UM5MRM17	HUMAN IMPACTS ON COASTAL ECOSYSTEMS	
6 ECTS	*Keywords*	environmental impact assessment, management, conservation, marine reserves, modelling, decision-making statistics
M2	*Managers*	François LANTOINE, Laurence MÉJANELLE (LECOB, Banyuls)
Banyuls	*Professors*	Julie BAUDART, Katell GUIZIEN, Fabien JOUX, Franck LARTAUD, Audrey PRUSKI (LECOB, Banyuls), Éric GOBERVILLE (BOREA, Paris)
	Tracks	Biodiversity and conservation of marine ecosystems

Description

Format

Teaching

The program includes 24 hours of lectures, 32 hours of tutorials/practical work, and 12 hours of field trips, offering a comprehensive overview of the scientific principles used in marine protection and illustrating practical tools used in the monitoring, assessment, modelling of costal ecosystems, such as:

- Presentation of the scientific framework and the legislative framework for marine environment protection
- Practical analysis of pollutants (hydrocarbons) routinely conducted during monitoring by the MSFD (The EU Marine Strategy Framework Directive)
- Presentation of various approaches for measuring the toxicity of compounds on marine microorganisms (marine microbial toxicity tests, experiments on microbial communities, the concept of community tolerance induced by pollution)
- Understanding the concepts of cumulative impacts, reference state, and the evolution of ecosystem trajectories
- Several field trips with encounters with professionals in management and conservation (France and Spain)
- Analysing the evolution of coastal ecosystems in response to the intensification of climate and anthropogenic impact pressures
- Use of digital tools to map the cumulative impact of human activities on marine ecosystems
- Use of models to monitor population dynamics and larval distributions in relation to conservation aspects

Evaluation

- 50% of the final grade is based on an oral defence. Students work in small groups (usually pairs) and present a concise and critical analysis of an impact study, its legislative framework, the data collected, and their legislative and scientific relevance in relation to the planning project.
- 50% is based on a 3-hour written exam covering all practical and theoretical aspects discussed during the course unit (UE).

Summary

This course focuses on understanding, quantifying, and modeling the impacts of human activities on coastal ecosystems, as well as strategies for protecting marine environments. Using real-world examples from the Mediterranean coast, it explores the sustainable management of marine reserves and effective stakeholder engagement.

The course covers three main topics: Environmental quality assessment of benthic and pelagic coastal ecosystems. Conservation, management, and restoration of marine habitats, Modeling approaches for understanding and protecting coastal ecosystems.

Through the following hands-on activities, participants will develop practical skills in marine resource

management, policy advocacy, and environmental impact assessment:

1. Field trips to wastewater treatment plants, lagoon ecosystems, and marine parks and reserves in France and Spain, with opportunities to engage with professionals.
2. Laboratory techniques, including pollutant measurement and microbiological assessments of water and shellfish quality.
3. Modelling exercises to conceptualize key environmental processes, such as the effects of current dynamics on connectivity and larval dispersion, as well as species distribution modelling.

Learning objectives

By the end of this course, participants will be able:

1. to use scientific tools to assist in the management of seawater quality and the preservation of marine biodiversity.
2. to apply laboratory techniques to measure microbiological and chemical pollutants under guidance.
3. to critically assess the strengths and weaknesses of an environmental impact assessment.

They will gain an overview of effective communication techniques to engage stakeholders and the public in the protection of marine waters and species.

Prerequisites

The student should preferably have a background in general ecology, basic knowledge in oceanography and mathematics.

Bibliography

Halpern, B. S., Walbridge, S., Selkoe, K. A., Kappel, C. V., Micheli, F., d'Agrosa, C., ... & Watson, R. (2008). A global map of human impact on marine ecosystems. Science, 319(5865), 948-952.

Halpern, B. S., Frazier, M., Potapenko, J., Casey, K. S., Koenig, K., ... Walbridge, S. (2015). Spatial and temporal changes in cumulative human impacts on the world's ocean. Nature communications, 6(1), 1-7.

Quemmerais-Amice, F., Barrere, J., La Rivière, M., Contin, G., & Bailly, D. (2020). A methodology and tool for mapping the risk of cumulative effects on benthic habitats. Frontiers in Marine Science, 7, 569205.

