Post-doctoral fellowship – 18 months

NETDIV: NETwork modelling for the bioDIVersity of species communities

Summary
Assessing and understanding patterns among species communities for their management and conservation is a crucial issue worldwide given the increasing human pressure and global environmental changes. Yet, further improvements are still needed to provide efficient methodological frameworks to assess the complexity of communities (compositional, taxonomic, phylogenetic and functional diversity), and to identify underlying species assembly processes and anthropogenic conditions at different spatio-temporal scales. Network-based modeling, relying on graph theory and social network methods, are on the rise across many scientific disciplines, i.e. physics, genetics, health and ecology. They are suited to handle different information sources to characterize and reveal complex patterns within big data sets. In this context, the aim of this project is i) to provide a methodological framework based on network modeling ii) to assess fish community within the EU MEDITS program, funded by the European Commission with the Data Collection Framework, which monitor marine resources of ecosystems exploited by fishing at large spatio-temporal scales overall the northern Mediterranean sea to enhance their management and conservation.

1) Context and objectives

Quantifying and understanding patterns among and between species communities is challenging and crucial given the increasing direct human pressure and global environmental change. One of the key research area in ecology aims to understand how community diversities (compositional, taxonomic, phylogenetic and functional diversity) are driven by assembly processes and anthropogenic conditions at different spatio-temporal scales (Sutherland et al., 2013). It may also help to predict how communities could respond to future changes and to adapt their management and conservation (Socolar et al., 2016). Quantifying community diversities and revealing the assembly processes that lie behind patterns (neutral, environmental filtering and/or anthropogenic forcings) have been performed through increasing development of quantitative approaches. Three methodological approaches based on the use diversity indices are mainly used in the literature for the common aim to assess the relative influence of structuring processes (stochastic or deterministic) on communities: i) FD index based on the construction of dendrograms from the distance matrix between species pairs, ii) FRic index based on the modeling of a convex hull, iii) the n-dimensional hypervolume index. However, these approaches suffer from limitations (e.g. Fontana et al., 2016 ; Loiseau et al., 2017). Notably, FD index and the convex hull volume are only based on presence/absence data, while the structure and response of communities in the face of disturbance are strongly dependent of the distribution of species abundances. In addition they suffer from methodological drawbacks preventing accurate conclusions on the processes structuring communities. They notably mainly have limitations in their sensitivity to some particular species (depending their relative degrees of ecological functions), capture not all diversity components, and are not suited for big data sets due to modeling limitations (Loiseau et al., 2017). Recently, some approaches and review have been provided (Delmas et al., 2019; Legras et al., 2019; Ohlmann et al., 2019; Siwicka et al., 2020), and a methodological framework to assess the complexity of community diversity and to identify underlying species assembly processes and anthropogenic conditions at different spatio-temporal scales is still needed.

Network-based analyses, relying on graph theory and/or social network measures (Bondy & Murty, 2008 ; Scott, 2013), are on the rise across many scientific disciplines, such as physics, genetics, health and ecology. These methods are getting an increasing interest due to the number of different information and data they can handle as well as their ability to describe and reveal complex, often emergent, patterns and dynamics (Bullmore & Sporns, 2010 ; Jacoby and Freeman, 2016). These analyses involve modeling algorithms, mathematical indices and graphical approaches that complement traditional tools of these disciplines (Jacoby and Freeman, 2016). Network-based modeling has been used in different fields related to various ecological and evolutionary phenomena such as animal behaviour, landscape ecology, trophic ecology, as well as mutualistic and host-parasitoid networks. Recently, network-based algorithms have been used to describe and understand patterns of vegetal communities and its link with ecosystem functioning (Siwicka et al., 2020). In community ecology, networks can be viewed as spatio-temporal dynamic structures composed of nodes or entities (e.g. species) and links (e.g. species (dis-)similarities). In this frame, network modeling can quantify many functional and relational characteristics including structural and dynamic complexity, and the effect of explanatory/forcing variables (Strogatz, 2001). To assess graph structures and networks' properties, many approaches and indices have been developed (e.g., degree of node assortativeness, node importance to overall network and centrality metrics, among others). However, in the field of community ecology, modeling development and applications are still scarce (e.g. Delmas et al., 2019; Legras et al., 2019*;* Ohlmann et al., 2019; Siwicka et al., 2020), and a methodological framework and guidance are still needed.

