FoProBiM

Fondation pour la Protection de la Biodiversite Marine

Evaluating anthropogenic risk factors to the Caracol Bay ecosystem using Habitat Risk Assessment models

DRAFT #1

(source: Wiener/OAS, 2013)

	Coral Reef
	Mangrove
	Sea grass
	River
	Approximate extent of lower TdN River watershed

A. Project Objective(s)

To evaluate the risks to Caracol Bay from anthropogenic factors, using the Habitat Risk Assessment models (RIOS, InVEST), with a view to explore strategies that would reduce the exposure of the Bay to a certain stressor activities. It is hoped that this activity could be replicated for other locations in Haiti along with the identification and implementation of strategies that would reduce the exposure of a particular habitat to a particular activity would contribute significantly to the overall health of Haiti's environment.

B. Methods

Anthropogenic impacts to ecosystems / habitats will be modeled in four steps:

Step 1. Determining the likelihood of exposure of the habitat to the stressor and the consequence of this exposure.

Step 2. Combining the exposure and response values to produce a risk value for each stressor-habitat combination.

Step 3. Quantification of the cumulative risk of all stressors on the habitats.

Step 4. Identification of habitats that are risk hotspots. Areas where the influence of human derived stressors is so great that ecosystem structure and function may be compromised. In these areas, there may be trade-offs between human activities and a range of ecosystem services.

Step 5. Analyze data to determine which activities are contributing the most to habitat risk /degradation and identify strategies that may reduce the exposure of a particular habitat to a particular activity.

C. Risks / Assumptions

1. There will be adequate access to the software and required applications
2. There will be adequate data for inclusion into the software
3. Field visits will be conducted
4. Users of the site will be interviewed
5. All products generated will be shared with the Government and International Agencies
6. Project will proceed in accordance with the terms and conditions of the funding agency.
7. The project will be concluded by October, 2014

E. Deliverables

The project's deliverables will be:

1. A map depicting the habitats and stressors of Caracol Bay.
2. A map depicting the level of ecosystem risk by the various stressors in Caracol Bay.
3. A matrix of strategies that would reduce the exposure of a particular habitat to a particular activity.

Contents

Abstract

The need to understand how human activities are affecting ecosystems and the services they provide is becoming a large area of study. The reason for this is due to the increasing risk on the habitats from anthropogenic factors; overfishing, charcoal production, and salt pan creation primarily. The Natural Capital Project, a software suite developed to help investors and stakeholders to understand the goods and services provided by the environment, was used to better understand the future scenarios that could take place with and without management practices. This paper will look at the risks associated from the anthropogenic factors and attempt to visually represent and quantify these impacts while adding a special extent as to where the areas of highest risk are present. The high risk areas are near residential areas and primarily disturb the mangroves. Better management practices need to be put into place in order to protect the environment from the human impact. A need for alternate food and charcoal sources is required to mitigate these impacts

Background

Caracol Bay is considered to be Haiti's most productive coastal and marine ecosystem. It is located in northeastern Haiti near the border with the Dominican Republic and has just recently been declared a marine protected area (MPA) by the government of Haiti due to its intrinsic values of combined mangrove, seagrass, and coral reef ecosystems. A recent ecosystem services valuation (OAS/FoProBiM, 2013) has placed the values of these ecosystems and their services at over US$ 3 billion. Due to it intrinsic value this area has been targeted by several international initiatives including the Caribbean Large Marine Ecosystem (CLME) project, the Caribbean Biological Corridor (CBC), and the Ecologically or Biologically Significant Area (EBSA).

Currently, over-exploitation of fisheries resources, salt pan development, and mangrove harvesting for charcoal and fuel-wood production are the primary concerns. The recent development of an industrial park near the village of Caracol has raised various alarms concerning the potential damaging effects of this installation on the local ecosystems. Concerns over waste management, increased resource use and destruction, and infrastructure development top these concerns.

The monitoring and evaluation of the risks posed by all of these anthropogenic factors to the health and integrity of the local ecosystems are a serious concern to the livelihood and wellbeing of local communities.

The need to understand how human activities are affecting ecosystems and the services they provide is becoming a large area of study. The reason for this is due to the increasing risk on the habitats from anthropogenic factors; overfishing, charcoal production, and salt pan creation primarily.

