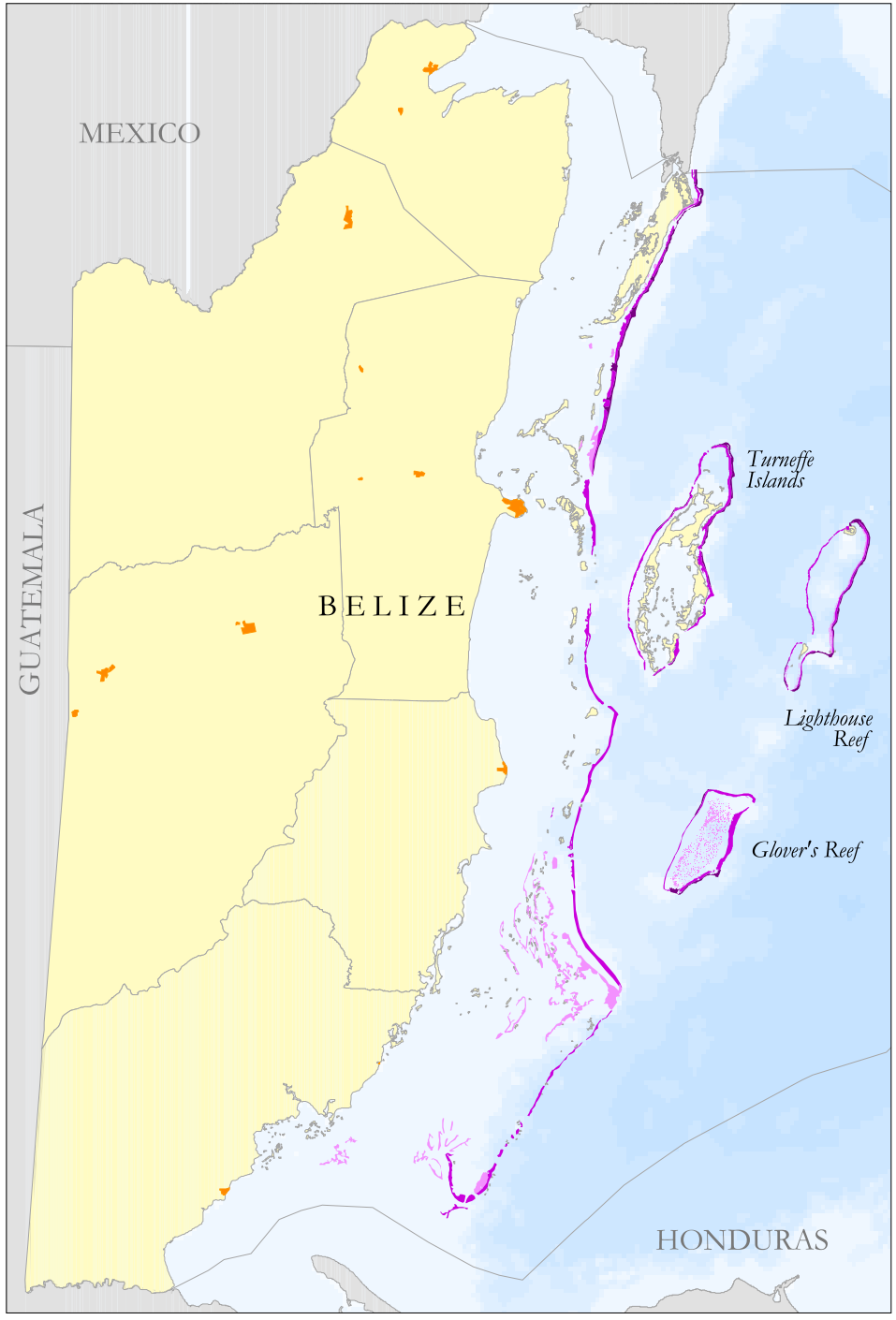
These detailed assessments and "expert mapping" of threats have been complemented by an analytical approach implemented under the Reefs at Risk in Belize project. Reefs at Risk Belize is centered on the use of a geographical information system (GIS) to visualize and analyze the relationship between human activities (pressures) and coral reef health. The project has developed a series of standardized indicators of human pressure on coral reefs from coastal development and marine-based threats and from land-based sources of sediment and pollution. The analysis of land-based threats includes a watershed-based analysis for all watersheds discharging along the Mesoamerican barrier reef region. This atlas provides an opportunity to compare modeled estimates of threat with those derived from expert opinion.

Belize Coastal Threat Atlas – Contents

The *Belize Coastal Threat Atlas* includes fifteen maps, beginning with maps on coastal habitats and marine protection, to provide an orientation to coastal resources and management in Belize. Next are a series of national-extent maps on threats to coral reefs from fishing pressure, coastal development, agricultural runoff, marine-based threats, and natural disturbances. Mapping of threats by local stakeholders and scientists during the workshops are denoted as "expert mapping." These include maps of fishing-related threats, coastal development, and agricultural runoff. Threat estimates modeled under the Reefs at Risk analysis (coastal development, agricultural runoff, and marine-based threat) are denoted as "modeled." The atlas concludes with detailed maps of threat to each of the five reef systems in Belize. These maps reflect the three or four key threats identified by local stakeholders and scientists at the threat assessment and mapping workshops.

Maps

Coastal Bathymetry and Coral Reefs of Belize



Stretching for 250 km along the entire length of the Belize, the country's reef complex is the second largest continuous reef system in the Western Hemisphere, extending from the northern end of Ambergis Cay to the Sapodilla Cays in the south. The barrier reef system encloses approximately 6,000 sq km of lagoon and includes over 1,000 cays. The lagoon is 20 to 40 km wide and only a few meters deep in the north, deepening to 50 m towards the south. Throughout the reef lagoon there are numerous patch reefs. Reef growth along the Belize mainland is limited by fluctuations in salinity and high turbidity and nutrients. Some fringing reefs occur in the far south between Placencia and Punta Ycacos, but have low species richness.

Three atolls lie east of the barrier reef, separated by deep water: Turneffe Islands, Lighthouse Reef, and Glover's Reef. Wave exposure plays a key role in shaping reef communities and development, both between atolls and within the atolls (on windward versus leeward reefs). In addition, a major influence on the barrier reef structure is the wave energy after attenuation by the atolls.

Urbanized Areas

Coral Reefs
- Patch Reefs
- Shallow Reefs
- Spur and Groove

Administrative Districts
Belize Maritime Boundary
National Borders

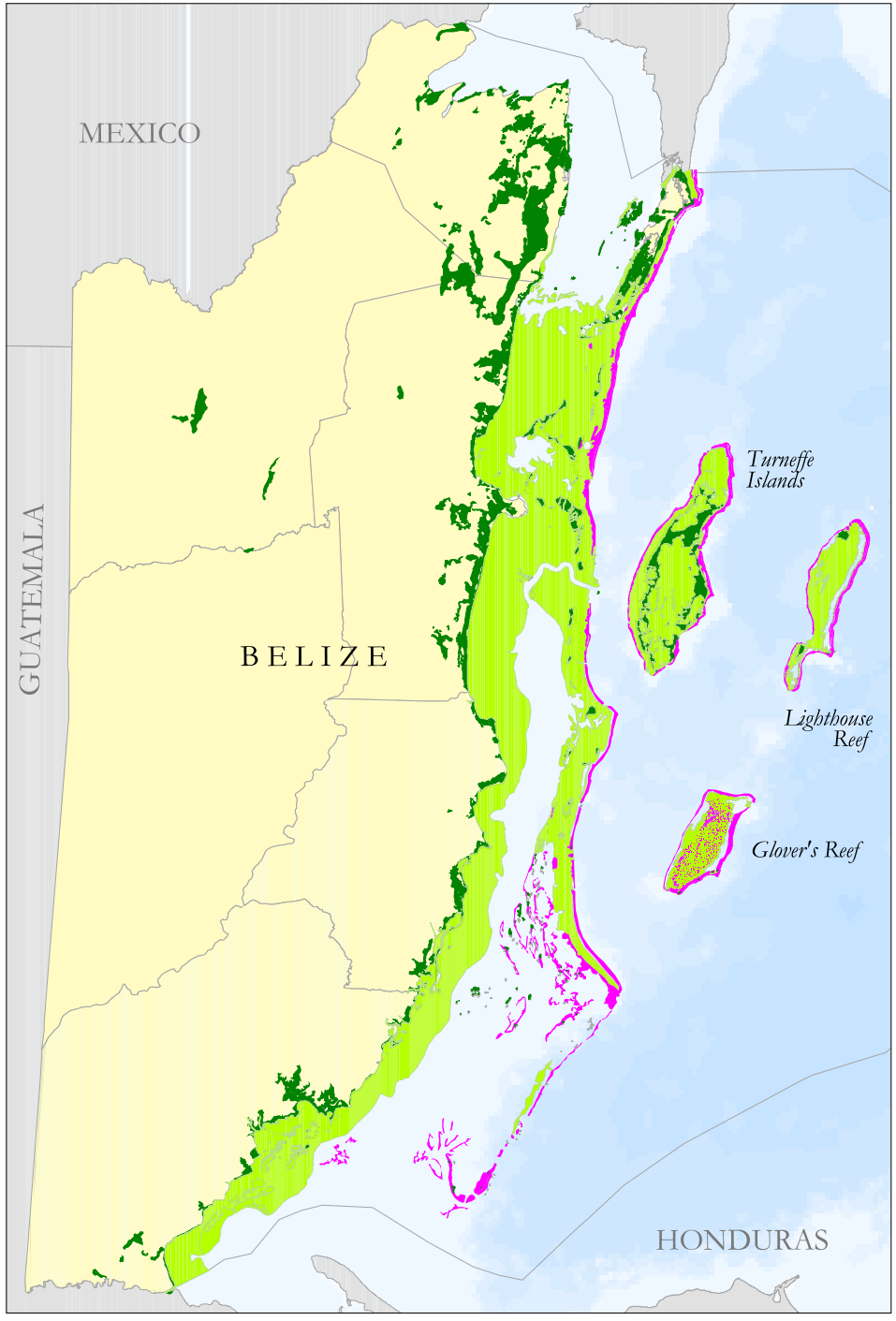
Bathymetry (m)
- -7000 - -5000
- -5000 - -3000
- -3000 - -2000
- -2000 - -1000
- -1000 - -500
- -500 - -200
- -200 - -100
- -100 - 0

Data Sources: Coral reef data from Belize Biodiverstiy Mapping Service (Belize Ecosystem Map, 2004) and CZMAI, 1997 (for Glover's Reef); Bathymetry from WRI, 2004; Administrative Districts for Belize from CCAD (www.ccad.ws).

