Coral Reef Fisheries Technical Summary

Overview

Under the Caribbean Regional Oceanscape Project (CROP) Subcomponent 2.1, the Organisation of Eastern Caribbean States Commission (OECSC) engaged The Nature Conservancy (TNC) to develop ecosystem service (ES) models for five countries in the Eastern Caribbean (Dominica, Grenada, Saint Lucia, St. Kitts and Nevis, and St. Vincent and the Grenadines) using methodologies developed under TNC's Mapping Ocean Wealth (MOW) initiative, and to develop training and resources to improve data access for decision-makers.

This document provides a technical overview of the Coral Reef Fish and Fisheries models and maps derived under this project by Florida International University. Click here to see the full technical report.

Coral reefs in the Eastern Caribbean provide food and income to fishers and communities, but are threatened by a range of stressors that have impacted the health of reefs and the fish assemblages they support. To address these stressors and manage coral reef ecosystems for continued provision of ecosystem services, a local understanding of the factors that influence fish biomass, the current distribution of fish biomass, and insight into the potential outcomes of management is useful. This analysis followed similar methods employed in Micronesia, the Bahamas, and Florida, and used fish surveys, socioeconomic, and biophysical data from across the Eastern Caribbean to model and map fishing impact, model and map current fish biomass, and assess the potential benefit of conservation and management measures on reef fisheries. Although the research focused on the five CROP countries listed above, models were produced for the entire region from Anguilla (in the North) to Grenada (in the South) to account for connectivity among fish populations and to increase the number of fish surveys available to parameterize models.

The datasets produced from this model will enable planners to examine management scenarios for the effects on fish biomass, specifically fishing closures on snapper-grouper, and increase in coral cover for parrotfish.

Data Sources

Table 1. List of model input data and sources

Data input	Source(s)
Biophysical Variables	
Depth	GEBCO
Diadema density	Siegel et al. 2019
Geomorphology	Google Earth imagery
Coral Reef Habitat	TNC (benthic habitat maps created under the ECMMAN Project) and TNC Reef Report Cards
Oceanic net primary productivity	Oregon State University (mean net primary productivity from monthly data 2012 – 2016)
Protected status	TNC protected areas layer
Sea surface temperature	NOAA CoRTAD satellite-based ocean temperature dataset
Wave exposure	Chollett et al. 2012
Fishing-related variables	
Demography	Various governmental and non-governmental sources
Fish Landing Sites	Stakeholder input and various reports and articles (e.g. Staskiewicz et al. 2008, Guyader et al. 2 13, Ramdeen et al. 2014a, de Graaf et al. 2017, Gumbs et al. 2015, Lindop et al. 2015
Fisheries economy	Siegel et al. 2019
Fish Survey datasets	Atlantic and Gulf Rapid Reef Assessment (AGRRA); Steneck et al. 2018, Waitt Institute, Institute for Tropical Marine Ecology (ITME), Observatoire du Milieu Marin Martiniquais (OMMM), and the FORCE project.
Governance	Worldwide Governance Indicators Kaufman et al. 2010; compiled by Siegel et al. 2019
Market gravity	Cinner et al. 2018
Population	LandScan human population data
Ports	Various governmental sources and non-governmental sources

Modelling and Geoprocessing

The methods presented below in the conceptual overview (Figure 1) and the subsequent descriptions were informed by previous efforts, adapted to the needs and data availability in the region. Methodologies and interim results were reviewed by stakeholders at in-person and virtual workshops in 2019 and 2020.

