São Paulo School of Advanced Science on Ocean Interdisciplinary Research and Governance

Role of the environment in the catch of hake (*Merluccius productus*) in the northern gulf of California

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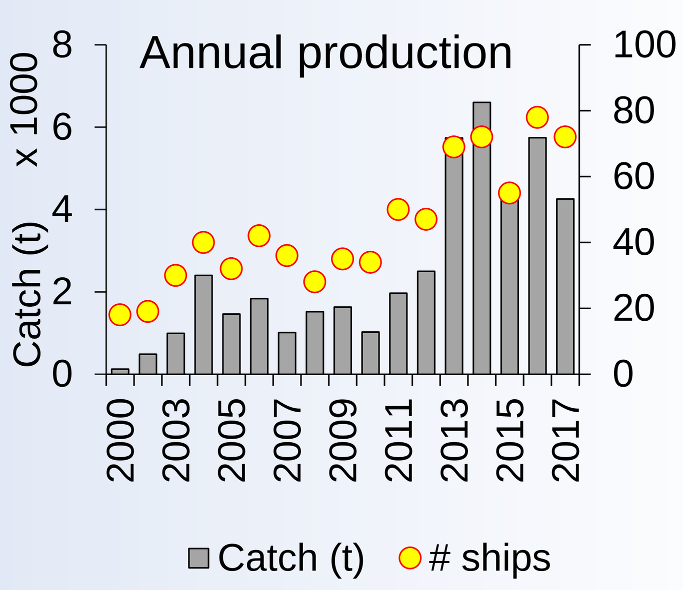
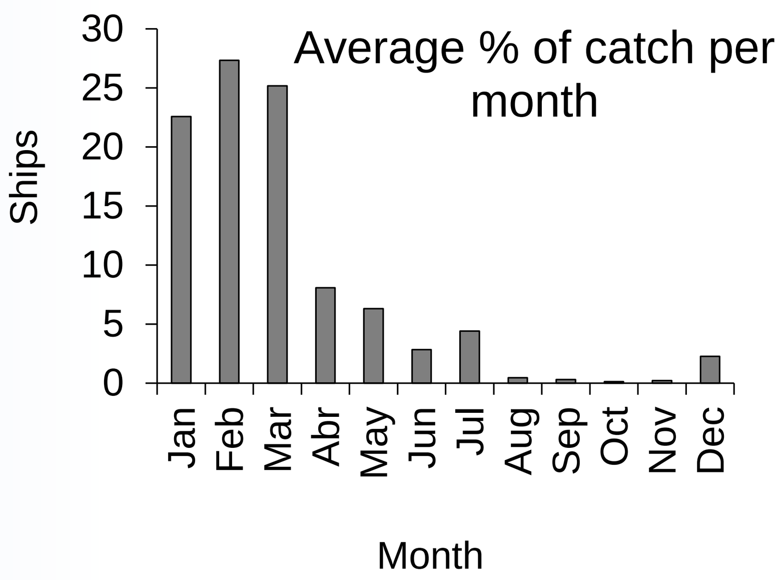
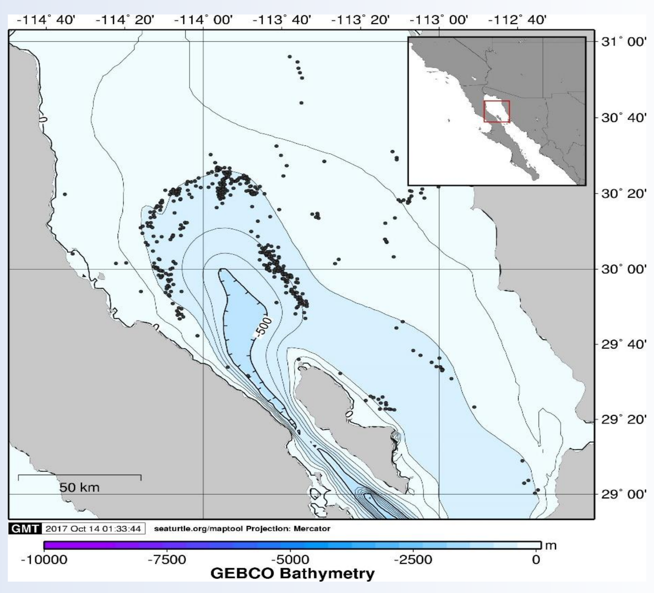
Introduction

The gulf of California (GC) is a unique large marine ecosystem that holds a rich biodiversity, high biological productivity and endemism of marine life, which are the basis of Mexico's most important fisheries[1]. There is an important fleet of trawlers (953 ships) that catch shrimp and other scale fishes. In the northern side of the gulf of California there is an alternative fishery that is gaining more attention from year to year, the hake (*Merluccius productus*) fishery that peaked in 2014 with 6,600 t landed with 78 ships in 2017[2].