Reefs at Risk in Belize

A collaboration between the World Resources Institute, Belize Coastal Zone Management Authority and Institute, and many other partner organisations in Belize. Datasets available on the Belize Coastal Data CD (email datacen@coastalzonebelize.org for more information).

Coastal Habitats of Belize



Map Projection: UTM, Zone 16, NAD1927

Coral reefs, mangroves and sea grass all contribute to the rich biological diversity of Belize. Mangrove forests grow in the intertidal range, lining a considerable extent of the coastline of Belize. Further offshore, groups of flowering plants known as seagrasses form extensive "meadows" over soft sediments. Mangroves and seagrasses bind soft sediments, facilitating coral reef development in areas that might otherwise have too much silt for coral growth. All three habitats are very biologically productive and play significant role in the health of many finfish and shellfish fisheries by providing spawning and nursery habitat and nutrients for many species. Seagrass also provides important feeding areas for manatees and sea turtles. Like coral reefs, mangroves protect coastal communities by stabilizing sediments and preventing shoreline erosion. In turn, coral reefs buffer wave impacts, helping to minimize erosion of soft sediments that mangroves and seagrasses need to grow.

Coastal Habitat
- Mangrove
- Seagrass
- Coral Reefs
- Administrative Districts
- National Borders
- Belize Maritime Boundary

Data Sources: Coral reef data from Belize Biodiverstiy Mapping Service (Belize Ecosystem Map, 2004) and CZMAI, 1997 (for Glover's Reef); Mangrove and seagrass data from Belize Biodiverstiy Mapping Service (Belize Ecosystem Map, 2004, http://biological-diversity.info) Administrative Districts for Belize from CCAD (www.ccad.ws).

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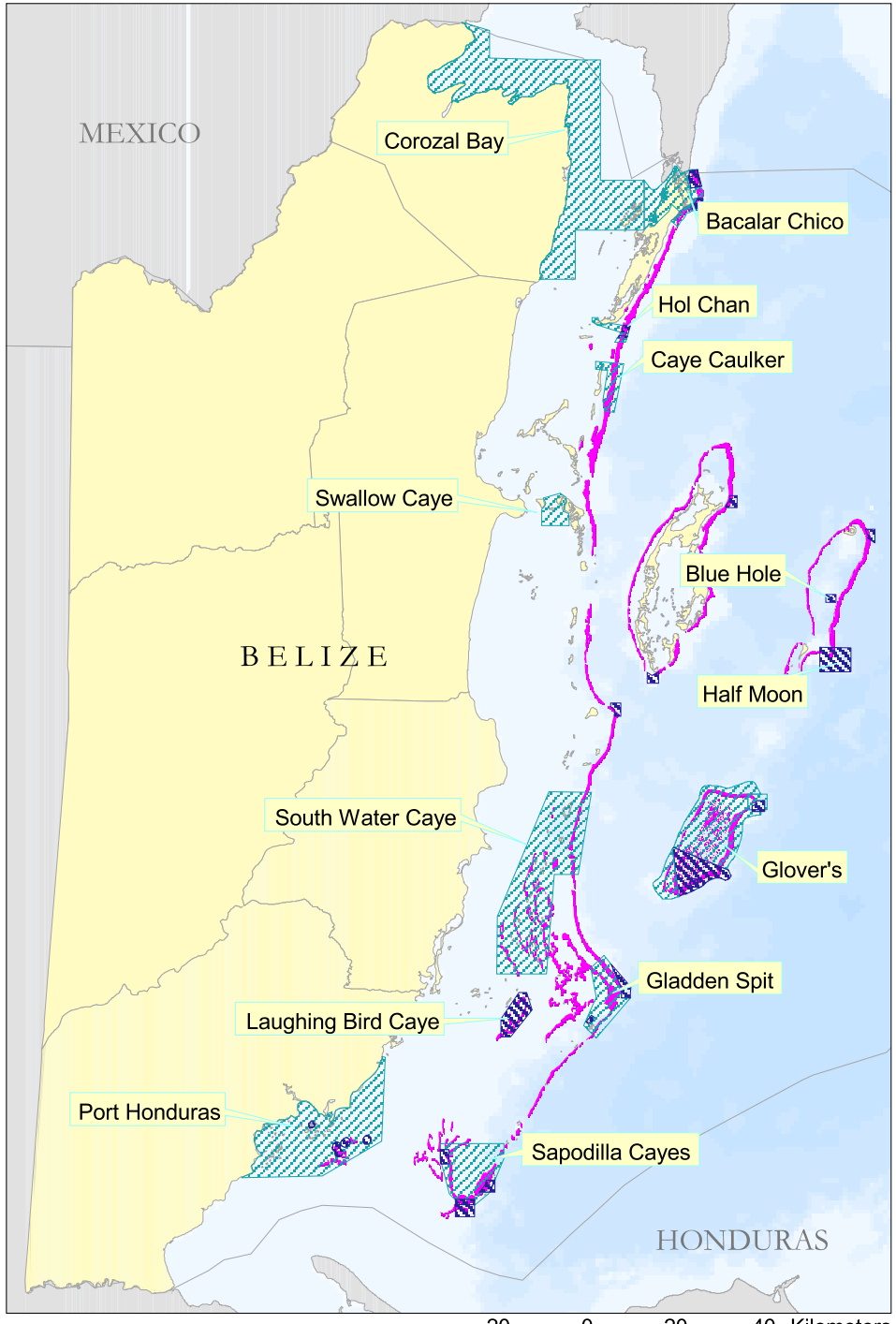

Map Projection: UTM, Zone 16, NAD1927

Marine Protected Areas of Belize

Belize is richly endowed with highly diverse and valuable coastal resources, but many areas are threatened by human activities. Considerable effort has been directed towards coastal management and developing a system of marine protected areas in Belize. The legal and institutional policy framework for managing coral reefs is in place, and MPA management is a mix of both government (either the Fisheries Department or the Forest Department) and NGOs. The Belize Coastal Zone Management Authority and Institute (CZMAI) was established in 1998 as a model of integrated coastal management for the region, and the country's system of 13 MPAs is well established, with almost all under active management. In addition, there are 11 Species Aggregation Sites (SPAGS) that have been declared marine reserves, several of which fall partially within existing marine reserves. Seven of these sites have been declared World Heritage sites and all are world renowned for spectacular marine life.

Belize has the legal and institutional policy framework to manage coral reefs, but may lack the long-term funding for enforcement and monitoring of the extensive system of MPAs. There is considerable reliance on international support, with some support originating from the Protected Areas Conservation Trust (PACT) which is funded through a portion of visitor departure taxes. A regional financing mechanism, the Mesoamerican Reef Trust Fund, has been established from the environmental trust funds of Belize, Guatemala, Honduras, and Mexico, and a major aim of this fund includes sustainable financing of MPAs. Over the last ten years, major support for Belize's MPAs has come from the GEF funded "Coastal Zone Management Projects" for which funding ceased in 2004. Future support (political and financial) for CZMAI is in doubt, which will inhibit effective management of the precious coastal resources of Belize.

Marine Protected Areas (MPAs)
- General Use
- No Take
- Coral Reefs

- Administrative Districts
- National Borders
- Belize Maritime Boundary

Data sources: Marine Protected Areas with no take zones from Coastal Zone Management Authority and Institute, 2004.