Stanford University and other private investors have formed an organization called the Natural Capitol Project in order to develop models to help map and value goods and services provided by nature that help support human life. The models being used to assess these risks are part of a set of models called InVEST (Integrated Valuation of Environmental Services and Tradeoffs). Ecosystem service is a term used to encompass the ecosystem outputs as a part of the country's total good's and services value. This will allow proper management and policies to be put into place that will have both the human and environment components working together in synergy, though some scenarios do have tradeoffs, the impacts of such tradeoffs can be mitigated by proper planning with the use of these models. This paper primarily uses the Habitat Risk Assessment (HRA) model, which was developed primarily for marine and coastal regions where these impacts are less understood and in many instances more important.

The model outputs can help identify areas where human activities will have the least effects on the habitat so that the ecosystem can prosper without hindering economic development. In short how the economic services and the environment services can work together with the least amount of interference.

For the purpose of this study Caracol Bay is characterized into three habitats; mangroves, seagrasses, and coral reefs. Each of these habitats is effected differently by each stressor; salt pans, charcoal production, farming, residential area, and fishing. In order to best understand the total effect on the Caracol Bay's environment as a whole, each environment has values that depict how each stressor will affect it. The results are then compiled to display a cumulative risk assessment of Caracol Bay.

Objectives:

Determine the impacts of overfishing, charcoal production, and salt production on mangroves, seagrasses, and coral reefs within Caracol Bay. Anthropogenic impacts to ecosystems / habitats will be modeled in four steps:

Step 1. Determining the likelihood of exposure of the habitat to the stressor and the consequence of this exposure.

Step 2. Combining the exposure and response values to produce a risk value for each stressor-habitat combination.

Step 3. Quantification of the cumulative risk of all stressors on the habitats.

Step 4. Identification of habitats that are risk hotspots. Areas where the influence of human derived stressors is so great that ecosystem structure and function may be compromised. In these areas, there may be trade-offs between human activities and a range of ecosystem services.

Step 5. Analyze data to determine which activities are contributing the most to habitat risk /degradation and identify strategies that may reduce the exposure of a particular habitat to a particular activity.

Model Inputs and Assumptions

The InVEST Habitat Risk Assessment model (HRA) uses the spatial extent of each habitat and stressor as a function of the habitats exposure and the consequences of the exposure from any given stressor (InVEST_User_Guide). The model interprets the interaction between each habitat and stressor by values in the habitat stressor ratings table. This table requires multiple inputs in order to properly represent the habitats ability to grow while also taking into consideration how the stressors will affect each habitat. The values given are based on current and past effects between each habitat and stressor while also taking into consideration research that has been done on similar interactions. More detail on how the model works can be found in the InVEST User Guide, Release 3.0.0 section 4.2 Habitat Risk Assessment.

Definitions from (InVEST_User_Guide)

Recruitment rating (biotic habitats only). Frequent recruitment increases recovery potential by increasing the chance that incoming propagules can re-establish a population in a disturbed area.

Natural mortality rate rating (biotic habitats only). Habitats with high natural mortality rates are generally more productive and more capable of recovery.

Connectivity rating (biotic habitats only). Larval dispersal and close spacing of habitat patches increases the recovery potential of a habitat by increasing the chance that incoming propagules can re-establish a population in a disturbed area.

Age at maturity/recovery time. Biotic habitats that reach maturity earlier are likely to be able to recover more quickly from disturbance than those that take longer to reach maturity. Here we refer to maturity of the habitat as a whole (i.e., a mature kelp forest) rather than reproductive maturity of individuals. For abiotic habitats, shorter recovery times for habitats such as mudflats decrease the consequences of exposure to human activities. In contrast, habitats made of bedrock will only recover on geological time scales, greatly increasing the consequences of exposure.

Habitats

The figure below outlines the 3 habitats that are being taken into consideration for this study.