In this context, the aims of this post-doc research is i) to provide a methodological framework based on network modeling, with both graph theory and social network methods, in order to assess and quantify community diversity and ecological processes that underpin the observed complex patterns, and ii) to apply this framework to Mediterranean exploited fish communities in order to investigate and identify the processes (neutral, environmental filtering and/or anthropogenic forcings) that lie behind observed large spatio-temporal patterns, and identify priority zones of interest for management and conservation of these critical marine resources for human populations.

First, a review of existing methods in network-based modeling and analyses will be performed. The goal of this task is to identify which methods can be more suitable to assess and quantify ecological community and underlying processes. The research could benefit from the convergent development across different disciplines involving various data. Then, once methods and techniques are identified, the post-doctoral research will work on how to develop, adapt and implement these methodologies to analyze ecological communities (article 1, submitted month 9). Second, this framework will be applied to Mediterranean fish communities to address above research questions, with implication for the management and conservation of these communities (article 2, submitted month 18). All the data needed are already available within the European MEDITS program "Mediterranean international trawl survey" (Spedicato et al., 2019). This program is funded annually by the European Commission within the Data Collection Framework (DCF), since 1994 until at least 2027 (obligatory in the frame of the EU Common Fisheries Policy (CFP)). Within this program, marine ecosystems exploited by fishing are monitored at large spatio-temporal scales overall the northern Mediterranean sea to enhance their management and conservation (Figure 1). These data consist in 154 fish abundance from about 20, 000 hauls within the range of 10 to 800 m depth performed annually between 1994 and 2019 by standardized scientific bottom trawl field surveys across the northern Mediterranean Sea (Spain to Cyprus). Functional traits and phylogenetic data of fishes are also available (Granger et al., 2015), as well as 6 variables characteristic of environmental gradients (e.g. climate change and changes in productivity) and anthropogenic pressures: depth, temperature, chlorophyll a, nitrate, dissolved oxygen, fishing pressure due to exploitation (Mérigot et al., 2019).

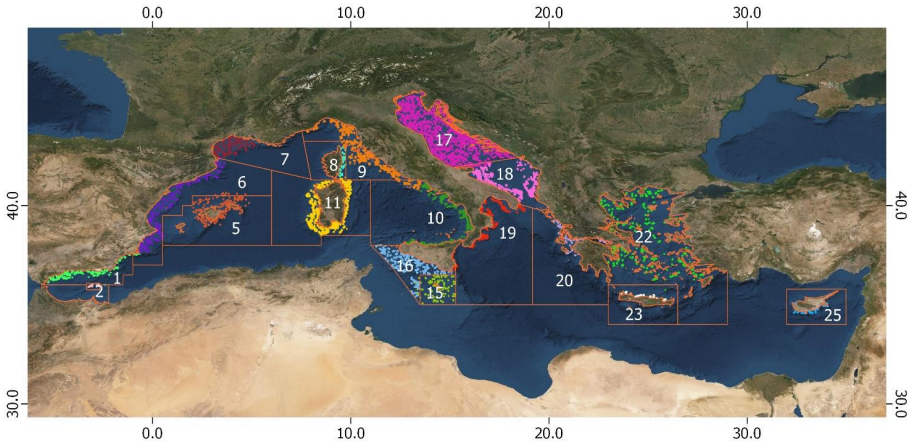

Figure 1: Stations sampled each year within the EU MEDITS "Mediterranean international trawl survey" program, by a scientific fishing trawl surveys to monitor marine demersal resources since 1994. Numbers are Geographical Sub Areas (GSA) defined by the fisheries management organization GFCM "General Fisheries Commission for the Mediterranean". Source: Spedicato et al. (2019).