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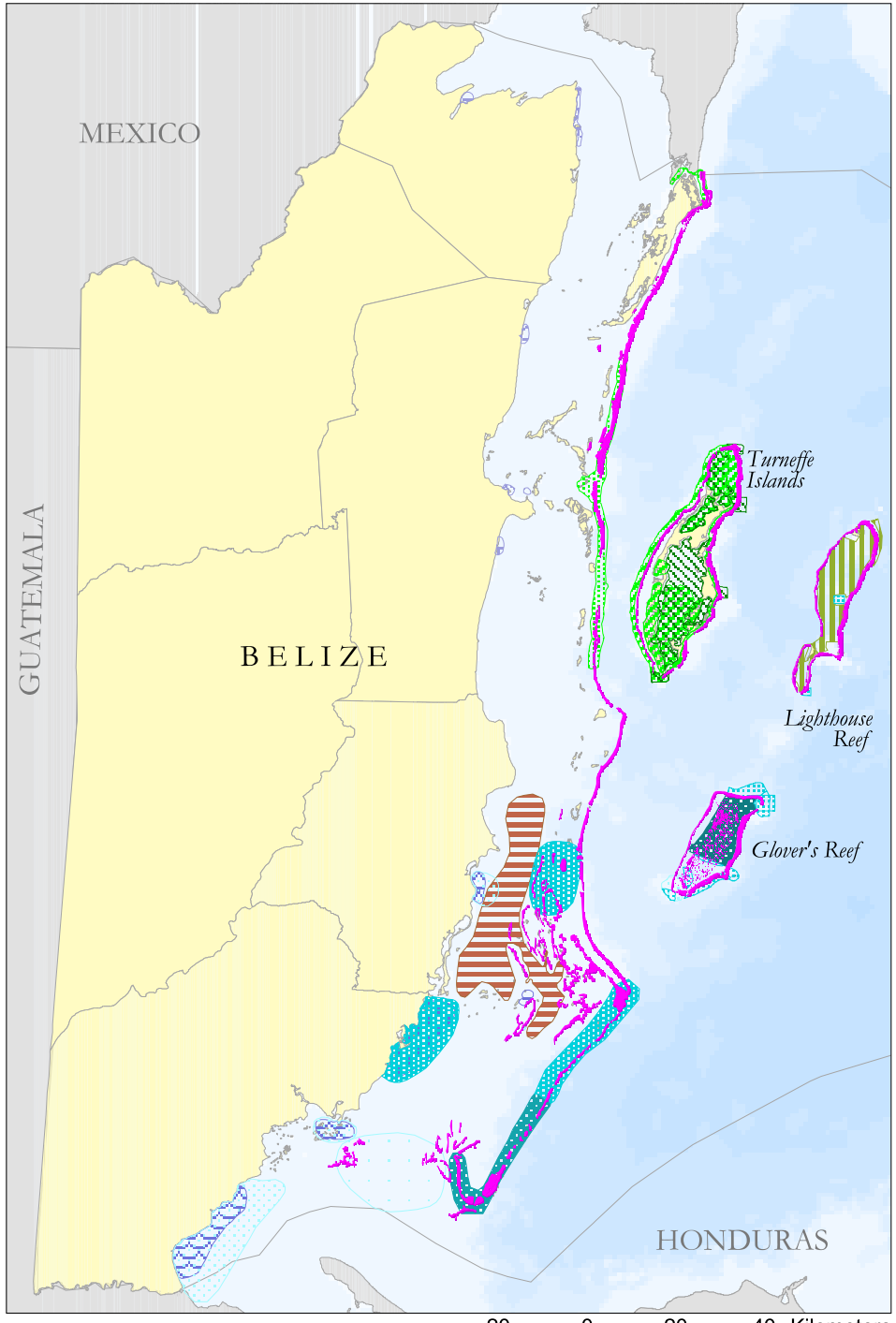
Fishing Pressure on Coral Reefs in Belize - Expert Mapping



Map Projection: UTM, Zone 16, NAD1927

Fishing is a mainstay for many coastal communities in Belize, but overfishing, illegal fishing, and fishing with inappropriate gear (e.g. concern about gill netting at river mouths) threatens the natural resources base that supports near shore fisheries. Fishing in Belize is mainly artisanal and carried out in inshore waters inside the barrier reef and three offshore atolls. Fishing methods include diving for conch and lobster, spearfishing, use of lobster traps and 'shades', fish traps and weirs, hand-lining, gillnetting, and shrimp trawling. Target species are mainly the spiny lobster, queen conch, reef fish, and coastal or inshore pelagics. Several of the larger grouper and snapper species, from areas spanning several hundred square kilometers, congregate at known localities once or twice a year to spawn in vast numbers (known as spawning aggregations or SPAGs).

Local stakeholders and scientists participated in four expert workshops evaluating threats to the four major coral reef systems in Belize. All four workshops identified some type of fishing pressure as one of the most important threats to those reefs. Overfishing (fishing above sustainable levels; at increased effort), illegal fishing (fishing outside of allowed areas and time periods, such as inside Species Aggregation (SPAG) sites or conservation zones), and poaching (unlicensed fishing) were identified as threats to the fishery resources. Along the Southern Barrier Reef, shrimp trawling was also identified as a key threat to benthic habitats that support fisheries, such as coral reefs and seagrass beds.

Overfishing
- Moderate Severity
- Serious

Gill Netting
- Slight to Moderate
- Moderate to Severe

Trawling
- Severe

Illegal and Overfishing
- Moderate Severity

Poaching / Illegal Fishing
- Isolated
- Less Intense
- Moderate Severity
- Intense
- Very Intense
- Serious

Data Sources: Fishing pressure maps based on results from four "Belize Threat Assessment and Mapping" workshops. Wildlife Conservation Society (WCS) for Glover's Reef; Belize Audubon Society and WCS for Lighthouse Reef; CZMAI, Turneffe Islands Coastal Advisory Committee, and WCS for Turneffe; and World Wildlife Fund (WWF) and WCS for the Barrier Reef.

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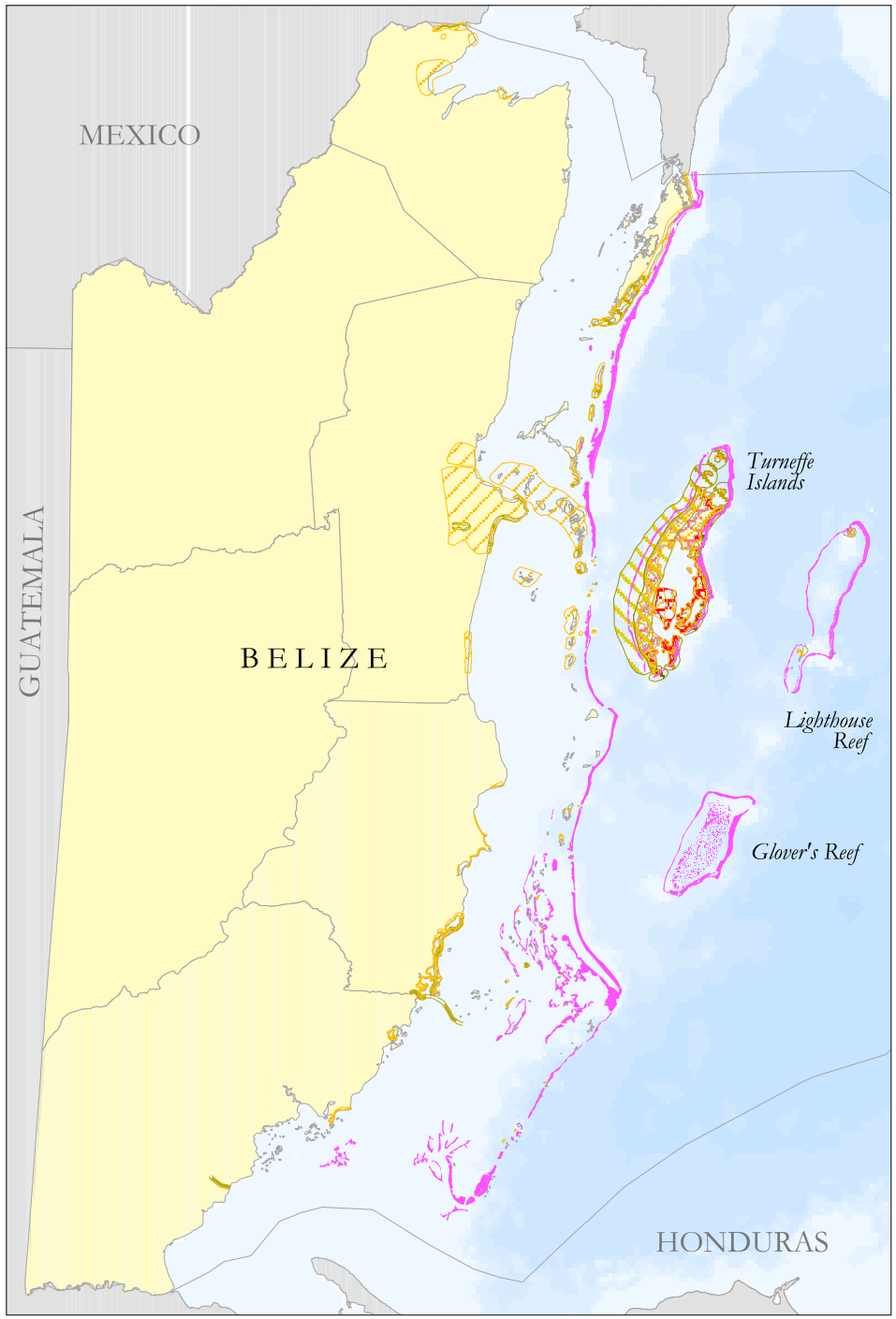

Map Projection: UTM, Zone 16, NAD1927

Coastal Development Threat in Belize - Expert Mapping

Belize is endowed with a beautiful and highly productive coastal environment. Mangroves, seagrass and coral reefs support valuable finfish and shellfish fisheries and attract hundreds of thousands of tourists each year. Many coastal areas, both along the mainland and on atolls, are developing rapidly. Development can impact coastal ecosystems through removal of coastal habitat (such as mangroves), dredging (which obliterates submerged habitat and affects nearby reefs and seagrass beds), runoff from construction sites and roads, and discharge of sewage and grey-water. Coastal development was identified by local stakeholders and scientists at expert mapping workshops as a key threat to coral reefs on Turneffe and Lighthouse Atolls, and along the Belize Barrier Reef. The threat from coastal development is particularly high along the northern Belize Barrier Reef, near Belize City, and near Placencia.

Development
- Moderate Severity
- Mod / High Severity
- High Severity

Dredging
- Medium Threat
- High Threat
- Highest Threat

Mangrove Clearing
- High Threat
- Medium Threat
- Recently Cleared (5 Years)

- Coral Reefs
- Administrative Districts
- Belize Maritime Boundary
- National Borders

Data Sources: Coastal development threat maps based on results of "Belize Threat Assessment and Mapping" workshops - Belize Audubon Society and Wildlife Conservation Society (WCS) for Lighthouse Reef; CZMAI, Turneffe Islands Coastal Advisory Committee, and WCS for Turneffe; and World Wildlife Fund (WWF) and WCS for the Barrier Reef.