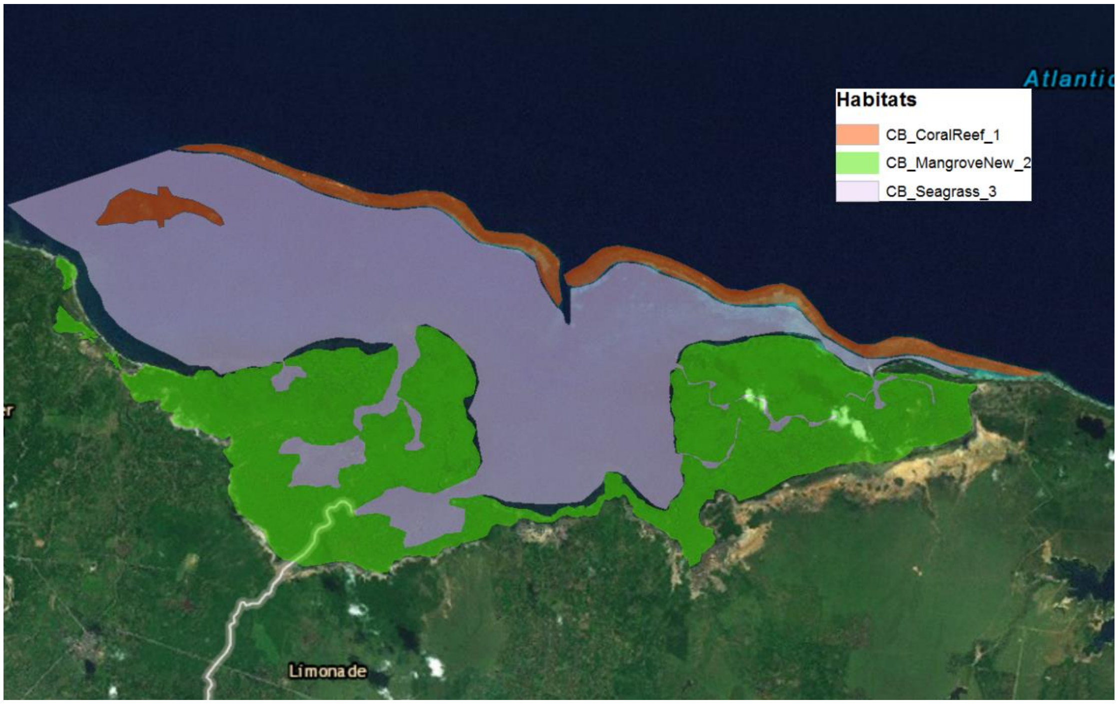

Figure 1: Habitats of Caracol Bay

Mangroves

Mangrove forests have been decreasing rapidly due to clearing for residential and agricultural initiatives. The importance of the mangrove forests range from

1. Coastal protection from natural disasters, both in sediment retention and wave reflection
2. Protection for larvae and juvenile fauna to mature.
3. Reducing sediment loads from waterways by creating turbulence breaking up laminar flow out to sea. Sediment retention also aids in the seaward expansion of land.
4. Carbon sequestration from the air and water alike.
5. Homes for birds and amphibious fauna.

The mangroves will also be affected by the dwindling coastal protection from the coral reef barrier. Pollution, pesticides and sediment from the rivers can also destroy the mangroves.

Seagrasses

Seagrasses are a vital component to both fauna and sediment retention. The turbulence created by the seagrass helps particulate settle creating a muddy bottom for mollusks and other fauna to filter the water. The root system also helps to maintain the muddy composition during storms reducing littoral transport away from the bay. Sea turtles and other fauna get most of their nutrients from seagrass. Sea grass beds are the primary location for fish to start the first stage of their life.

Coral Reefs

Coral reefs represent some of the most diverse ecosystems in the world. The importance of the ecosystem is not only for the fauna that inhabit the ecosystem but also for the coastal protection they provide. The fringing reef at Caracol Bay separates the rough mid-water ocean and the calm seagrass beds. As this reef is destroyed from fishing and pollutants the protection it provides from the ocean waves will uproot the seagrass and move sediment away from the bay. The images below are taken at the eastern side of the Caracol Bay fringing reef. You will notice very little coral growth and almost no fish. The importance of fish stock on a coral reef is vital to coral growth by cleaning surrounding rock from invasive algae species allowing new coral to grow. The figure to the right displays a Acro. Palmata that has been stressed out and started to bleach in multiple areas. This is the state of many corals left in the area.

