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Estimation of fish biomass in the exclusive economic zone of the pacific of Costa Rica

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Introduction

The conservation and management of marine resources and the consequent measures are based on the determination of a baseline of those objective resources. The initial estimate of this baseline requires that subsequently, and periodically, information continues to be updated.

The objective of this analysis was to estimate the annual biomass available for some targeted marine species, as well as their probability of occurrence in the Exclusive Economic Zone (EEZ) of the Pacific of Costa Rica.

The Cocos Marine Conservation Area (ACMC) and the National Conservation Areas System (SINAC), with the support of the Friends of Cocos Island Foundation (FAICO), considered executing this first assessment in order to lay some foundation for the management of the marine resources of Costa Rica, as well as building bridges between the conservation objectives and the sustainable use of the country's marine resources.

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Methodology

The analysis focused on the main target species for fishing: Tuna, Sailfish, and Mahi Mahi (Dorado). Shark catches were also included.

For the estimation of biomass, the "depletion" method was used (Leslie's method). This method takes as a basic reference the Catch per Unit of Effort (CPUE) considering the repetition of the catch in a geographic unit (data obtained from the IATTC database). Thus, in theory, assuming a closed population (without mortality, recruitment, immigration, or emigration) and with enough statistics (1993-2014 and 2015-2017), it is possible to determine the biomass. Under these conditions, CPUE yield, in theory, would always show a downward trend, which is calculated from the available data. In reality, eventually the data show an increase due to external impacts (favorable oceanographic conditions, increased migration, climatic aspects, etc.).

To determine the probability of occurrence of yellowfin tuna in the EEZ, the "random forests" model was used., in which a map that goes from 0 (unlikely to occur) to 1 (very likely to occur) is obtained. For the analysis, the entire EEZ was subdivided into squares of 4.5 km per side, and the reported data of the yellowfin tuna catches of each fishing set was located. For each successful set, a value of 1 (presence of fishing) or 0 (absence of fishing) was assigned to said grid. Using these presence/absence data, a random forest model was made using sea surface temperature, bathymetry, and chlorophyll as predictive variables.

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Results

Tuna biomass throughout the EEZ of Costa Rica

Tuna volumes have had a slight reduction in their stock over time (Figure 1). The temporal graphic analysis clearly shows a reduction in stock. This situation warrants taking measures to stabilize the resource and reverse this trend.

