MASTER SCIENCES DE LA MER

UM5MRM13	ECOLOGY OF COASTAL COMMUNITIES	
6 ECTS	*Keywords*	spatio-temporal variations of benthic and pelagic communities, abiotic constraints, biotic interactions, ecological succession, modeling of interactions
M2	*Managers*	François LANTOINE, Jadwiga ORIGNAC (LECOB, Banyuls)
Banyuls	*Professors*	Audrey PRUSKI (LECOB, Banyuls), Eric GOBERVILLE (BOREA, Paris)
	Tracks	Marine ecosystems functioning and global change AND Biodiversity and conservation of marine ecosystems

Description

Format

Teaching

UE based on lectures (21h), practical's + tutorials (36h), and a sea outing (4h). Organized into four main thematic **sessions**:

1. Effects of abiotic constraints on community structure (bottom-up effect).
2. Effects of biotic interactions on community structure (top-down effect).
3. Spatio-temporal variability of communities (ecological succession).
4. Modelling of interactions.

Evaluation

- 50% of the final grade is based on four oral presentations corresponding to the four workshops. Students must deliver a concise presentation analysing the data collected during the workshops. The presentations are conducted in groups of three students.
- 50% written exam (3 hours) covering all practical and theoretical aspects studied during the UE.

Summary

Ecosystems are complex systems composed of biotic communities living within a more or less stable abiotic environment. The challenge of studying communities arises from the vast diversity of interactions between numerous species at different trophic levels and their connections to environmental factors. In this context, coastal environments are particularly relevant due to the great diversity of ecosystems they encompass and the strong spatial and temporal constraints they experience, especially those of anthropogenic origin.
The objective of this UE is to illustrate, through theoretical, practical, and modelling approaches, how coastal communities are structured and evolve over spatial and temporal scales, either maintaining stability or undergoing destabilization, using concrete practical examples.
This UE is relevant both for applied conservation pathways (coastal ecosystem management) and for more fundamental research tracks

Learning objectives

By the end of this UE, students will be able to:

1. Understanding Ecological Processes

- Characterize the effects of **abiotic factors** and **biotic interactions** on community structure and dynamics through practical workshops.
- Distinguish between **acclimation and adaptation** processes in response to environmental changes affecting community succession.
- Analyse and describe the **development of benthic communities** and their modifications during

primary and secondary succession processes.
- Integrate acquired knowledge to enhance understanding of **coastal ecosystem functioning**.

2. Experimental and Analytical Skills
- Design experiments to test the effects of biotic and abiotic factors on communities, including:
  - **Photoacclimation** experiments
  - **Phytoplankton ingestion kinetics** by bivalves and selectivity mechanisms
  - **Benthic community succession** analysis at different colonization stages
- Apply laboratory techniques such as:
  - **Pigment analysis** (spectrofluorimetry)
  - **Cell counting** (flow cytometry)
  - **Digital image acquisition and analysis**
- Sort and identify **macrofauna organisms**.
- Calculate **ingestion and filtration rates**.

3. Data Analysis and Modeling
- Analyse, interpret, and present **experimental results**.
- Design and code **simple models** of species community dynamics.
- Use modelling to **predict diversity dynamics** within communities.

4. Communication and Personal Development
- Present and synthesize acquired data through **oral presentations**.
- Develop **critical thinking** by analysing data and drawing meaningful conclusions.
- Enhance **oral communication** skills through research presentations and data analysis discussions.
- Work effectively in **teams**, collaborating on group projects and fieldwork.
- Improve **time management** by organizing tasks efficiently within deadlines

Prerequisites

A minimum knowledge of marine biology, taxonomy, oceanography, and statistics is required. For the modelling aspect, familiarity with R will be useful.

Bibliography

S. Frontier, D. Pichod-Viale, A. Leprêtre, Dominique Davoult, Christophe Luczak (2008). *Ecosystèmes: Structure, fonctionnement, évolution*. Dunod, 4th edition, Paris, 558p. ⟨hal-00481137⟩

Rickleffs, R.E., Schluter, D. (1994). *Species Diversity in Ecological Communities*. Chicago University Press.

Organisation details

PART 1: Abiotic Constraints on Phytoplankton Communities – Spatio-Temporal Variations

F. Lantoine, 7h of lectures / 16h of practical work and field work / 4 h tutorial sessions

1. Introduction to coastal phytoplankton communities
- Importance and specificity of coastal environments
- Structure and temporal/spatial variations of phytoplankton communities

2. Key Environmental factors affecting pelagic communities
- Light characteristics in the marine environment
- Interaction with other physicochemical parameters

3. Phytoplankton response to light variations and community changes
- Acclimation and adaptation to light intensity
- Chromatic acclimations/adaptation

4. Methodology for studying phytoplankton variations
- Use of photosynthetic pigments in oceanography
- Flow cytometry techniques for community analysis

Practical Work: Field and laboratory approaches

- **Fieldwork**: Sampling at three stations along a coastal-offshore gradient
- **Laboratory experiments**: Cultures under different light intensities and colors
- **Analysis**: Pigment concentration measurements and cell counts
- **Data interpretation**: Comparative analysis of experimental and in situ results