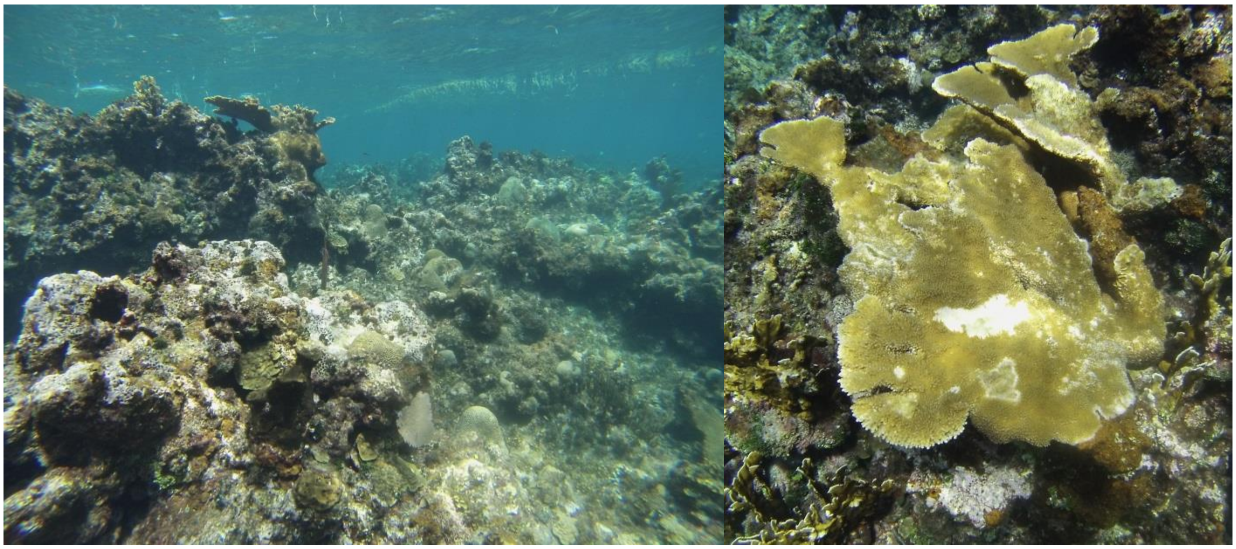

Figure 2: Fringing reef on the eastern part of Caracol Bay. Notice low fish populations and poor coral density and quality

Stressors

The figure below displays the current stressors in the Caracol Bay area

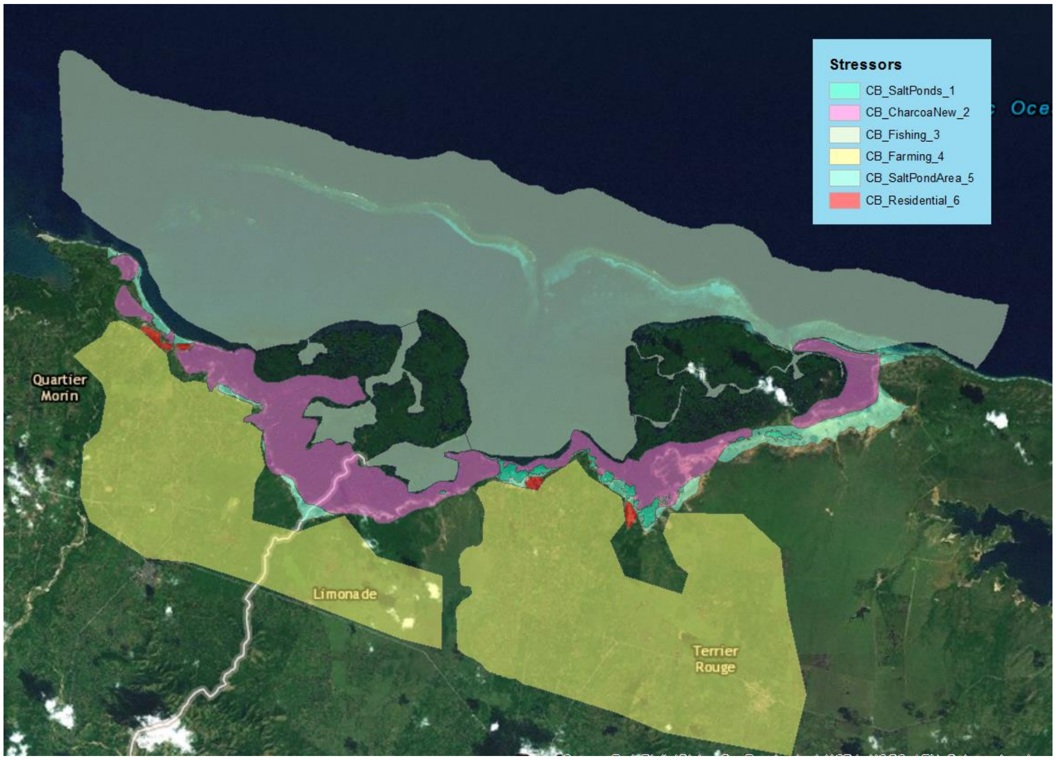

Figure 3: Spatial representation of stressors affecting Caracol Bay

Salt Pans

Salt pans utilize shallow water basins and the suns heat to evaporate the water leaving behind salt. The salt is then collected then refilled with new saltwater. They must be flat, shallow and have easy access to saltwater to get the best yields. This environment is very similar to mangroves, thus the mangroves are being cleared to make room for more salt pans. The expansion of salt pans is slow, though devastating to the soil quality and would require significant time and effort to rehabilitate.