The hake fishery has some particularities:

- The fishing season of hake lasts 3 months (in average) each year in a very sharp depth profile and a limited zone of the northern gulf of California.
- The fishery occurs over a spawning aggregation.
- The main challenge of this fishery is that **very little is known about its biology and ecology** and it has just been recognized by the government as a national fishing resource (DOF, 2018).

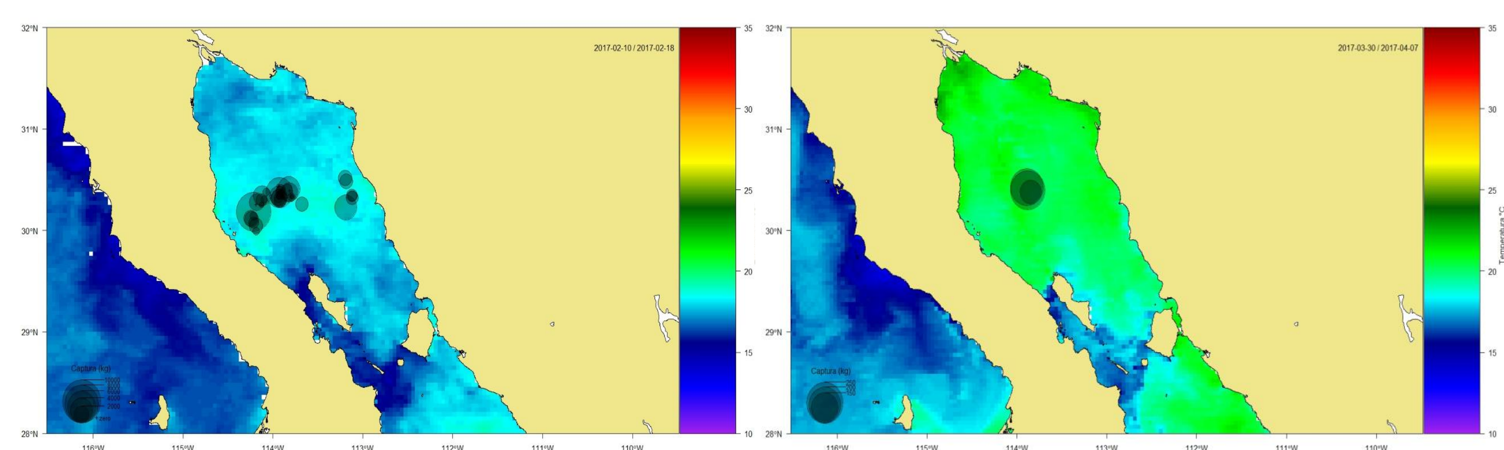
WHAT?

The main **objective of this study is to understand the role of the environmental variables in the availability of hake to provide advice on its management regulations**

HOW?

Two sources of information:

1. Data provided by the on board observers of the hake fishery
2. Satellite images of sea surface temperature (SST) and primary productivity (PP).



Modelling approach

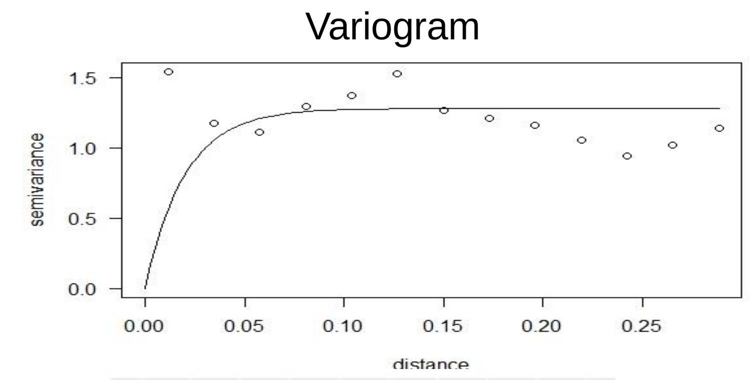
- Catch ~ Standardized effort + Environmental covariables[3]
  - In a generalized linear model approach
- "*Everything is related to everything, but closer things are more related than distant things*" [4]
  - Test for spatial autocorrelation of residuals of the model

