Modelling spatio-temporal variability of parameters in population dynamics and stock-assessment models

Ce sujet de stage est rédigé en anglais car il s'inscrit dans le cadre d'un projet européen.
Mais l'équipe d'accueil est francophone

Context

Recent climate-induced environmental changes in the marine ecosystem, combined with other direct or indirect anthropic pressures like habitat degradation and over harvesting affect the productivity of many fish populations. Understanding the demographic and ecological mechanisms shaping the response of fish populations to multiple stressors is a prerequisite for scientific expertise on the status of population and for sound science-based management.

Failure to consider variability of key demographic parameters such as survival or maturation rates, can lead to biased estimates of population dynamics and productivity and of biological and management reference points (Mangel et al., 2010; Thorson et al., 2015; Szuwalski et al., 2023). In the context of environmental changes, this may also impede the use of stock assessment models (SAMs) to forecast future population dynamics and population productivity.

Developing the next generation of stock assessment models that explicitly capture the effect of environmental changes on key demographic parameters is therefore paramount to foster the shift towards an ecosystem-based approach to fisheries management.

This is especially timely for diadromous fishes like salmon or eel whose populations are highly depleted and endangered. However, developing assessment tools to quantify the effects of multiple pressures on populations is particularly challenging for diadromous fishes, whose life-cycle is shaped by long-range migrations from rivers towards offshore marine spawning (eel) or feeding (salmon) habitats, where individuals from different spatial origins (subunits) mix. The life cycle is affected by a combination of drivers acting in a hierarchy of nested spatial scales, ranging from global factors that can affect large numbers of subunits to regional/local factors that affect only parts of a few subunits (Bornarel et al., 2018; Drouineau et al., 2018; Olmos et al., 2019; Olmos et al., 2020). This may in turn create pattern of spatio-temporal variability between several populations that must be considered in models.

The MSc internship project is part of the EU-funded project DIASPARA (EMFAF-2023-PIA-FisheriesScientificAdvice). The project aims at developing and enhancing cross-boundary assessment tools for salmon and eel, by assessing stocks at various levels of spatial aggregation from continental to more local/regional scales. It will re-enforce the use of stage-based population models that explicitly capture the effect of environmental pressures on key life history traits and demographic transition rates. This will provide a better understanding of past changes and will improve our capacity to forecast population dynamics and productivity in the context of climate change. This will ultimately improve the quality of scientific advice to inform cross-boundary management of these species, while adapting it to the upcoming challenges such as climate change,

and related impacts on ecosystems.

Objectives, research questions and missions

The overall objective of the MSc internship is to contribute to the improvement of SAMs by enhancing the representation of the spatio-temporal variation of key life history traits and demographic parameters from multiple populations. The development will be applied to data and models used in the context of several ICES (International Council for the Exploration of the Sea) working groups on salmon in the Atlantic (WGNAS), in the Baltic (WGBAST) and eel (WGEEL).

Research questions

The MSc internship will address the following research questions:

- Can we identify spatio-temporal covariations in times series of demographic transitions rates (e.g., survival rate, maturation rate) or key life history traits (e.g., length at age) from multiple populations?
- Could patterns of spatio-temporal variations at different spatial scales (all populations, groups of populations) be interpreted to infer the drivers and mechanisms responsible for these variations? For instance, a signal shared by large groups of populations may be a response to large scale environmental changes.

Main steps of the work

- Review the literature on the different statistical modelling approaches used to model the spatio-temporal variability of demographic transition rates or life history traits from different populations;
- Compare the performance of different approaches with regards to different criteria:
    - Objectives of the method: quantification of the spatial covariation, detection of common trends, predictions …
    - Implementation costs and ease of application to different case studies;
    - Compatibility with stock assessment models.
- Develop application of those methods to different datasets from applications on eel and salmon. Various data sets will be available from the DIASPARA project before the beginning of the internship;
- Summarize pro's and con's of each method. Provide guidelines and recommendations on how/when it is recommended to use a specific method depending on the objectives and the data at hand.

Modeling approaches will be developed in R and associated packages.

The applicant will beneficiate from pre-existing data sets, models and codes.

The report will be written in English and will serve as a basis for a DIASPARA project deliverable or a scientific manuscript.

Collaborations

The successful applicant will be based in a stimulating research group of the research unit DECOD (Ecosystem Dynamics and Sustainability) in Rennes, France. The person will work under the direct supervision of Etienne Rivot (DECOD, Rennes) and in close collaboration with a post-doc recruited in the same project, as well as with several collaborators of the EU-funded DIASPARA project (Marie-Pierre Etienne (IRMAR, ENSAI, Rennes), Marie Nevoux (DECOD, Rennes), Hilaire Drouineau (INRAE, Bordeaux), Rob van Gemert (SLU, Sweden), Rebecca Whitlock (SLU, Sweden) and others).

The local host team in Rennes and other collaborators offer a challenging and creative working environment. It uses a broad range of modelling techniques ranging from populations to ecosystem levels, with expertise in statistical inference from integrated models, Bayesian statistics, and connection between demographics, population dynamics and ecosystems.

There will also be some connections with ICES working groups WGNAS, WGEEL and WGBAST. The project will address several challenges raised in the road maps of those expert groups for future development of their assessment framework.

Benefits of the internship in terms of learning outcomes and skills

- Demographics and population dynamics models
- Analysis of spatio-temporal variability of demographic transitions rates and life history traits
- Integrated population models
- Hierarchical Bayesian modelling

Location / Supervision

Location	UMR DECOD, Rennes, France
Local supervision	**Etienne RIVOT,** UMR DECOD, Institut Agro, Rennes.
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	Marie-Pierre Etienne, UMR IRMAR, Institut Agro, Rennes & ENSAI Rennes
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	Marie Nevoux, UMR DECOD, INRAE, Rennes
	email: marie.nevoux@inrae.fr
Close collaborations	Partners of the DIASPARA project, including Hilaire Drouineau (INRAE, Bordeaux), Rob van Gemert (SLU, Sweden), Rebecca Whitlock (SLU, Sweden)

Requirements

This internship involves significant quantitative analysis, including population dynamics, modelling, data analysis, and statistics. It is designed for a Master's level student (Master 2) or a 3rd-year engineering student (e.g., Ingénieur Agro) with a background in ecology/fisheries and a strong interest in modelling and statistics, or for a student with expertise in modelling and statistics who has a keen interest in ecological applications.

Required skills: Population dynamics, statistical modelling. Prior experience with Bayesian statistical analysis is preferred but not mandatory.

Duration, traineeship grant

6 months between January and August 2025

Grant: 630€ / month

Application

CV + motivation letter, by email to etienne.rivot@institut-agro.fr, marie-pierre.etienne@ensai.fr and marie.nevoux@inrae.fr

Deadline for application: 1st November 2024

References

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