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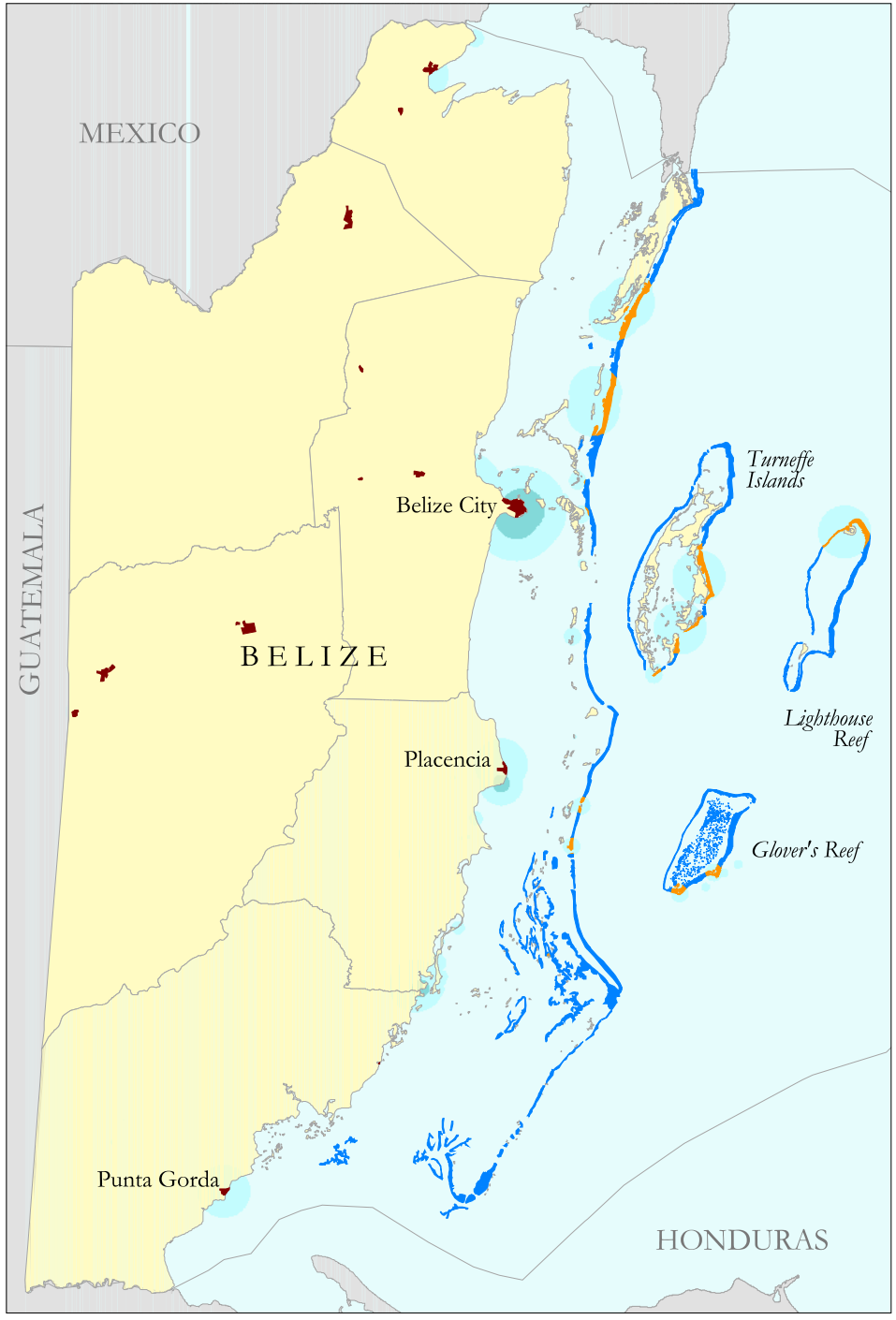
Coastal Development in Belize - Modeled Threat



This map shows threats to coral reefs from coastal development evaluated through spatial modeling of threat based on the location of population, infrastructure and tourism development. Threats to coral reefs from coastal development were also evaluated through "expert mapping" by local stakeholders and scientists (shown on previous map, "Coastal development threat in Belize - expert mapping"). These approaches are complementary, with the expert-based approach capturing local perception of priority threats, and the modeled approach identifying areas that merit closer examination for potential management intervention.

Poorly managed coastal development can threaten coral reefs through dredging, land reclamation, mining of sand and limestone, dumping of spoils, and runoff from roads and construction. Sewage discharge is also a growing threat to coral reefs, as coastal communities expand. Tourism is an important driver of coastal development, with over 240,000 tourists and 850,000 cruise ship visitors in 2004, and tourism projected to grow at 6 percent per year. Threats to reefs from coastal development in Belize were evaluated on the basis of distance to human settlement (ranked by size), ports, airports, and tourism centers. Coastal development threat was identified as threatening to coral reefs along the Northern Barrier reef and on parts of the three atolls. Threat was also identified near Belize City and Placencia, but not reaching out to the reef.

Urbanized Areas
Reefs by Coastal Development Threat
Low
Medium
High
Coastal Development - Modeled Threat
Low
Medium
High
Administrative Districts
Belize Maritime Boundary
National Borders

Data Sources: Modeled threat to coral reefs from coastal development from the "Reefs at Risk in Belize" analysis, World Resources Institute (WRI), 2005.

Reefs at Risk in Belize

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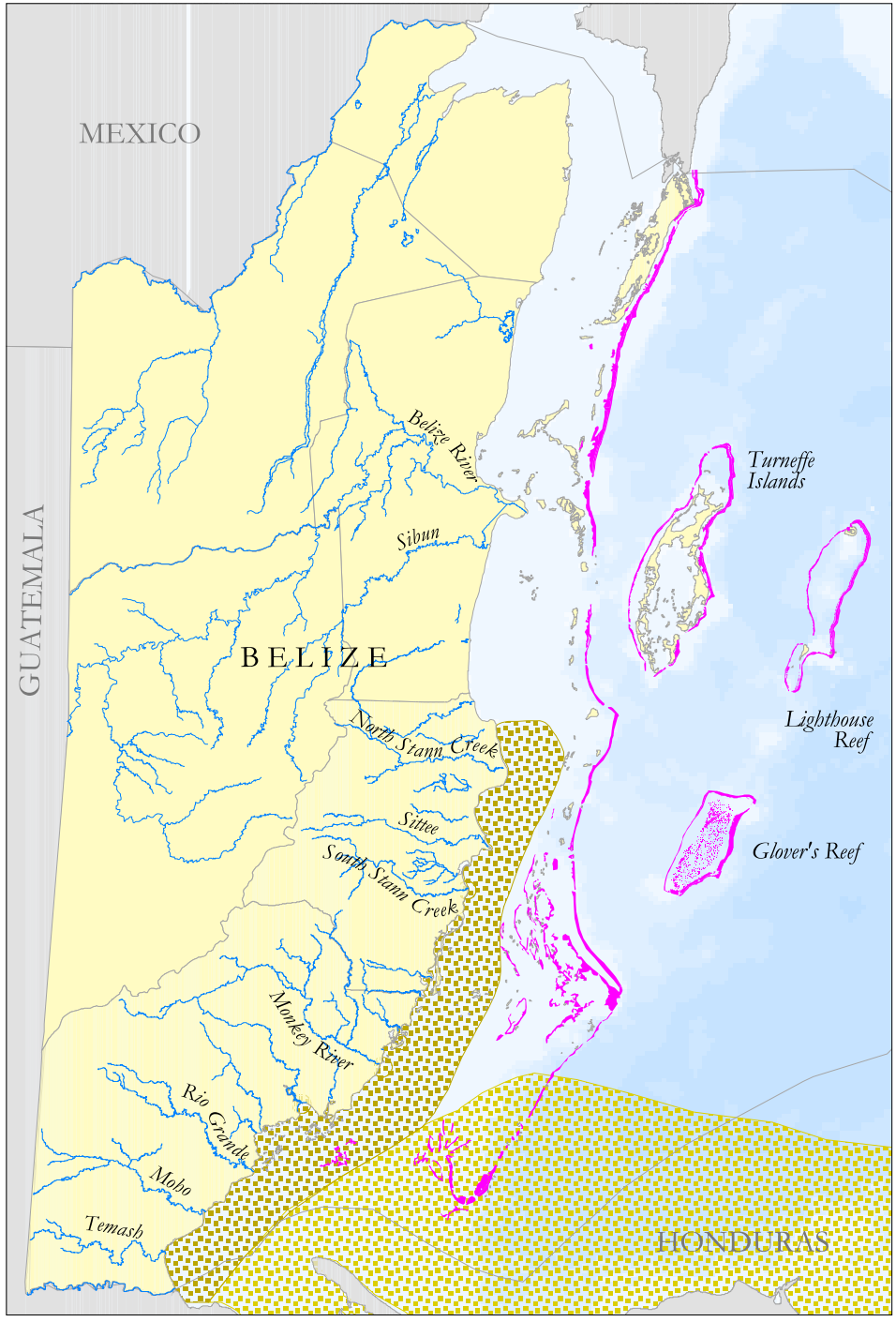
Threat from Agricultural Runoff - Expert Mapping

Agricultural activities in watersheds draining adjacent to the Mesoamerican Reef system, which includes the Belize Barrier Reef, contribute increased sediment and pollutants from fertilizer and pesticide application. Increased nutrients from fertilizer runoff promote growth of algae at the expense of coral reefs. Runoff of pesticides and other chemicals can be toxic to both coral and fish. Excessive delivery of sediment to coastal waters can smother coral. Cultivation of bananas, pineapple, citrus, oil palm and sugar cane in Honduras, Guatemala and Belize was identified by local stakeholders and scientists at a threat assessment workshop as a key threat to coral reefs in the southern Belize Barrier Reef.