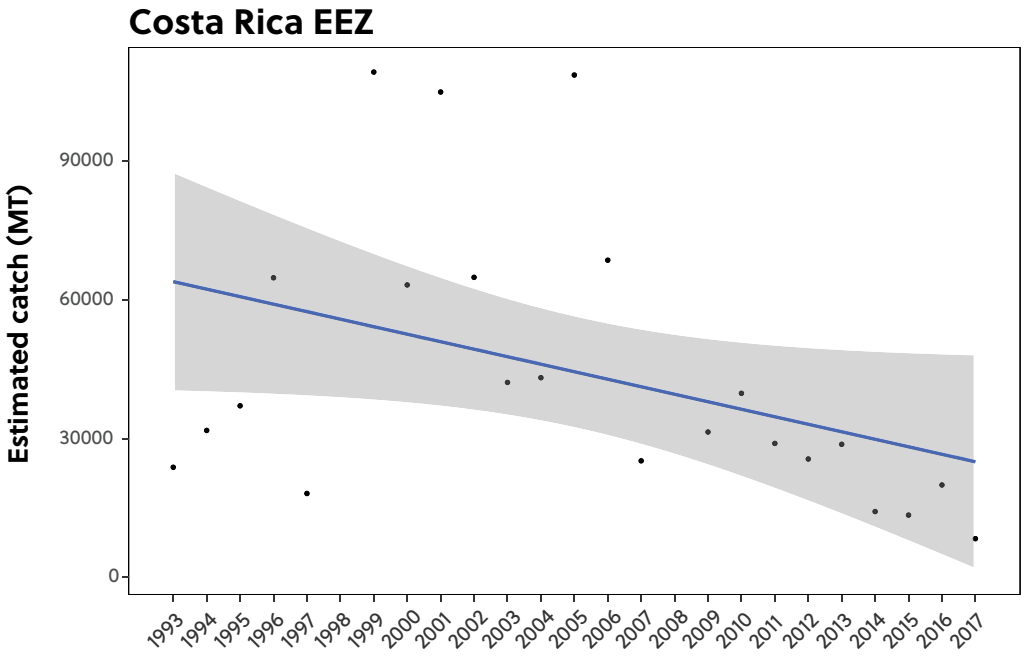

Figure 1. Biomass estimated in metric tons (MT) for the yellowfin tuna fishery throughout the EEZ of Costa Rica. Source: SINAC, 2018.

Biomass in Other Fisheries or Catches

With regard to other fisheries such as Mahi-Mahi (Dorado) and sailfish, as well as sharks, the estimations are:

Fishery / Catch	1993 – 2011 (Average)		2012 – 2017 (Average)	
	Total Period	Annual average	Total Period	Annual average
Mahi – Mahi	696.13 (309.08 – 1083.19)	38.67	55.65 (32.29; 79.02)	11.13
Sailfish	6,532.2 (0 – 146,158)	362.9	Not enough data	Not enough data
Sharks	821.1 (536.6; 1,156.9)	45.61	37 (25.5; 99.4)	7.4

Table 1. Biomass estimates in metric tons (MT) ±95% CI * by species / group for two groups of years within the EEZ.

In the biomass estimation, a downward trend in volumes is observed over time. In the case of species such as sharks, which have a very slow reproductive maturity, the annual decline could lead to the resource entering a complicated recovery curve.

Probability of Occurrence (by Geographic Cells)

To represent geographically the productivity of Tuna within the EEZ of Costa Rica, the probability values of each geographic cell were converted into shades ranging from light blue (close to zero), through yellow (around 0.5) to intense red (close to 1). Thus, the intense red means an area in which successful fishing sets are very likely to occur.