This project is thus multi-disciplinary as it involves various and complementary domains of mathematics, data mining from social network analysis and graph theory, as well as quantitative and theoretical ecology. The post doctorate will work in a multidisciplinary team composed by experts in data science, network modeling and quantitative ecologists. The Research Units involved in the project are: the UMR MARBEC "Marine Biodiversity, Exploitation and Conservation" (Dr. B. Mérigot), UMR LIRMM "Laboratory of Computer Science, Robotics and Microelectronics of Montpellier" (Prof. P. Poncelet), and UMR TETIS "Territory, Environment, Teledetection, Spatial Information" (Dr. D. Ienco). The project i) involves collaborations with scientists among 10 countries participating to the EU MEDITS program which still continues at least until 2027: Spain, France, Italy, Malta, Slovenia, Croatia, Montenegro, Albania, Greece, Cyprus, and ii) will develop a methodological framework for species communities flexible to be applied for both terrestrial and marine ecosystems, thus with potential interest of a broad scientific community.
Clusters for modeling are available through the MBB "Montpellier Bioinformatics and Biodiversity" platform. A personal computer for the post-doctorate will be provided by UM-MARBEC.

2) Outcomes

Two articles in international scientific journals are planned: one proposing methodological framework (article 1, submitted month 9), one applying the framework one the exploited marine fish communities to enhance their management and conservation (article 2, submitted month 18). These latter are of critical concern for socio-economic aspects, dealing with marine resources to feed human populations, for the fisheries management organization GFCM "General Fisheries Commission for the Mediterranean", and European Commission funding the MEDITS program by the Data Collection Framework (DCF). The proposed project is thus in line with the main scientific pillars of the I-Site Montpellier University of Excellence (MUSE), « Feed, Care and Protect ».
In addition, according to the progress of the above works, the post-doctorate could participate to the FISHGLOB project (co-PI B. Mérigot with Maria L.D. Palomares from the University of British Columbia, Vancouver, Canada) which consists in analysing fish biodiversity trends faced to global change based on an ongoing creation of a worldwide database of scientific trawl surveys.

3) Skills and requirements

The postdoc position is open for two different kinds of profile, both are welcome to apply: 1) PhD in quantitative ecology with interest in computational science and network analysis or 2) PhD in Computer Science and statistics with a previous record of publications in the field of complex network analysis, community detection and link prediction/characterization. In both cases R and/or Python language skills should be already acquired. We are also looking for a person with open mind attitude, proactive and capable to carry out research with a certain degree of autonomy.

4) Salary

Growth salary is 3 886.48€/month, INM 564 for 2-years and 10 months after PhD defense.

5) Period of contract

The post-doc could start between september and december 2020. A first contract will be done for 12 months, and the commission of the LabEx NUMEV will plan an audition around month 9 for advance assessment in order to decide 6 months more of contract (i.e. 18 months in total).

6) Location

UMR MARBEC « Marine Biodiversity, Conservation & Exploitation » at Sète, and UMR LIRMM at Montpellier, France.

7) Application

Please send for the 12th of june 2020 the latest your CV, motivation letter, as well as a maximum of 2 recommendation letters to the following responsibles of the NETDIV project:

Name	Email	Structure	Laboratory
Dr. Bastien Mérigot	bastien.merigot@umontpellier.fr	Univ. Montpellier	UMR MARBEC
Pr. Pascal Poncelet	pascal.poncelet@umontpellier.fr	Univ. Montpellier	UMR LIRMM
Dr. Dino Ienco	dino.ienco@inrae.fr	INRAE	UMR TETIS

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