Map Projection: UTM, Zone 16, NAD1927

Agricultural Runoff
- Low to Moderate Severity
- Moderate Severity
- Major rivers
- Coral Reefs
- Administrative Districts
- Belize Maritime Boundary
- National Borders

Data Sources: Threat from agricultural runoff based on results of "Belize Threat Assessment and Mapping" workshops. World Wildlife Fund (WWF) and Wildlife Conservation Society (WCS) for the Barrier Reef. Rivers from CZMAI, 2005.

Reefs at Risk in Belize

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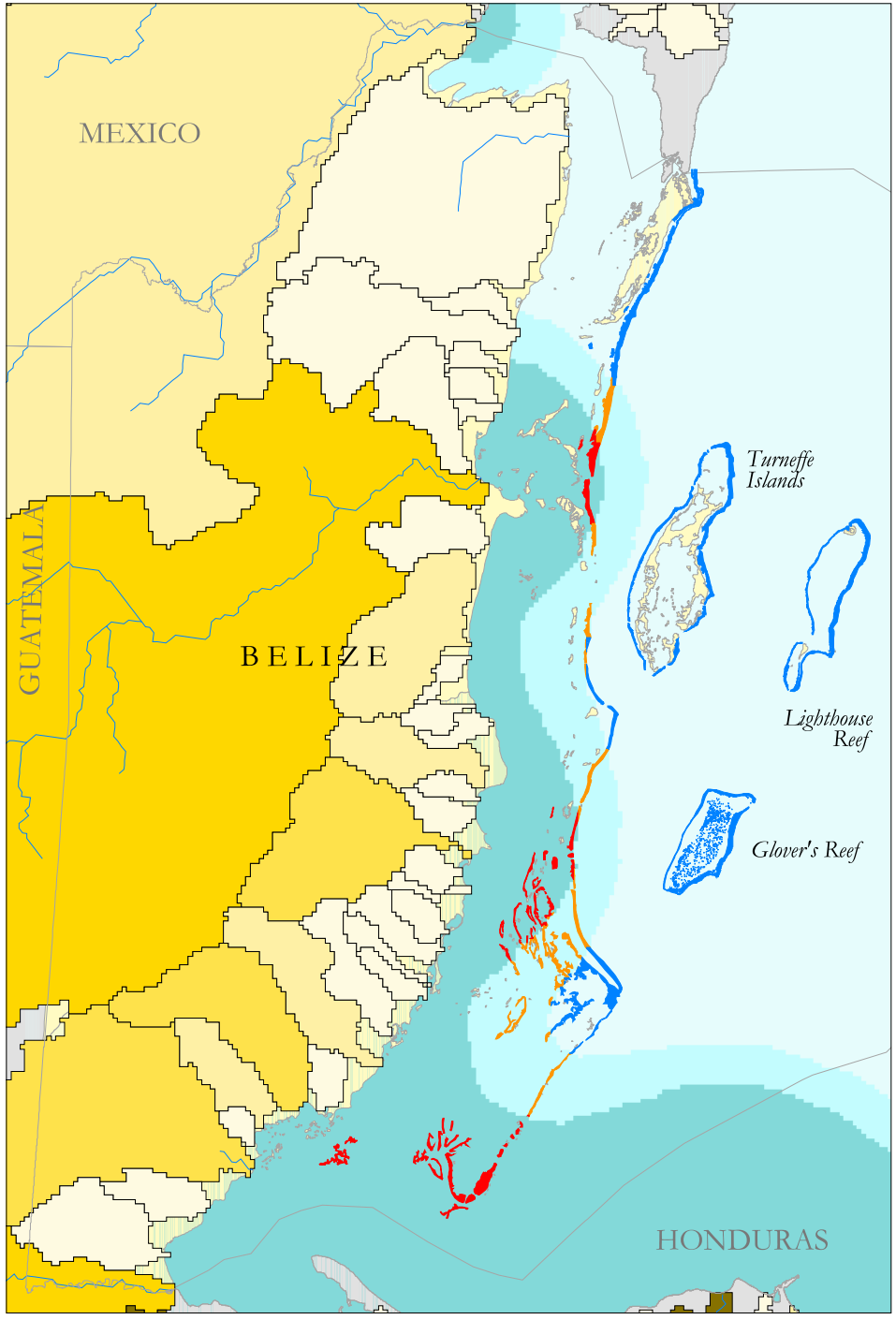
Agricultural Runoff - Watersheds and Modeled Sediment Delivery

Agriculture and other land use activities far inland can have an adverse impact on coral reefs through the increased delivery of sediment and pollution to coastal waters. Watersheds are an essential unit for analysis, since they link land areas with their point of discharge to the sea. A watershed-based analysis of land-based sources of pollution (LBS) was implemented at 1-km resolution to develop a preliminary estimate of this threat. This analysis incorporates land cover type, slope, soil characteristics, and precipitation in order to estimate relative erosion rates for all land areas. These estimates are then summarized by watershed, allowing for estimation of relative sediment delivery at the river mouths, which is being used as a proxy for both sediment and pollution delivery. Sediment plumes were estimated on the basis of relative sediment delivery and distance from each river mouth. Areas of elevated sediment threat are large, reaching reefs off of Punta Gorda, the Sapodilla Cayes, and many segments of the Belize Barrier Reef. This modeling of threat from agriculture produces results similar to those from the expert mapping of threat from agricultural runoff.



Data Sources: Modeled threat to coral reefs from watershed-based sources of sediment and pollution from the "Reefs at Risk in Belize" analysis, World Resources Institute (WRI), 2005. Watershed boundaries from the "Reefs at Risk in the Caribbean" analysis, WRI, 2004. Rivers from USGS, HYDRO1k, 2000.

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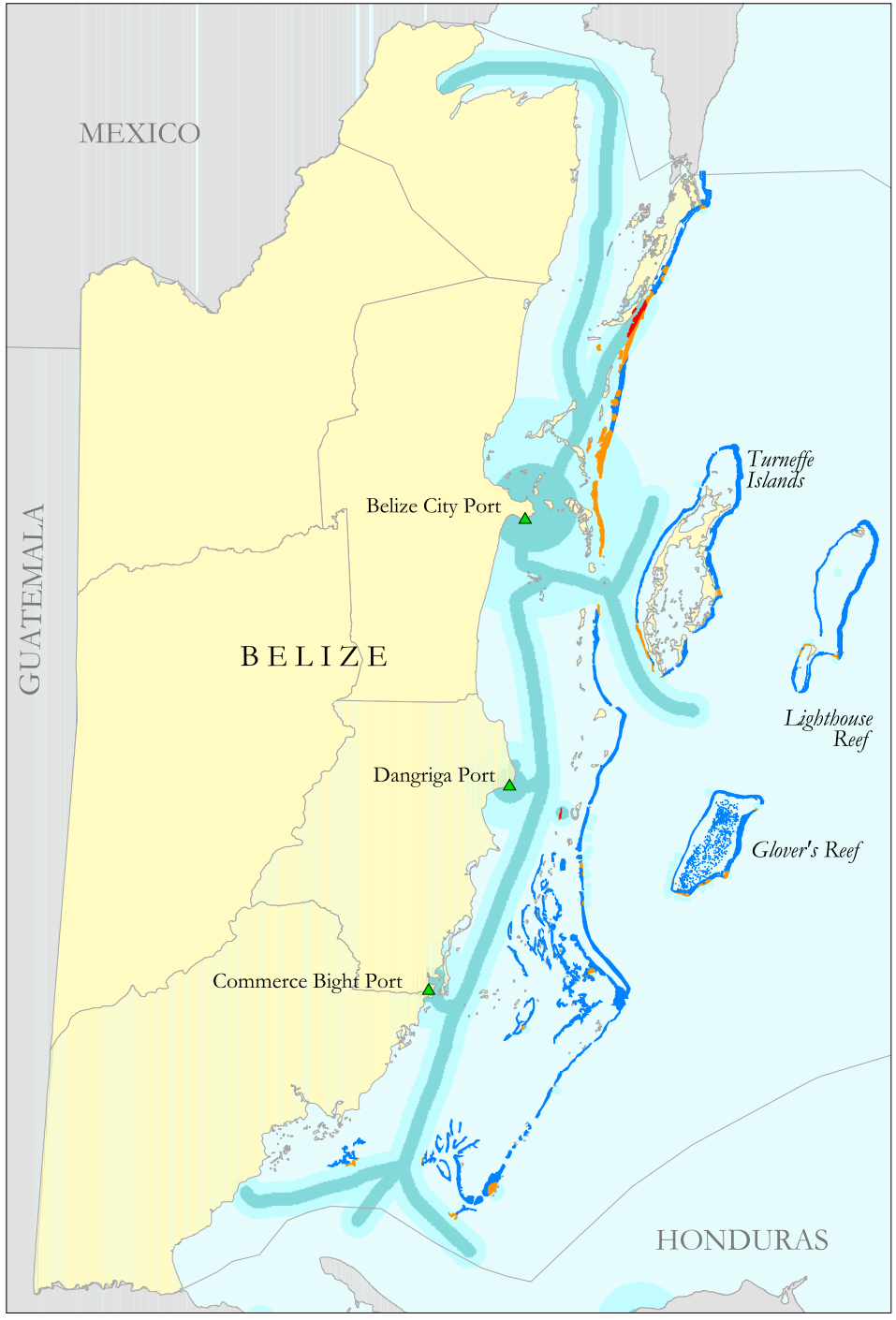
Marine-based Threat in Belize - Modeled



Map Projection: UTM, Zone 16, NAD1927

Marine-based activities threaten coral reefs through pollution from ports, oil discharge and spills, ballast and bilge discharge, dumping of garbage, and direct physical impacts from groundings and anchor damage. Threats to coral reefs from marine-based sources of pollution were evaluated on the basis of location of ports and shipping lanes, the location of dive centers, and volume of cruise ship visitation. Cruise ships are a significant source of pollution in the Caribbean. A typical cruise ship generates an average of 8 mt (2,228 gallons) of oily bilge water and 1 mt of garbage each day. Belize had an estimated 850,000 visitors from cruise ships in 2004, more than three times the number of land-based visitors. The volume of cruise-ship tourism has increased by a factor of 25 in the last five years - from 34,000 in 1999 to an estimated 850,000 in 2004.

