# Modelling Fishers' Activity as a Response to Weather and Economy: First Step Towards Building Adaptive Capacity under a Changing Climate

# Modelando las Actividades de los Pescadores como Respuesta al Clima y a la Economía: Un Primer paso para Incrementar la Capacidad de Adaptación bajo Cambio Climático

# Modéliser l'Activité des Pêcheurs en Réponse aux Conditions Météorologiques et Économique: Une Première Étape pour Renforcer les Capacités d'Adaptation au Changement Climatique

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## EXTENDED ABSTRACT

### Background

The artisanal fishing sector provides about 90% of all fishing employment worldwide and nearly 25% of the world catches. Artisanal fishing is, however, an economically risky activity, due to the high livelihood and income dependency on local resources and their unpredictability. This makes the activity highly vulnerable to changes. Changes in weather and economy have the potential of modifying fishing activity through changes in target abundance and (most overlooked) fishermen behaviour. Changes in costs of fishing and expected catch value can shape where and how often fishermen will fish. On the other hand, weather aspects such as rainfall, strong winds, or storms can restrict the number of fishing days, and exposure to waves define fishing accessibility with areas that are too rough being unusable for fishing.

### Objectives

Here we use novel methods to assess the effects of both weather and economical aspects on artisanal fishing activity. The uniqueness of this research include the spatially-explicit quantification of wave exposure (which restricts fishing access) and the use of a novel modelling approach (*MaxtEnt*, a presence-only model) due to the occurrence of unreliable zeros in our dataset, a common problem in fisheries data. We apply the model in Honduras, where weather seemed to be particularly relevant in shaping fishing activity.

### Methods

We used daily fishing records for Utila, Bay Islands, Honduras, to assess how changes in weather affect fishermen access to fishing grounds. Daily records for the period August 2010 – September 2011 were recorded at the Utila Cays (16.0639°N, 86.9667°W). The 1,186 records collected include data on the date, departure time, coordinate of the fishing ground visited, and total landings. Daily in situ rainfall and wind speed data for Roatan airport (16.31°N, 86.53°W) were also obtained for the period 2010 – 2011.

Wave exposure maps describe the sea condition and the degree of wave action on an open shore, and therefore are a proxy for site accessibility, with rough, high wave exposure areas being inaccessible for fishing. Daily wave exposure maps (at 50 m spatial resolution) for the period 2010 – 2011 were produced following the methods described in Chollett and Mumby (2012).

Because the fisheries around Utila are unsaturated and many times suitable weather conditions are present but fishing grounds are still not visited, we could not apply traditional modelling methods to predict fishing activity. Therefore, we borrowed an approach used in ecological and conservation applications called *MaxEnt*, which allows predicting fishing activity from environmental predictors using presence-only data. As explanatory variables, we included weather (rainfall, wind speed, exposure to waves), economic (distance to port), and cultural (day of the week) variables. Additionally, fishing around Utila occurs during morning and evening hours, and we added that covariate as well (categorical: morning or afternoon fishing). We explored the initial dataset in order to remove highly correlated (and therefore redundant) variables before the analyses. Model refinement was done using the jackknife feature in *MaxEnt* to assess performance of each variable in terms of AUC (Area Under the Curve of Receiver-Operator Characteristic) gain.

## RESULTS AND DISCUSSION

The final model including five variables explains well the fishing activity patterns (AUC = 0.83). *MaxEnt* results indicate the distance to port (contributing 56% of the variability) is the most influential variable in the model, followed by time of fishing (30.7%). Weather and cultural variables have less importance in modulating the response. Fishing activity is associated to intermediate distances to port (5 – 40 km), which indicate avoidance of fishing grounds close to port (probably related to overexploitation of fish resources) and far away from it (likely related to lack of profitability of the trip if fuel expenses increase). Fishing activity is also associated to lower rainfall and wave exposure. The relative importance of these variables is, however, very small, 10.5 and 1.8%, respectively.

These results could be considered an early warning signal of overfishing in the Bay Islands, which were considered as fisheries in their early stage with moderate fishing pressure. In this region, it seems unlikely for climate change to affect fishing activity. Projected increases in fuel costs, however, might be problematic.

This model, coupled with economic and downscaled climate change predictions for the area, will be used to assess likely changes in fishing intensity under a changing climate and economy. The predictions would help, in turn, to build adaptive capacity to climate change in this vulnerable socio-economical system.

**KEY WORDS:** Artisanal fisheries, weather, optimal foraging theory, climate change, adaptation

## LITERATURE CITED

Chollett, I. and P. Mumby. 2012. Predicting the distribution of Monastrea reefs using wave exposure. *Coral Reefs* **31**(2):493-503.