Conceptual Overview

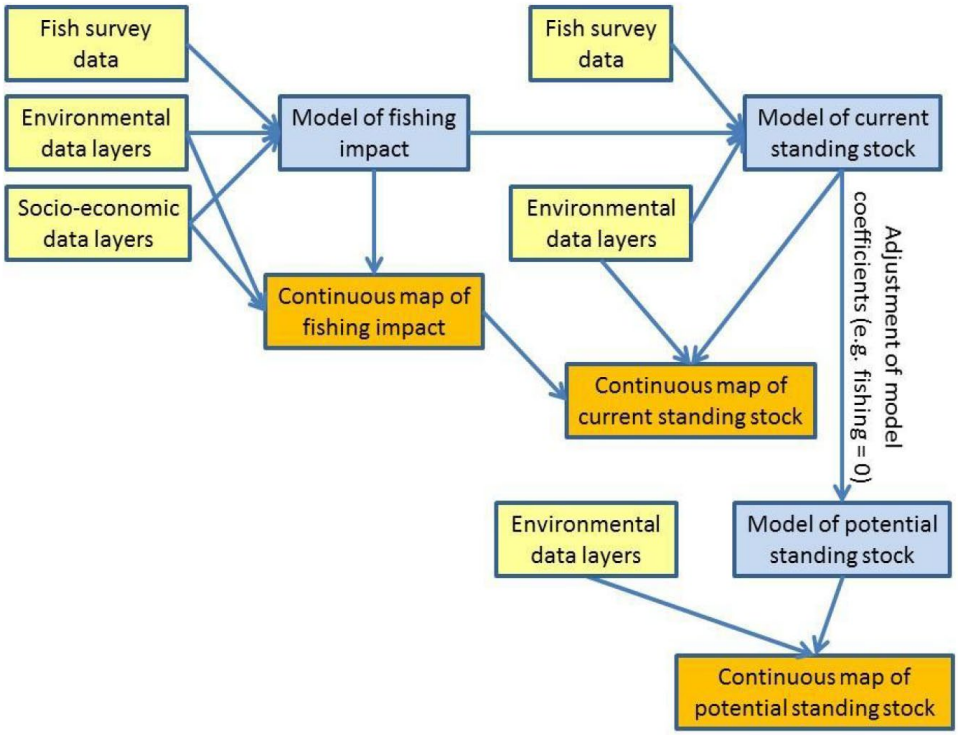

Figure 1. Overview of the methods for modelling and mapping fishing impact and fish biomass. Yellow boxes represent input data, blue boxes represent output models, and orange boxes represent output maps.

Map of Coral Reefs

A high-resolution benthic habitat layer developed by TNC (Schill et al. *in prep*) using Planet Lab Inc.'s Dove satellite 4-meter imagery (Li et al. 2019) was used to establish the extent of reef areas for the model. The layer categorizes shallow benthic habitats across the region, including five coral reef habitat types: Reef Crest, Reef Fringing, Reef Fore, Reef Back, Spur and Groove. This map was rasterized to a 100m (1ha) resolution, such that all map products from the project are at a 1ha resolution. To further capture differences in fishing and fish biomass across habitat types in the models, a higher-resolution habitat layer developed by TNC for only the five CROP countries was used to assign additional information to sites in those countries. This second, higher-resolution layer included the following habitat classes: Boulders and Rocks, Coral *Acropora*, Coral Algal Rim, Coral Framework, Coral *Orbicella* (*Montastraea*) with Gorgonians, Coral Patch Reef, Deep water, Hardground Algal, Hardground Gorgonian, Hardground Turf, Land, Mud and Silt, Rubble, Sand, Sand with Macroalgae, Seagrass Dense, Seagrass Sparse.

Fishing Impact

Fishing impact was modelled using the metric of mean parrotfish length (derived from fish survey data), which has been shown to be negatively correlated with fishing pressure. Mean parrotfish length was modelled in relation to environmental (e.g. wave exposure) and fishing-related (e.g. population) variables to isolate just the fishing-related factors influencing parrotfish length. This allowed for estimates of fishing impact that are based on fishing-related factors, but that control for the influence of biophysical gradients on parrotfish length. The model of fishing impact was parameterized using data from reefs where fish survey data were available, but it was used to extrapolate values across the region using continuous data layers of each significant explanatory variable, thus deriving a continuous map of fishing impact. The maps of fishing impact generated by the project represent relative, unitless patterns of estimated total fishing impact, as opposed to absolute fishing rates as measured by metrics such as catch per unit effort.

Current Biomass

The predicted values of fishing impact were then a key input into a model of current fish biomass. The model of current biomass used data independent of the data used to model fishing impact to ensure robust statistical models (i.e. we did not derive fishing impact from a dataset, then use the fishing impact metric to model biomass in the same dataset). Predicted fishing impact was combined with environmental data (Table 1) to model the biomass of two species groups: snapper and grouper species and parrotfish species, in addition to the total biomass which included all species documented in AGRRA surveys. The model was then used to extrapolate these results to all 1ha cells, resulting in high-resolution maps of the current biomass of each species group across the region.

Potential Biomass

Coefficients from the current biomass model were adjusted to estimate potential biomass under different management initiatives. This report includes the results of adjusting fishing impact to zero, simulating the effects of a no-take marine reserve on snapper and grouper species. It also includes increasing the percentage of hard coral cover to simulate the effects on parrotfish species of a restoration effort that increases live coral. These adjusted models were combined with all significant environmental data layers to generate continuous maps of potential biomass under the two management scenarios.

Other Considerations

These are modelled data products, with overall accuracy dependent on the quality of input datasets. Due to low sample sizes, a full range of management scenarios, other species/species groups, and relationships between fish biomass and other variables have not been evaluated under this project. These products can be most useful in a management

context when used together with other forms of data and knowledge regarding the distribution of fishing and fishing impacts and fish biomass on these reefs.

Suggested Citation

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Data Access

Coral Reef Fisheries Data Models

Other Fish Survey Data

- AGRRA
- Waitt Institute

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