Reefs by Marine-based Threat
- Low
- Medium
- High

Threat from Marine Sources - Modeled
- Low
- Medium
- High

- Ports
- Administrative Districts
- Belize Maritime Boundary
- National Borders

Data Sources: Modeled threat to coral reefs from marine-based threats from the "Reefs at Risk in Belize" analysis, World Resources Institute (WRI), 2005.

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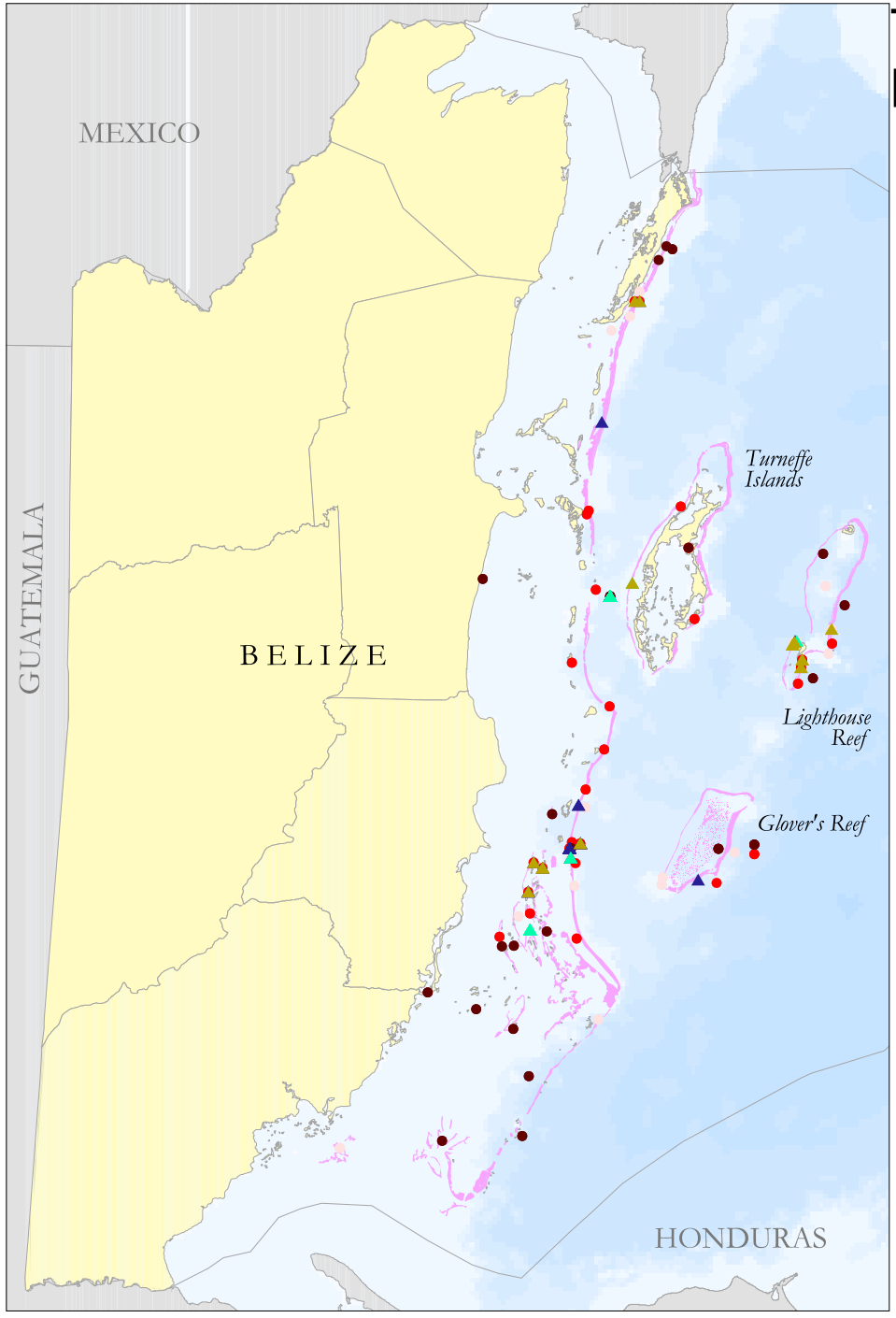
Threat from Natural Disturbances - Coral Bleaching, Coral Disease and Hurricanes



Map Projection: UTM, Zone 16, NAD1927

Coral bleaching and coral disease were identified as important threats to coral reefs by local stakeholders and scientists at the expert mapping workshops. There were over 80 observations of coral bleaching in Belize between 1995 and 2004, with most observations during the 1998/99 El Nino/La Nina. Incidence of coral bleaching will further increase with rising ocean temperature. Many coral diseases have been observed in Belize, though Black Band, White Band, and White Plague appear to be the most common. Factors causing increased incidence of disease are unclear. Pathogens that cause disease are more easily transported in our globalized world; disease might be more common in areas stressed by other pressures, such as pollution, or after coral bleaching. Coral bleaching and coral disease are two major threats to coral reefs in Belize, that are very difficult to control.

Several of Belize's reefs have been affected by repeated and/or coinciding events in recent years. Widespread bleaching took place for the first time off Belize in September 1995, when bleaching occurred throughout the Caribbean. In the autumn of 1998, the reefs were again disturbed by a mass bleaching event, with some individual colonies bleaching more than 90 percent, over large geographic areas. The same year Hurricane Mitch, a Category 5 storm, impacted much of the coast when reefs experienced battering waves for several days. Bleaching caused catastrophic coral loss in Belize's lagoonal reefs, while the hurricane caused widespread coral destruction in fore reefs and outer atoll reefs. Then, Hurricane Keith followed in 2000 and Iris in 2001. These storms had different paths, intensities, and impacts but they both reduced coral cover at a number of locations.

Coral Disease
- Obs. of White Plague Disease
- Obs. of White Band Disease
- Obs. of Black Band Disease

Coral Bleaching
- Low Severity
- Moderate Severity
- Severe

- Coral Reefs
- Administrative Districts
- Belize Maritime Boundary
- National Borders

Data Sources: Reefbase, Coral Beaching Dataset, download from http://www.reefbase.org on 1 May 2005. Disease data from UNEP-WCMC, 2000

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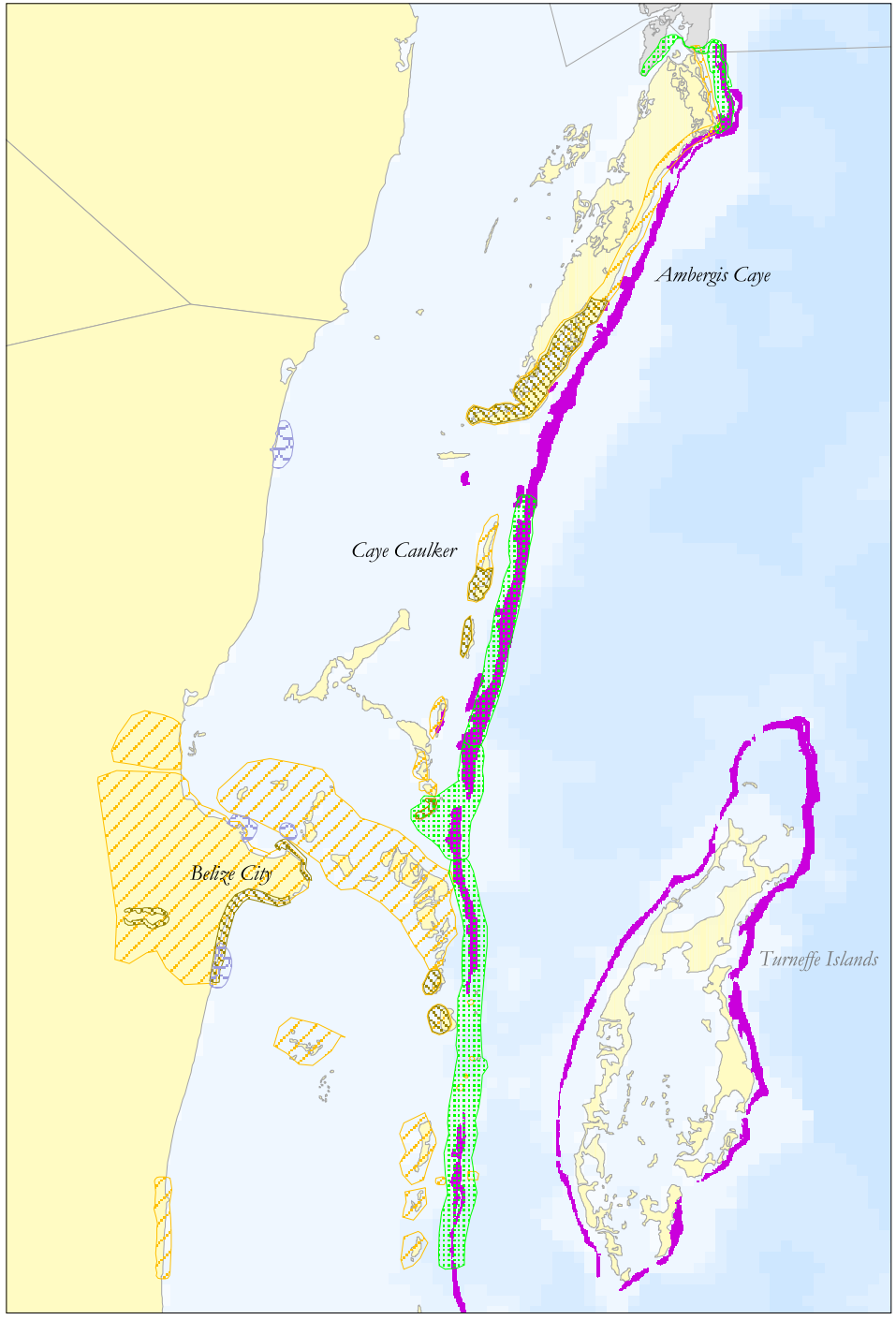
Belize Barrier Reef (Northern) - Key threats from Expert Mapping



Local stakeholders and scientists at a threat analysis and mapping workshop for the Belize Barrier Reef identified coastal development, dredging and overfishing as key threats to the Northern section of the Barrier Reef. Coastal development was identified as a threat along most cayes (from Ambergis Caye to Belize City and further south. Dredging was also identified as a threat in most of these areas. Overfishing was identified as a threat in the far north (along the Mexican border) and in the central portions of the Belize Barrier Reef. Gill netting was identified as a threat at several river mouths along the mainland.