Figure 4: Caracol Bay salt ponds bordered by once lush black mangroves

Charcoal Production and Deforestation

Mangroves are destroyed for charcoal production. This process completely destroys mangrove forests. The mangroves are also destroyed for wood products needed to build houses, fishing nets, and boats. Because of these services that mangroves provide they are also the most at risk from human activities, thus values to best represent this interaction have been entered into the model.

Figure 5: Mangroves being cut along the canals

Figure 6: The Burning of Mangroves for Charcoal in north eastern Caracol Bay

Fishing

The effects from fishing primarily affect the coral reefs and seagrass habitats. The use of fine mesh nets has increased the bycatch, unwanted fish, and prohibits juvenile fish from getting through and growing larger. Also putting seine nets around the mouths of canals so fish are forced into them during low tide prohibits the ability for reproduction and growth. Most game fish spend the first stage of their life in the seagrasses then the second stage in the mangroves and their final 2 stages in the reef and forereef area. By cutting off the last 2 stages of this life cycle fish are unable to reproduce. Commercial fishing ships that use trawling methods can uproot seagrass beds and destroy coral reefs. Cutting of mangroves used in the creation of fishing nets and supplies will also increase the risk of the habitat. Over fishing will also reduce fauna around reefs and other coastal systems which rely on the fish for nutrients, algae control, and even protection from corallivores.

Residential and Commercial Areas

Residential and commercial infrastructure can have a large impact on all environments. The conversion/clearing of habitats to make way for new and growing residential areas will drastically change the landscape and any habitat in the way. In order to reduce this impact, areas for current and new construction should be added to the model as to determine the best positioning for these sites and create protected areas where habitats are the most vulnerable to conversion.

Not only land conversion but also extra loading from increased human activities must be taken into consideration. This includes extra sediment erosion and deposition in waterways and coastal areas. Also pollution from poorly managed residential areas and commercial policies that are not enforced.

Increases in population will create a large stress on the habitats and the environmental services they provide. Population increase also reduces the per person yield while increasing the total yield taken from the ecosystem. This effect is exacerbated when stock intakes are near or over the stock outputs the environmental services can provide. Resulting in a sharp decline in available stocks which can cripple an economy.

Farming

The effects from farming vary greatly based on the crop being farmed. The soil Needs for certain crops may prefer dry well drained soil or wet soil with high nutrient content. Thus the effects of farming are hard to take into consideration. Clearing of mangroves for nutrient rich soil represents the largest impact on the habitat though runoff from fertilizers and sediments can have an effect on both seagrasses and coral reefs alike. Excess nutrients leaching into the water will create bacterial blooms which take in lots of oxygen causing low dissolved oxygen levels in the water essentially suffocating all fauna in the area.

Sediment plumes in the northwest and mid Caracol Bay. These plumes are caused by poor farming practices that destroy the ability for the ground to naturally filter out sediment. Pollution is also a large factor on the coastal environment.

Figure 7:Sediment Plumes to the North West of Caracol Bay

Figure 8: Sediment Plumes near Caracol

Results

The model outputs can be seen below with a grid cell size of 50 meters. The cumulative risk per habitat (figure 1) displays the risk hotspots with respect only to that habitat. From the figure it is clear that the areas nearest the shoreline are the most affected, which is to be expected.