Organisation details

The course contains 7 classes with practical work and field trips associated. A group assessment is mentored by several teachers.

Conservation and restoration of coastal ecosystems (F. LANTOINE)

This course provides an introduction to the ecology, impairment, and management of Mediterranean lagoons. Students will engage in field visits to natural reserves in France (Salses-Leucate, Canet Lagoons) and Spain (Cap Creus, Medes Islands), where they will meet park and reserve curators. The course includes a presentation on the various management structures in these parks and reserves, as well as an illustration of natural ecosystem restoration through the LIFE project of Pletera. Emphasis is placed on professional practice in lagoon management.

Course objectives (Bloom's taxonomy education levels and numbers indicated in italics):

1. *Remember:* Identify key features of Mediterranean lagoon ecology, impairment, and management practices.
2. *Understand:* Explain the ecological functions of Mediterranean lagoons and the impacts of human activities on these ecosystems.
3. *Apply:* Apply knowledge of lagoon management by analysing case studies, including the LIFE project of Pletera.
4. *Analyse:* Compare and contrast the management structures of various parks and reserves across different countries.
5. *Evaluate:* Assess the effectiveness of restoration projects, such as the Pletera LIFE project, in enhancing

endemic species protection by lagoon ecosystems.

6. *Create:* Engage in class and field trip discussion to conceive basic lagoon management strategies based on field observations and project case studies. Conservation and restoration of coastal ecosystems

Coastal change: pressure and management in the coastal zone (A. PRUSKI)

This course provides a comprehensive overview of land and coastal management challenges, focusing on their impacts on coastal landscapes, marine biodiversity, and ecosystem services

Lecture notes (1h30):

1. Major threats to Europe's coastal ecosystems
   1.1. Land-induced pressures affecting the coastal area
   Overview of pressures linked to the alteration of water runoff, modifications of the natural areas on the watershed, sediment export to the ocean, impairment of fresh water quality, increase occurrence of turbid waters
   1.2. Direct pressures on coastal areas
   Overview of pressures linked to coastal development and activities, coastal infrastructure management, dredging and disposal of sediments, adaptation to climate change also affect coastal areas, exploitation of marine resources
2. Coastal environmental changes
   2.1. Change in coastal landscapes: coastal erosion, coastal squeeze, artificialization, coastal defense, land reclamation
   2.2. Modification of the seabed: in link with sediment extraction/disposal and trawling
   2.3. Loss of habitats and biodiversity
   2.4. Effects on fish stocks and food webs
   2.5. Ecosystem disequilibrium and crisis
3. Towards an Integrated Coastal Zone Management
   3.1. The need for integrated coastal Ecosystem management
   3.2. Timeline of European legislative frameworks
   3.3. Integrated coastal zone management (ICZM)
   3.4. ICZM in the Netherlands
   3.5. ICZM in the Salses-Leucate lagoon?

Learning objectives (Bloom's taxonomy education levels and numbers indicated in italics):

By the end of this lecture, students should be able to:

2. *Understand.* Explain the major land-induced and direct pressures affecting European coastal ecosystems.
4. *Analyse.* Analyse the impacts of environmental changes on coastal landscapes, seabed morphology, habitats, biodiversity, and food webs.
5. *Evaluate.* Critically evaluate the effectiveness of ICZM strategies using case studies from the Netherlands and the Salses-Leucate Lagoon
6. *Create:* Synthesize key principles of sustainable coastal management and discuss their relevance in addressing current environmental challenges.

Environmental impact assessment (A PRUSKI)

This topic provides students with a comprehensive understanding of Environmental Impact Assessment (EIA) as a key regulatory tool for evaluating the potential environmental consequences of coastal development projects. Through case studies and practical exercises, students will learn to analyse EIA reports, assess regulatory compliance, and critically examine the effectiveness of environmental management measures.

