

School of Zoology

The George S. Wise Faculty of Life Sciences

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Research proposal:

Non-stationarity in fish community networks along environmental gradients

*רשתות דינאמיות של חברות דגים לאורך גרדיאנטים סביבתיים*

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# Introduction

It is well understood that both biotic interactions and abiotic circumstances affect the structure of a community, but their relative importance is still controversial (D’Amen et al. 2018, Delmas et al. 2018, Zurell et al. 2018). Previous researches have described the importance of species interactions in dictating community assemblage and distribution of species (Bar-Massada and Belmaker 2017, D’Amen et al. 2018). Understanding the importance of biological interactions is critical if we are to predict the distribution of species in face of global changes.

The most used tools by ecologists for learning distribution patterns of species are Species Distribution Models (SDMs) (Zurell et al. 2018). These models typically use abiotic environmental predictors (e.g. temperature, elevation) alone and do not account for interactions among species. Joint species distribution models, or jSDMs, are an emerging class of model that accounts for patterns of species co-occurrence while controlling for abiotic predictors. Residual correlation among species co-occurrences, random (no association), positive or negative, can then be used to infer associations after accounting for species-specific habitat preferences.

However, jSDMs usually assume that biotic interactions are stationary over space and environmental settings. This holds a potential pitfall, as estimations of interactions based on fixed relations between species and the environment may result in inaccurate predictions (Pollock et al. 2014, Anderson 2017, Bar-Massada and Belmaker 2017, Delmas et al. 2018). There is an plethora of methods to quantify and predict the changes in community assembly (Tikhonov et al. 2017, Clark et al. 2018, Delmas et al. 2018), but most of them do not account for dynamic interactions.

One approach which can address this challenge uses Markov Random Fields (MRFs) to create networks of interspecies conditional associations (Clark et al. 2018). MRFs are graphic networks which are used in a wide array of disciplines, and increasingly in ecology, to examine the conditional interactions of variables (Azaele et al. 2010, Harris 2016, Clark et al. 2018). This statistical framework allows to create meaningful models from observational presence-absence data, matched with environmental predictors, and to examine directly the conditional association of species among themselves in the context of their environmental setting (figure 2). This is a major enhancement to jSDMs, in which species interactions are only inferred from residual correlations (Harris 2016). Moreover, using MRFs allows to compare the coefficients of interactions with the ones of predictors and thus to distinguish between their contributions to patterns of co-occurrence (Clark et al. 2018).

A close up of a map

Description automatically generated

Figure 1: A hypothetic graphic representation of community networks along a gradient of covariate (predictor) x. Species (nodes) are connected by links that depict their co-occurrence probabilities: orange links show a positive association and blue links show negative association.

The Mediterranean Sea contains strong spatio-environmental gradients. Exploring ecological communities along these gradients, will allow me to gain insights into how community interactions change with temperature. The Mediterranean Sea includes Marine Protected Areas (MPAs) whose varying size, protection level and age have been shown to influence local fish populations (Claudet et al. 2006, 2008, Lester et al. 2009) and therefore, can provide another layer of spatial predictors, potentially affecting species (co-)occurrence.

In this study, I intend to examine the variation in co-occurrence patterns of fish within and outside MPAs and along east-west gradients in the Mediterranean Sea . For this I will use MRFs and graphic networks that account for the non-stationarity in species associations. I will then asses to what degree co-occurrence patterns are stationary along these two gradients. This will provide an insight onto how ecological communities can function in altered environments, and how protected areas can affect their abilities.

# Objectives

1. To estimate the amount of non-stationarity in interspecific interactions within fish communities across the Mediterranean Sea.
2. To estimate the amount of non-stationarity in interspecific interactions within fish communities within and outside MPAs.

# Methods

The data for this project has largely been gathered already. Visual fish census surveys took place in 85 locations along the Mediterranean Sea (figure 2) by teams of skilled SCUBA divers. Locations were comprised of sites within MPAs with varying size, age and enforcement level, and unprotected sites which are adjacent to these MPAs. To date, the database is comprised of approximately 49,000 observations of 93 species of fish and includes abundance data, as well as presence-absence data. Additional data will be collected during 2019 and will be added to the main database.

A close up of a map

Description automatically generated

Figure 2: Sampling locations along the Mediterranean Sea. Each green point represents a sampling site.

Data will be analysed using the MRFcov R package (Clark et al. 2018, R Core Team 2019), which expands MRFs into Conditional Random Fields (CRFs) by incorporating environmental covariates (predictors) in the estimation of conditional dependencies between species pairs. This model assesses a species probability of occurrence given the probability of occurrence of all other species and environmental predictors (temperature, protection level). These probabilities are estimated through a series of logistic regressions which are then combined into a joint network. Since species dependencies can vary over gradients the output of this model allows to explore the relationships between species along these gradients. Additionally, it provides the option to measure the relative input of species co-occurrence patterns versus that of the environmental factors, by comparing their coefficients. This is an important improvement to existing jSDMs were the scales of the unexplained variance effect (which refers to species interaction) and the explained variance effect (usually environmental predictors) are not directly comparable.

# Schedule

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| Date | Task |
| May – June 2019 | Data wrangling and literature review on methods |
| July 2019 | Methods testing |
| August – October 2019 | Data analysis |
| November 2019 | Data analysis: summarise results so far |
| December 2019 | Add new data from 2019 surveys |
| January 2020 | Data wrangling |
| February – May 2020 | Data analysis |
| June – September 2020 | Write thesis |

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