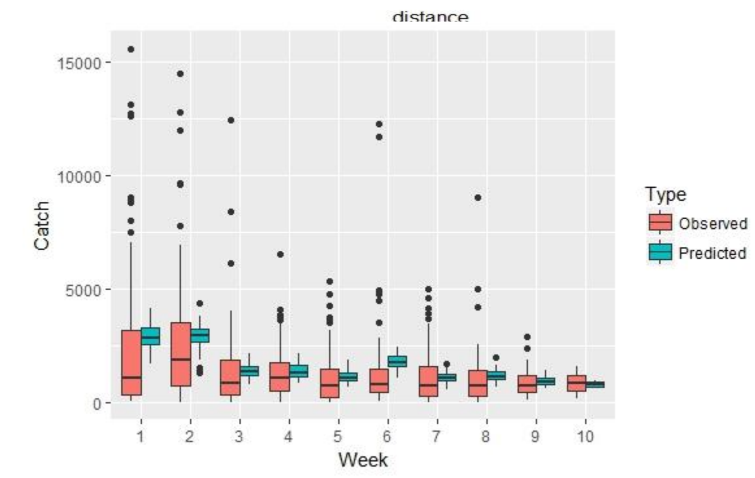
- $x_j = 1, \dots i-1 \dots . N, j \neq i$ (habitat)
- $Y_i = \mu_i + S(x_i) + \varepsilon_i$ (predictive model)
- $E[S(x_i)] = 0$ (spatial autocorrelationated error component)
- $cov[S(x_i), S(x_j)] = \sigma^2 \rho(xi - xj)$ (var-cov matrix)

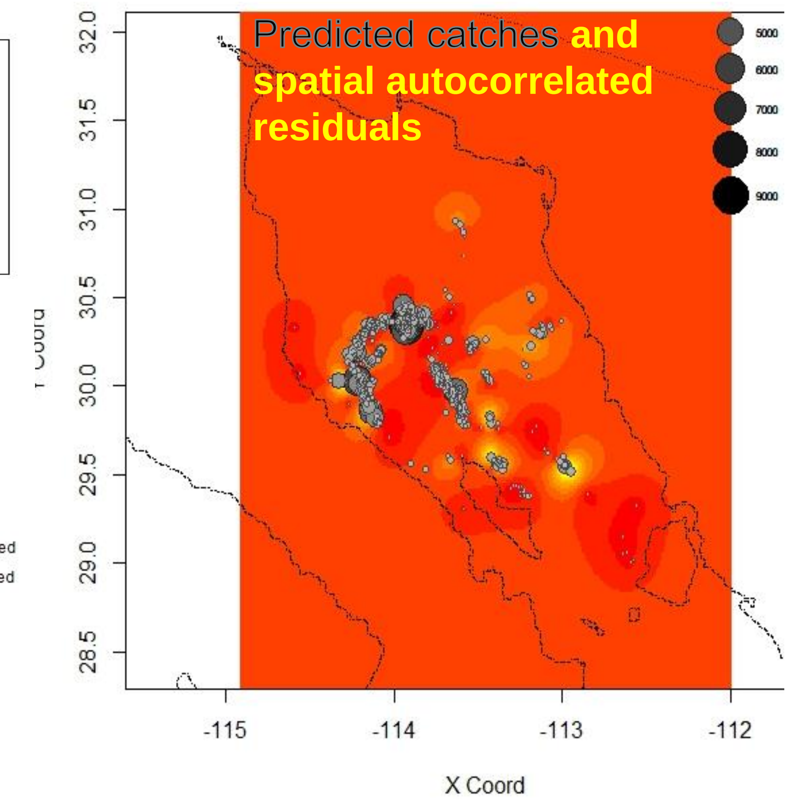
Preliminary results

Model

glm(Hake + 1 ~ SST + PP + hour + week + Long + Lat + Depth + Phase + ENSO, Gamma(link = "log"))







WHAT IS NEXT?

Expand the catch prediction in the entire distribution zone to find new likely fishing grounds.

Estimate the expansion/reduction effect of warm and cold years.

Test the model to predict sizes or ages of the catch.

If a spatial structure in some characteristics of the population is found, core zones to protect from fishing can be evaluated.

References

1. Páez Osuna *et al*. (2016)
2. CONAPESCA (2014)
3. Agostini *et al.* (2008)
4. Tobler (1970).