Overfishing
- Moderate Severity

Gill Netting
- Slight to Moderate

Dredging
- Moderate Severity

Development
- Moderate Severity

Coral

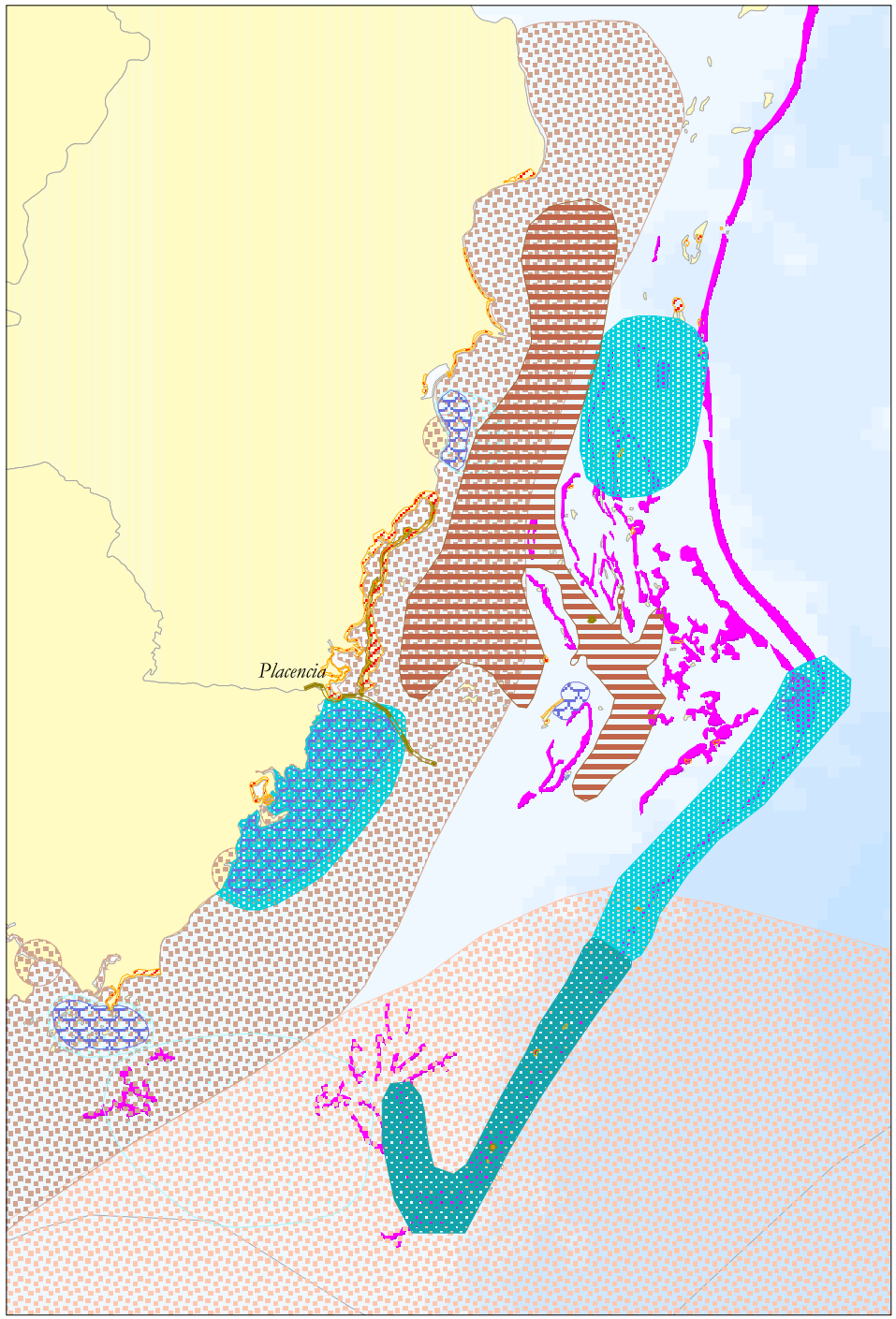
Administrative Districts
Belize Maritime Boundary
National Borders

Data Sources: Threat maps based on results of "Belize Threat Assessment and Mapping" workshop hosted by World Wildlife Fund and Wildlife Conservation Society for the Barrier Reef. Workshop report available on the Belize Coastal Data CD (see below).

Reefs at Risk in Belize

A collaboration between the World Resources Institute, Belize Coastal Zone Management Authority and Institute, and many other partner organisations in Belize. Datasets available on the Belize Coastal Data CD (email datacen@coastalzonebelize.org for more information).

Belize Barrier Reef (Southern) - Key Threats from Expert Mapping



Local stakeholders and scientists at a threat analysis and mapping workshop for the Belize Barrier Reef identified runoff from agriculture, illegal fishing, coastal development, and shrimp trawling as key threats to the Southern section of the Barrier Reef. Runoff from agriculture sends nutrients and pollutants into nearshore waters and threatens reefs, particularly in the far south of the Belize Barrier Reef. Illegal fishing, primarily by Hondurans and Guatemalans, often conducted at night, threatens large areas in the South. Shrimp trawling was identified as a threat in a large area near the central portion of the Belize Barrier Reef, and gill netting as a threat along several portions of the mainland coast. Coastal development and dredging were identified as threats in isolated areas of the mainland coast, particularly near Placencia and on a few cayes.

Data Sources: Threat maps based on results of "Belize Threat Assessment and Mapping" workshop hosted by World Wildlife Fund (WWF) and WCS for the Barrier Reef. Workshop report available on the Belize Coastal Data CD (see below).

Reefs at Risk in Belize

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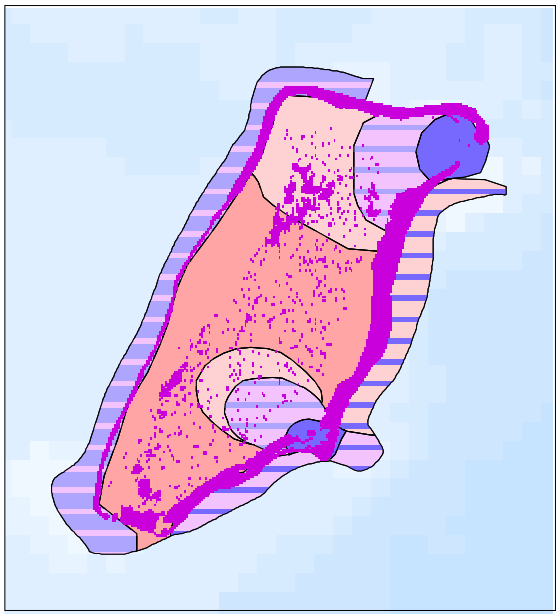
Glover's Reef - Key Threats from Expert Mapping



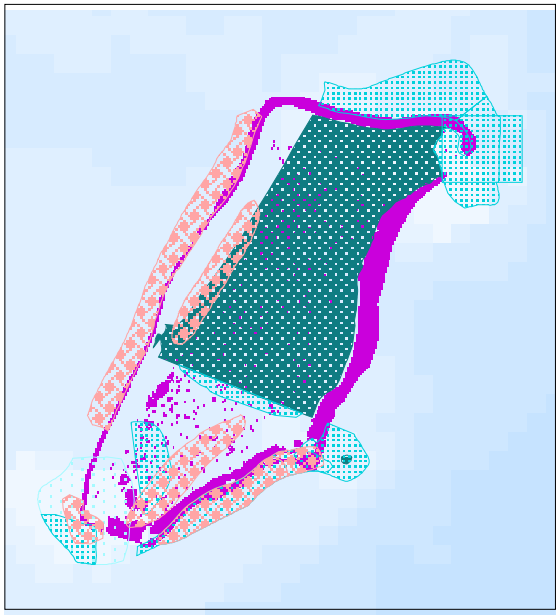
Coral Bleaching Resilience
- Lowest
- Low
- Medium
- Higher
- Highest

Resistance to Coral Bleaching
- Lowest
- Low
- Medium
- High
- Highest

Coral

Local stakeholders and scientists at a threat analysis and mapping workshop for Glover's Reef identified coral bleaching, physical damage from recreation (anchors and snorkelers) , and overfishing (both local and non-local fishers) as key threats to the reef.