Oral presentation and results Interpretation / Group-based synthesis and presentation of findings

Competencies by Bloom's Taxonomy:

- Explain main spatio-temporal variation of phytoplanktonic communities
- Differentiate between acclimation and adaptation processes in response to light variations
- Conduct field sampling across a coastal-offshore gradient
- Utilize spectrofluorometry to analyse pigments
- Apply flow cytometry techniques to assess community composition
- Critically assess the effectiveness of methodologies used in phytoplankton studies
- Compare experimental and in situ results to assess phytoplankton responses to light changes

PART 2: Influence of predation on marine communities

A. Pruski, 3h of lectures / 8h of practical work / 4 h tutorial sessions

Marine ecosystems are exposed to a wide range of anthropogenic impacts, most notably climate change and fishing. How human-driven changes in plankton communities affect higher trophic levels depends on how the structure and function of the ecosystem is regulated. **Trophic controls** are among the most important in marine ecosystems, either through predation (**top-down controls**), including fishery, or through food abundance (**bottom-up controls**), often thought to be driven by climate or nutrient load. Understanding the relative importance of top-down and bottom-up effects is a scientific and societal challenge. It is critical for predicting impacts on fish populations and propose sound-based strategies for ecosystem restoration.

Lecture notes (3h):

1. Introduction: Biotic relationships in communities: What is predation?
2. Top-down and bottom-up controls by Suspension feeders in marine ecosystems
3. Influence of keystone predators
4. Conclusions: Consequences of overexploitation on bottom-up and top-down controls with perspectives for the restoration of degraded habitats

Key concepts:

- Concept 1: Pelagic predators affect the species composition and size structure of phytoplankton communities
- Concept 2: Benthic suspension feeders are ecosystem engineers (species that create, modify and maintain habitats)
- Concept 3: Keystone predators promote diversity in marine communities
- Concept 4: Degradation of coastal habitats is due to bottom-up controls (i.e. failure to control anthropogenic inputs of nutrients) and decrease in top-down controls by suspension feeders and keystone predators having trophic cascades effects on the whole ecosystems

Practical competences:

- Students perform an experiment to follow the grazing kinetic of microalgae by bivalves (4h)
- Students learn to determine the ingestion and filtration rates using Frost's model (2h)

PART 3: Ecology of coastal rocky community: Investigating primary succession in coralligenous community in the Mediterranean Sea

J. Orignac, 3h of lectures / 10h of practical work / 4 h tutorial sessions

1. Introduction to the ecology of coastal rocky community

- Concepts of community and successions
- Key characteristics of communities: species interactions, structure
- The role of abiotic and biotic factors in shaping communities

2. Community development and succession

- Types of succession: primary vs. secondary succession
- Stages of succession: pioneer, intermediate, and climax communities
- Factors influencing succession (e.g., disturbances, species availability)

3. Case study: Succession in rocky communitiy in the Mediterranean Sea

- Introduction to coralligenous: definition and distribution in the Mediterranean
- Environmental factors affecting succession
- Primary succession in the coralligenous community
- Summary of key concepts covered in the course
- Open discussion and Q&A

Practical Work: Laboratory approaches. Investigation of colonization on artificially created patches in rocky benthic communities.

- Explanation of the experiment and the method for monitoring a colonization
- Identify and classify organisms into functional groups
- Analysis of the collected data and interpretation of the results

Figure 1: Experimental setup submerged at a depth of 20 meters in a coralligenous community in the Mediterranean Sea.

Oral presentation and results interpretation

- Group-based synthesis and presentation of finding

Learning outcomes according to Bloom's taxonomy

- Identify and classify marine organisms
- Utilize ImageJ software tools
- Analyze ecological data to interpret colonization patterns and assess biodiversity
- Communicate research findings through oral presentations

PART 4: Species Distribution Modeling (Ecological Niche)

E. Goberville, 6h of lectures / 12h of practical work

1. Introduction

- Current context of **climate change**
- Impact of **climate change on biodiversity**

2. Understanding Species Distribution

- **Biodiversity distribution patterns**
- The **ecological niche concept** – historical perspective
- From **theory to modelling**

3. Data and Preprocessing

- **Acquisition and preparation** of biodiversity data
- **Retrieval and processing** of environmental predictors

4. Using Species Distribution Models

- **Selection and parameterization** of models

- **Assessing model quality and accuracy**
- **Interpreting results and spatial projections**

12h of Practical Work

- **Collection and preprocessing** of biodiversity data
- **Integration of environmental variables**
- **Modelling the distribution** of a target species
- **Parameter tuning and testing model effects**
- **Evaluating model robustness and reliability**
- **Projecting species distributions** under different climate scenarios

Learning outcomes according to Bloom's taxonomy

1. Understanding & Application

- Interpret the **ecological niche concept** and explain its influence on species distribution in the context of **climate change**.

2. Analysis & Evaluation

- Analyse **biodiversity and environmental data**, select appropriate models, and evaluate their accuracy in modelling species distribution.

3. Synthesis & Creation

- Develop a **robust modelling process** by integrating environmental predictors, testing different parameter settings, and projecting species distributions under different climate scenarios.

Note: This document is for informational purposes. The details of the content and format of the courses and evaluations may change from year to year.