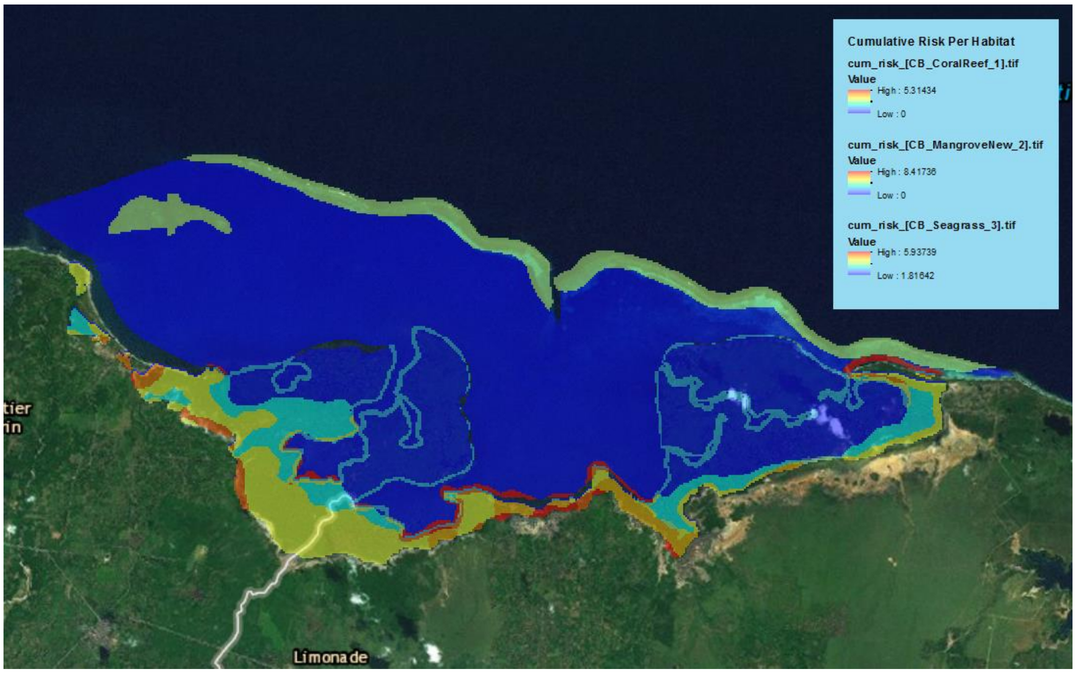

Figure 9: Cumulative risk assessment per habitat

The cumulative risk (figure 2) displays the sum of all risks in a particular study area, in this case Caracol Bay. Fishing has a large effect on the seagrass and coral reef habitats. The habitats that have the most overlapping stressors are at the highest risk from human activities. The mangroves are the highest risk from human activities because of their location near multiple stressors and there multitude of uses.

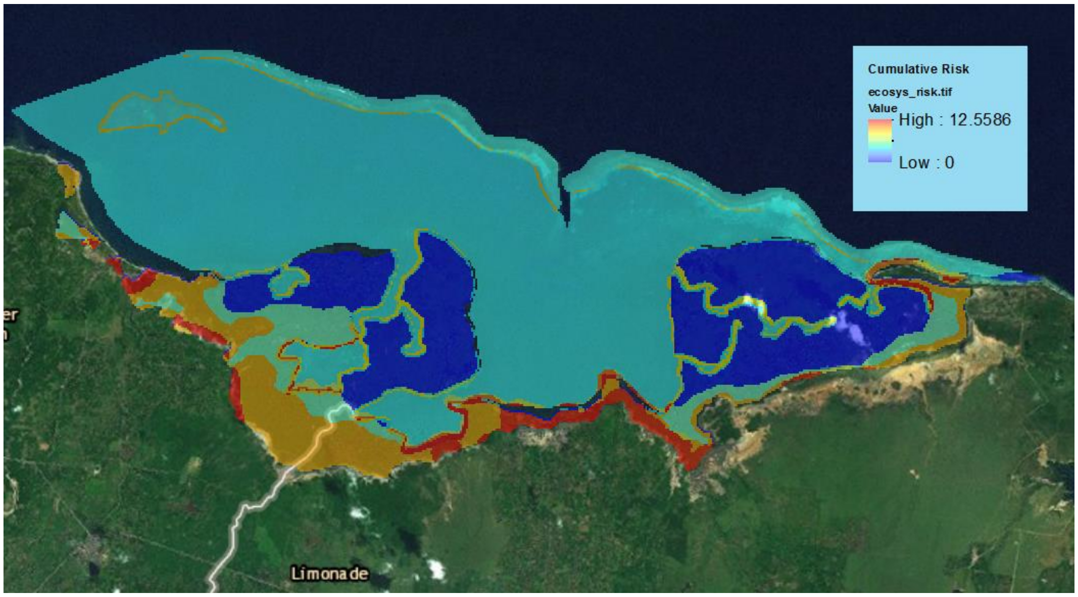

Figure 10: Cumulative Risk Assessment for Caracol Bay

The recovery potential (figure 3) of the habitats is still very high, 100%, because Caracol bay is still a very productive habitat that has seen very little human impact over time. The recovery potential displays the amount of regrowth/recovery by natural causes if human activities were removed.

Figure 11: Cumulative recovery per habitat

The figure below displays the risk for each habitat by consequence and exposure from each stressor. The higher consequence the more sensitive the habitat is to the given stressor, where higher exposure represents the continuing degradation of a habitat from constant stressors. The purpose of the charts is to help strategize better management practices for the particular habitat and stressor.