In evaluating the threat of coral bleaching, areas of high through low resistance and high through low resilience were mapped. High resistance areas are less likely to bleach because of depth, openness and faster water movement, which makes them less likely to heat up. High resilience areas are more likely to recover quickly because of factors promoting recovery, such as availability of coral larvae. At Glover's Reef, patch reefs in the lagoon have both low resistance (shallow with low flushing) and low resistance (limited inflow of larvae.) Reefs on the western side of the lagoon were identified as having high resistance to bleaching, while reefs on the eastern side were identified as having only medium resistance, but having the highest resilience (due to availability of larval recruits.) An area in the northeast, near a gap in Glover's Reef, was identified as having very high resistance and resilience.



Anchor and Snorkel Damage
- Severe

Poaching / Illegal FIshing
- Slight
- Moderate Severity
- Serious

Coral

In addition to the overarching threat of coral bleaching, poaching and other types of illegal fishing were identified as threats to many sections of Glover's Reef. Physical damage from anchors, diving and snorkeling was identified as a threat along the western and southern portions of Glover's Reef. Although not portrayed in a detailed map, runoff from farms and aquaculture was also identified as an important threat that needs to be monitored.

Data Sources: From a "Belize Threat Assessment and Mapping" workshop for Glover's Reef, hosted by the Wildlife Conservation Society in February 2004.

Map Projection: UTM, Zone 16, NAD1927

5 0 5 10 Kilometers

Reefs at Risk in Belize

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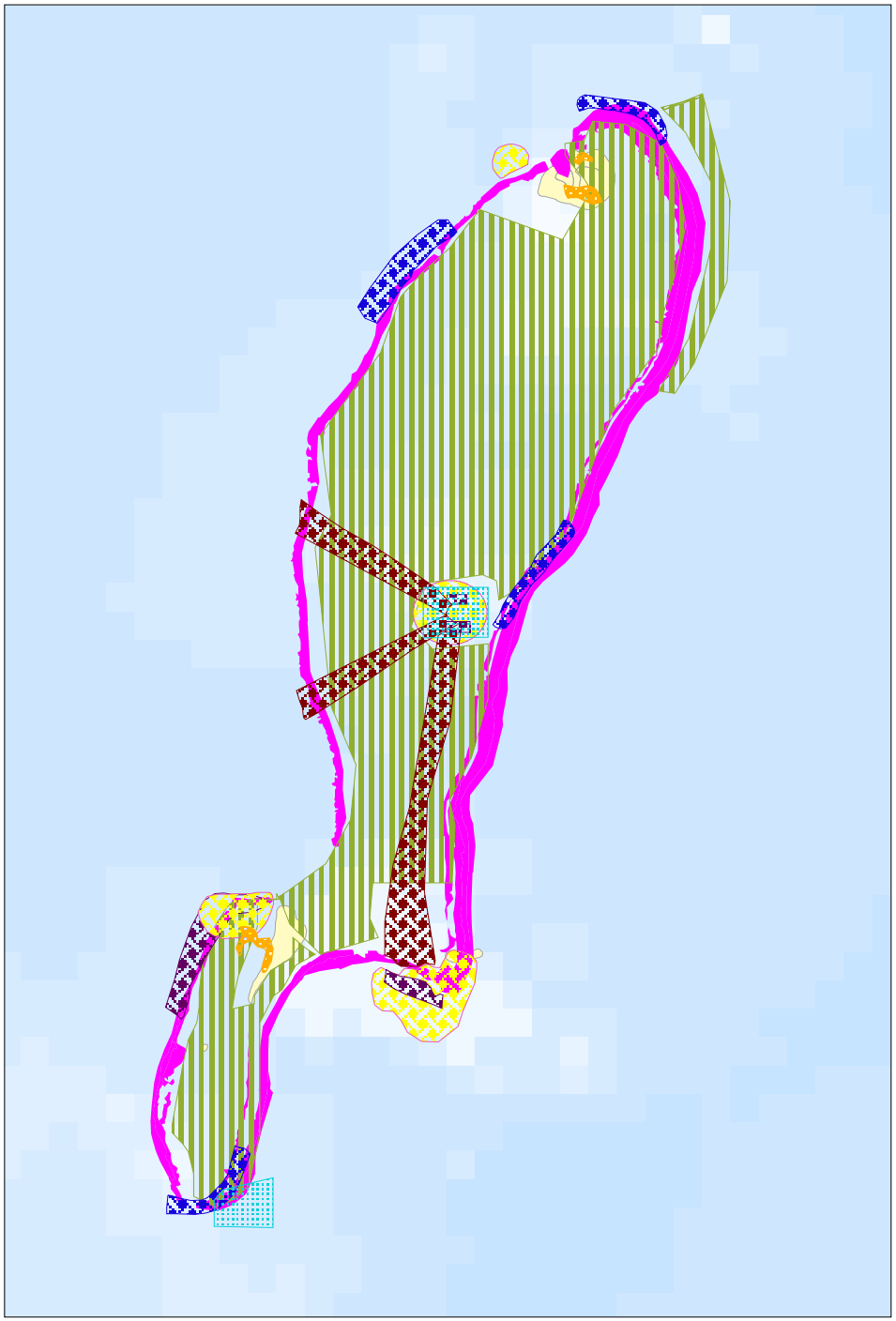
Lighthouse Reef - Key Threats from Expert Mapping

Local stakeholders and scientists at a threat analysis and mapping workshop for Lighthouse Reef identified overfishing, illegal fishing, development of cayes, and physical damage from recreation (anchors and snorkelers) as key threats to Lighthouse Reef. Illegal and over-fishing were mapped as the most pervasive threat to Lighthouse Reef. Poaching was identified as a moderate threat in the Blue Hole and South Point No-Take areas. Development was identified as a threat on Northern Two Caye, Sandbore Caye, and Philips Long Caye. Damage from boat propellers and groundings were identified as a threat along approaches to the Blue Hole. Anchor damage by fisherman and tourist boats were mapped as a threat along many sections of the atoll, while damage from tourists was mapped at the Blue Hole, and near the three cayes.



Map Projection: UTM, Zone 16, NAD1927

Development
- High Severity

Poaching / Illegal Fishing
- Moderate Severity

Boat and Anchor Damage
- Anchor Damage by Fishermen
- Anchor Damage from Tourist Boats
- Boat Groundings / Propeller Damage
- Tourist Damage (in Water)

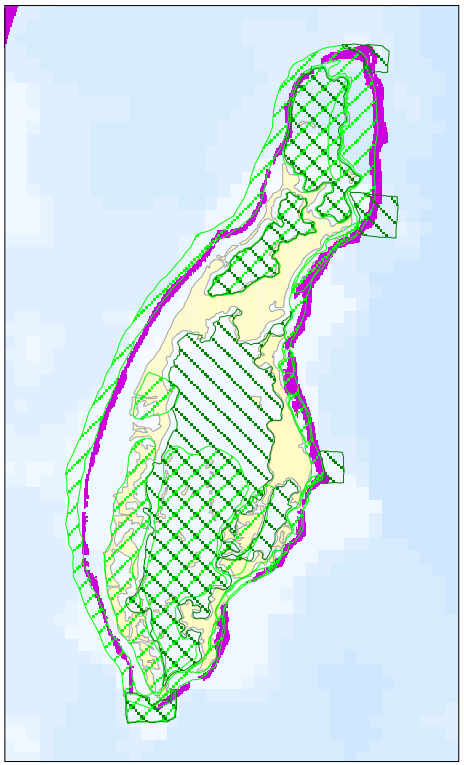
Illegal and Overfishing
- Moderate Severity
- Coral Reefs
- Administrative Districts

Data Sources: From a "Belize Threat Assessment and Mapping" workshop for Lighthouse Reef, hosted by Belize Audubon Society and Wildlife Conservation Society in October, 2004.

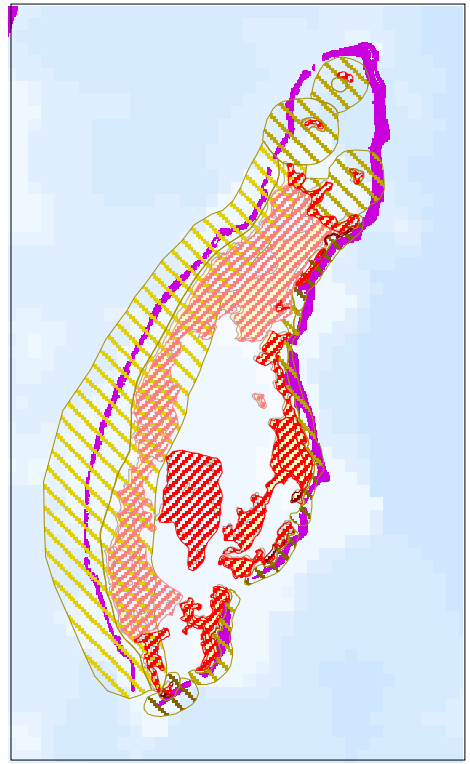
Reefs at Risk in Belize

A collaboration between the World Resources Institute, Belize Coastal Zone Management Authority and Institute, and many other partner organisations in Belize. Datasets available on the Belize Coastal Data CD (email datacen@coastalzonebelize.org for more information).

Turneffe Islands - Key threats from Expert Mapping



Local stakeholders and scientists at a threat analysis and mapping workshop for Turneffe Atoll identified unsustainable fishing (overfishing and illegal fishing), and coastal development (mangrove clearing, dredging, and overdevelopment) as key threats to the atoll. Overfishing was identified as a pervasive threat - of moderate severity on the western side and high severity in the lagoon and at several spawning sites. Development, particularly mangrove clearing and dredging were identified as threats across the atoll, but were both rated as highest risk on the eastern side.



10 0 10 Kilometers

Map Projection: UTM, Zone 16, NAD1927

Data Sources: From a "Belize Threat Assessment and Mapping" workshop for Turneffe Atoll, hosted by the Costal Zone Management Institute and Authority and Wildlife Conservation Society in September 2004.

Reefs at Risk in Belize

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