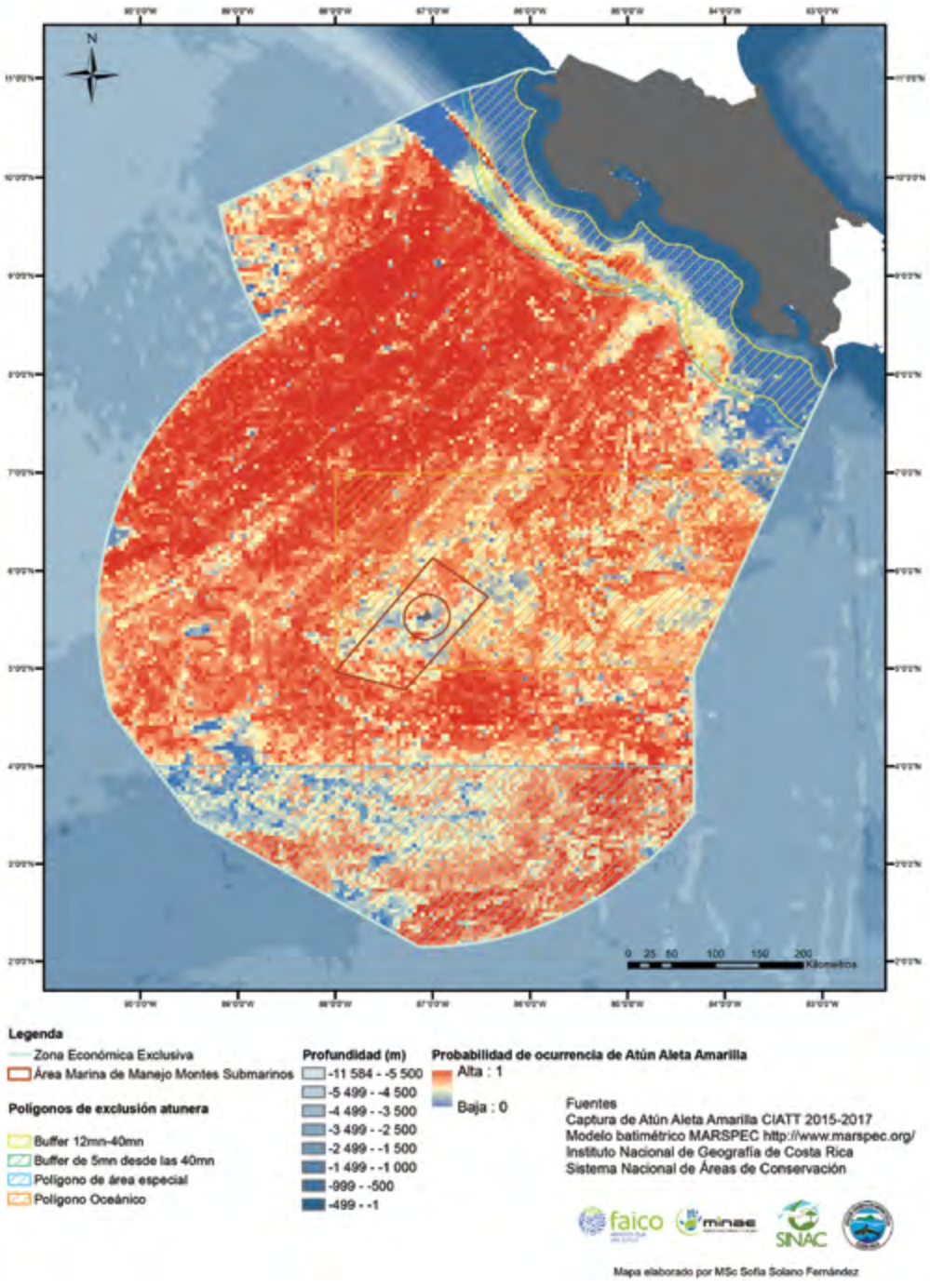

Figure No. 1. Probability of Landing/ Occurrence of Yellowfin Tuna in the EEZ of Costa Rica.

Random Forest Method 2015-2017.

Analysis, Conclusions, and Recommendations

- The available data have made it possible to determine gross results (long periods of time and the area over the entire EEZ), both for estimating the biomass in the main species and for georeferencing the productivity of the tuna fishery.

- For management purposes, it is necessary to move towards finer prediction, for example determining the dynamics of quarterly changes, obtaining catch data in uniform 10km x 10km cells, linked biological (ecosystem) data, etc.

- Current data do not allow conclusions to be drawn on seasonal dynamics or in lower resolution spatial units.

- In the future, it is important to implement a data collection system for catches per vessel in order to transfer this information to those of the trajectories and to automate CPUE calculations and actual estimates of biomass per unit area.

- In particular, it is recommended to implement periodic monitoring, and to deepen sustainability studies to guarantee that the management measures allow for the long-term sustainability of the resources.

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- Finally, it would be important to determine predictions/ projections of the condition of the resources and for this, the determination of indicators such as:
    - The maximum sustainable yield per fishery (total allowable catch in metric tons MT).
    - The appropriate range of vessels (according to type of vessel, size, gear, wells) to economically optimize the fishing activity.
    - The resilience of each resource.
    - The impact of external parameters in the stocks: oceanography, global warming, atmospheric situations, etc.
    - Eventual geographic variations in the location of resources.
    - A fair distribution of access to resources by national fleets (marine resources are by definition the property of the coastal State).
    - The identification, productive quantification, and protection of the recruitment sites or areas.
    - Measure the effectiveness of the Marine Protected Areas and other management initiatives, as tools to sustain the productivity of the EEZ.

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SINAC (Sistema Nacional de Áreas de Conservación). 2018. Estimación de la biomasa pesquera en el Área de Conservación Marina de los Cocos (ACMC-SINAC) y aguas circundantes (AMMMS) y predicción de la probabilidad de desembarque de las especies según condiciones bioclimáticas. Área de Conservación Marina Cocos. San José, Costa Rica. 16 p.