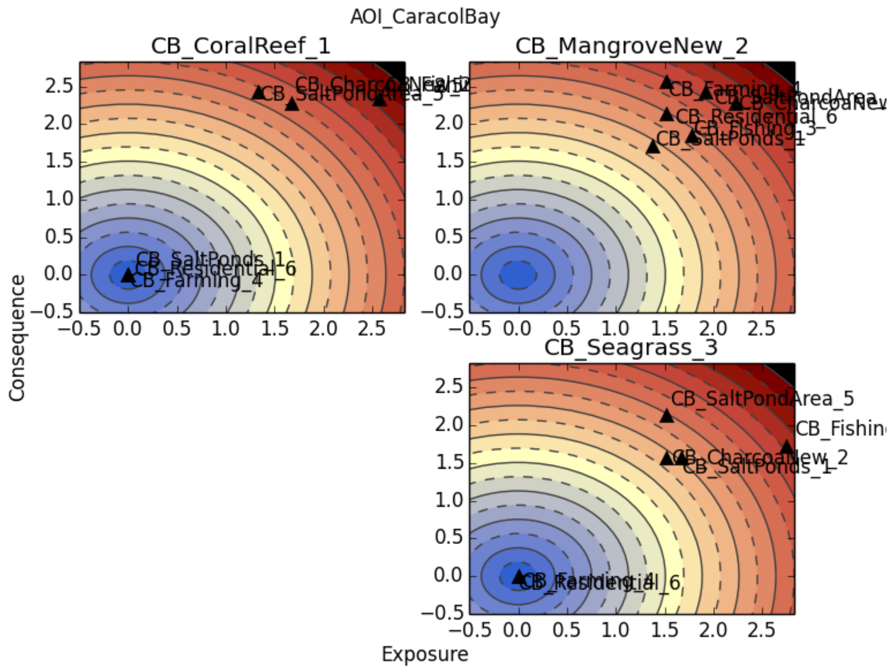

Figure 12: Consequence and Exposure impacts per habitat as a function of each stressor

AOI_CaracolBay

This table is a numerical representation of the graph above. It displays the effect of each stressor on each habitat and an exposure (E), consequence (C), risk and risk percentage are given here.

Habitat Name	Stressor Name	E	C	Risk	Risk %
CB_Seagrass_3	CB_CharcoaNew_2	1.52	1.57	0.77	16.14
CB_Seagrass_3	CB_Residential_6	0.0	0.0	0.0	0.0
CB_Seagrass_3	CB_Fishing_3	2.75	1.72	1.89	39.42
CB_Seagrass_3	CB_SaltPondArea_5	1.51	2.14	1.25	26.11
CB_Seagrass_3	CB_SaltPonds_1	1.67	1.57	0.88	18.34
CB_Seagrass_3	CB_Farming_4	0.0	0.0	0.0	0.0
CB_CoralReef_1	CB_CharcoaNew_2	1.67	2.29	1.45	29.14
CB_CoralReef_1	CB_Residential_6	0.0	0.0	0.0	0.0
CB_CoralReef_1	CB_Fishing_3	2.56	2.33	2.06	41.35

CB_CoralReef_1	CB_SaltPondArea_5	1.33	2.43	1.47	29.51
CB_CoralReef_1	CB_SaltPonds_1	0.0	0.0	0.0	0.0
CB_CoralReef_1	CB_Farming_4	0.0	0.0	0.0	0.0
CB_MangroveNew_2	CB_CharcoaNew_2	2.22	2.29	1.77	21.25
CB_MangroveNew_2	CB_Residential_6	1.51	2.14	1.25	15.01
CB_MangroveNew_2	CB_Fishing_3	1.78	1.86	1.16	13.9
CB_MangroveNew_2	CB_SaltPondArea_5	1.92	2.43	1.7	20.34
CB_MangroveNew_2	CB_SaltPonds_1	1.37	1.71	0.81	9.65
CB_MangroveNew_2	CB_Farming_4	1.52	2.57	1.66	19.84

Conclusion

The current state of Caracol bay habitat is in need of better management practices. Beyond the importance of conservation are the services provided by Caracol Bay to the second largest city in Haiti, Cap Hatien, and surrounding villages. The need for enforced management has passed. The mangroves are being cut for charcoal production and a strategy to replant young mangroves has not occurred. There are very few birds inhabiting the large expanse of mangroves present. The fish biomass in Caracol Bay has been reduced to such low levels that fish over 6” are hard to find while scuba diving in the best part of the reef. Poor methods of fishing and no management policies are to blame for such a small fish biomass. There have been many examples of similar environments around the world that are also on the brink of destruction because of poor management. One disaster is all that is needed to push this environment from years to decades of recovery.

Improvements

- Better bathymetry data in order to better classify which areas of the mangroves are not too deep. Also for coastal protection models.
- Where fishing and boats would be more likely to traverse. All travel and commercialization
- Land use and Land Cover data
- Better understanding of how the habitats and stressors interact
- Properly map the mangrove canals and mark the banks as areas for deforestation/charcoal production
- Need to run RIOS in order to better understand which areas will have the most output from the least investment.

