Exploring the influences of inter-annual variability of spawning and dispersal in coastal fishes

Context and objectives:

Most coastal fishes are characterized by a bipartite life cycle which largely governs how their populations structure in space and time. During the first dispersive phase (*Pineda et al., 2007*), a large number of individuals (eggs, that then hatch into larvae) are released in the water column (so-called 'spawning') and are then transported by ocean currents (so-called 'larval dispersal'). The second phase, rather sedentary, starts when juveniles settle in their preferential habitat where they spend most of their adult life, during which they are exploited by fisheries. Connectivity (i.e. the exchange of individuals among local populations within a metapopulation (*Cowen and Sponaugle, 2009*) is assumed to be primarily driven by the first pelagic dispersal phase which concerns a very large number of offspring and which has the potential to connect distant populations.

Studying dispersal of early-life stages (i.e. the connectivity from spawning to settlement) is thus essential to understand population structure and its dynamic, which are both crucial prerequisites for managing and conserving marine ecosystems. While some papers investigated connectivity for a single yearly spawning event (e.g. *Pujolar et al., 2013, Calò et al., 2018, Legrand et al, 2019*), its inter-annual variability is still to be explored. This is particularly relevant since (i) important inter-annual variability of the circulation and hydrography has been documented in the Adriatic Sea (*Civitarese et al., 2010; Mihanović et al., 2015)* and (ii) year-to-year variations of connectivity affect annual recruitment success, which then determine the future adult population available for fisheries (*Hidalgo, Rossi et al., 2019*). Actually, changes in connectivity patterns could be explained by the variability of ocean currents which directly affects dispersal and by abiotic factors such as water temperature and photoperiod which indirectly affects dispersal by influencing early-life traits such as spawning phenology and Pelagic Larval Duration PLD (*Green and Fisher, 2004*; *Vinagre et al., 2009*).

In that perspective, the trainee will address the following scientific questions: What is the inter-annual variability of spawning and of larval dispersal patterns? Which are the most important factors affecting directly (ocean currents) or indirectly (temperature, irradiance and photoperiod) early-life connectivity?

Based on two case-studies in the Adriatic Sea, the main objectives and steps of the internship are:

- update, read and summarize the relevant bibliography,
- identify relationship between spawning phenology and abiotic factors (temperature, irradiance and photoperiod) using two-years spawning date assessments from otolith schlerochronology (*Di Franco & Guidetti, 2011, Di Franco et al., 2012*),
- predict spawning phenology and PLDs for the last 10 years by analysing the variability of abiotic factors (temperature, irradiance and photoperiod) and by extrapolating the previously-defined relationships,
- explore the variability of dispersion scales and connectivity patterns with a focus on the potential larval replenishment of non-protected zones by Marine Protected Areas (MPAs),
- evaluate the relative importance of all environmental factors, comparing direct (ocean currents) and indirect (temperature, irradiance and photoperiod) effects on early-life connectivity,
- address both scientific questions by reporting and discussing the findings and conclude with the writing of a research report.

Our case-studies focus on the white seabream *Diplodus sargus sargus* and the two banded seabream *Diplodus vulgaris*, which are ecologically and economically important coastal species. They are widely distributed along the Mediterranean shorelines and are exploited by artisanal fisheries.

After completion, the internship should provide a better understanding of the inter-annual variability of dispersal scales and patterns of connectivity for a 10-year period. It will provide relevant scientific information to contribute to the growing consideration of both biological and environmental complexities into fisheries management and MPAs design.

Materials & methods:

To investigate dispersal patterns, the trainee will parametrise and run the Lagrangian Flow Network (*Rossi et al., 2014, Ser-Giacomi et al., 2015, Dubois et al., 2016, Legrand et al., 2019*) according to biologically-relevant starting points (spawning) and tracking duration (PLD). This off-line particle-tracking model using tools from network theory consists in integrating trajectories of virtual larvae based on a multi-year velocity field (2005-2014) of the Adriatic-Ionian Sea (AIFS model https://www.cmcc.it/models/aifs-adriatic-ionian-forecasting-system; *Cilliberti et al., 2015*). The Lagrangian Flow Network model will be parameterized and run to generate connectivity diagnostics that will be analysed to assess the variability of larval dispersal.

To evaluate the variability of abiotic factors, (e.g., temperature, irradiance and photoperiod, within pre-defined spawning regions (*Legrand et al., 2019*) for the 2005-2014 period, we will use various databases. For temperature, we will exploit the AIFS modelled temperature, satellite observations of Sea Surface Temperature or *in-situ* observations of both surface and sub-surface temperatures (http://www.t-mednet.org/). Photoperiod can be modelled while irradiance will be derived from atmospheric re-analyses (ECMWF).

Profil de l'étudiant(e): Interressé(e) par les questions pluridisciplinaires soulevées par les processus océanographiques (à l'interface entre physique, biologie et écologie). Attrait pour les problématiques de préservation de la biodiversité marine (MPAs, pêcheries). Goûts pour la programmation et l'analyse de données. Maitrise d'un langage de programmation scientifique (Matlab, Python ou R).

Compétences acquises pendant le stage: Démarche et réflexion scientifique, développement de diagnostiques innovants, modélisation Lagrangienne, programmation scientifique, utilisation de séries temporelles, connaissances multidisciplinaires sur la connectivité marine (des théories physiques à la gestion des MPAs).

Durée du stage: 6 mois (1er semestre 2020, début souhaité entre janvier et mars)

Gratification: env. 550 euros/mois

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Lieu du stage: Institut Méditerranéen d'Océanologie (MIO : http://mio.pytheas.univ-amu.fr), Campus de Luminy, 13288, Marseille.

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