- Represent the growth in fish population from better management practices
- Monetary increase and loss from management practices
- Effects of the Caracol bay industrial park
- Reduced fishing during seasons when fish are mating/laying eggs

Resources

http://ncp-dev.stanford.edu/~dataportal/invest-releases/documentation/current_release/habitat_risk_assessment.html

http://wwf.panda.org/about_our_earth/blue_planet/coasts/mangroves/

http://data.geocomm.com/catalog/HA/datalist.html

http://www.bmp.org/pdfs/BNMP-managementplan-part1.pdf

http://www.defence.gov.au/environment/swbta/defence%20soe%20report_chapter%207f.pdf

http://www.dpi.nsw.gov.au/fisheries/habitat/aquatic-habitats/estuarine#Seagrass

http://www.iaia.org/IAIA-BioEco-Symposium-DC/proceedings/presentations/Session%204A%20-%20Colin%20Rees.pdf?AspxAutoDetectCookieSupport=1

http://ncp-dev.stanford.edu/~dataportal/rios_releases/RIOSGuide_Combined_8-22-13.pdf

http://www.fbbva.es/TLFU/dat/04%20Valiela_Separata.pdf

http://www.plosone.org/article/fetchObject.action?uri=info%3Adoi%2F10.1371%2Fjournal.pone.0043542&representation=PDF

Appendix

Scoring the Habitat

HABITAT NAME	CB_CoralReef_1
HABITAT ONLY PROPERTIES	
	Rating
recruitment rate	<enter (3) every 2+ yrs, (2) every 1-2 yrs, (1) every <1 yrs, or (0) no score>
natural mortality rate	<enter (3) 0-20%, (2) 20-50%, (1) >80% mortality, or (0) no score>
connectivity rate	<enter (3) <10km, (2) 10-100km, (1) >100km, or (0) no score>
recovery time	<enter (3) >10 yrs, (2) 1-10 yrs, (1) <1 yr, or (0) no score>
HABITAT STRESSOR OVERLAP PROPERTIES	

CB_CoralReef_1/CB_Charcoal_2 OVERLAP	
	Rating
frequency of disturbance	<enter (3) Annually or less often, (2) Several times per year, (1) Weekly or more often, (0) no score>
change in area rating	<enter (3) 50-100% loss, (2) 20-50% loss, (1) 0-20% loss, (0) no score>
change in structure rating	<enter (3) 50-100% loss, (2) 20-50% loss, (1) 0-20% loss, (0) no score>
temporal overlap rating	<enter (3) co-occur 8-12 mo/year, (2) 4-8 mo/yr, (1) 0-4 mo/yr, (0) no score>
management effectiveness	<enter (3) not effective, (2) somewhat effective, (1) very effective, (0) no score>
intensity rating	<enter (3) high, (2) medium, (1) low, (0) no score>

Coral Reef Habitat Stressor Ratings

HABITAT NAME CB_CoralReef_1

HABITAT ONLY PROPERTIES

	Rating	DQ	Weight	E/C
recruitment rate	1	2	2	C
natural mortality rate	3	2	2	C
connectivity rate	3	2	2	C
recovery time	3	2	2	C

HABITAT STRESSOR OVERLAP PROPERTIES

CB_CoralReef_1/CB_Charcoal_2 OVERLAP

	Rating	DQ	Weight	E/C
frequency of disturbance	2	2	2	C
change in area rating	2	2	2	C
change in structure rating	2	2	2	C
temporal overlap rating	3	2	2	E
management effectiveness	3	2	2	E
intensity rating	1	2	2	E

CB_CoralReef_1/CB_Fishing_3 OVERLAP

	Rating	DQ	Weight	E/C
frequency of disturbance	1	2	2	C
change in area rating	3	2	2	C

change in structure rating	2	2	2	C
temporal overlap rating	3	2	2	E
management effectiveness	3	2	2	E
intensity rating	2	2	2	E

CB_CoralReef_1/CB_SaltPonds1
OVERLAP

	Rating	DQ	Weight	E/C
frequency of disturbance	3	2	2	C
change in area rating	1	2	2	C
change in structure rating	1	2	2	C
temporal overlap rating	1	2	2	E
management effectiveness	3	2	2	E
intensity rating	2	2	2	E

Stressor buffer

STRESSOR NAME	STRESSOR BUFFER (meters)
CB_Charcoal_2	100
CB_Fishing_3	200
CB_SaltPonds111	50