Lecture notes (1h30):

1. Environmental Impact Assessment (EIA) study: why, when, and what for?
2. Screening and Scoping by the owner

3. Dedicated environmental studies in EIA
4. EIA reporting and reviewing

Practical work (3h) : Critical analysis of an EIA

This practical work is organised as a role-playing exercise aiming to enhance students' critical thinking and argumentation skills by engaging them in a structured debate on a real Environmental Impact Assessment (EIA) case. Students will take on opposing roles, either defending or contesting a proposed coastal development project, using scientific, regulatory, and socio-economic arguments. This activity fosters a deeper understanding of the complexities of environmental decision-making and the challenges of balancing development with sustainability.

Learning objectives (Bloom's taxonomy education levels and numbers indicated in italics):

By the end of this lecture, students should be able to:

2. Understand. Explain the purpose, scope, and regulatory framework of Environmental Impact Assessments (EIA).

1. Remember and 2. Understand: Identify and describe the key steps involved in conducting an EIA, including screening, scoping, dedicated environmental studies, reporting, and reviewing.

3. Analyse. Analyse an EIA case study by assessing the potential environmental impacts of a coastal development project.

5. Evaluate. Critically evaluate the strengths and limitations of an EIA report based on regulatory requirements and environmental considerations.

3. Apply and 6. Create. Construct and defend a well-structured argument either in favor of or against a proposed coastal development project based on an EIA report.

Quantification and mapping of the impacts of human activities (É. GOBERVILLE)

3.5 hours of lecture

1. Ecological Systems in a Changing World
   1.1. General introduction
   1.2. Pressures in coastal environments and global changes
2. Methodologies for Quantifying Human Impacts
   2.1. Presentation of the methodological framework developed by Halpern and colleagues
   2.2. Identification and quantification of cumulative effects
   2.3. Mapping of risks related to cumulative effects
3. Integration of Climate Change into Impact Analysis
   3.1. Current context of climate change
   3.2. Evolutionary pathways defined by the IPCC (Intergovernmental Panel on Climate Change)
4. The Concept of Ecosystem Trajectories in Ecology: From Theory to Practical Applications
5. Tools and Applications
   5.1. Introduction to the EcoimpactMapper tool

11 hours of practical and directed Work (TD/TP)

1. From Learner to Actor
   1.1. Introduction to participatory approaches in environmental management
2. Mapping of Cumulative Effects
   2.1. Using the EcoimpactMapper tool to visualize impacts
3. Development of Relationship Matrices
   3.1. Collaborative construction of matrices linking human activities and environmental pressures
4. Case Study
   4.1. Application to the management of a coastal ecosystem.

Learning objectives (Bloom's taxonomy education levels and numbers indicated in italics):

1. Understand and Apply: Explain the main pressures in coastal environments and apply methods for

quantifying the cumulative effects on ecosystems.

2. *Analyse and Evaluate:* Analyse the interactions between human activities and environmental pressures by building relationship matrices and assess the risks associated with these cumulative effects.
6. *Create:* Design an ecosystem management approach using the EcoImpactMapper tool. Develop an integrated ecosystem management approach by combining knowledge of anthropogenic pressures and ecosystem functioning to propose tailored solutions for an applied environmental issue.

Cycle and monitoring of pollutants in the coastal zone (L. MÉJANELLE)

Lecture (3 H)

This class provides expertise on fundamental knowledge to assess water quality related to chemical pollutants.

1. Cycle of pollutants:
   1.1. Interconnections between land, atmosphere, and the ocean; contaminant transport; contaminant partitioning.
2. Legal protection of marine waters:
   2.1. Brief history of conventions, agreements and protocols addressing the protection of marine environments and the environment in general, with a focus on chemical pollution.
3. Structure of the EU Marine Strategy Framework Directive (MSFD):
   3.1. Ecosystem approach; ecosystem-based management; iterative evaluation; four descriptors related to chemical pollution.
   3.2. Examples of criteria within descriptors D8 and D9.
   3.3. French reporting for D8 and D9 descriptors and survey strategies:
   3.4. Examples of criteria, indicators (e.g., sediments, bivalves, fish), and measurements.
   3.5. Selection of pollutants: heavy metals and organic pollutants based on the OSPAR survey strategy.
   3.6. Selection of environmental threshold values and normalization of concentrations.
4. Reported environmental status for French Mediterranean waters concerning sediments, bivalves, and fish.

Practical labwork to Analyse PAHs from sediments (7H)

PAHs will be Analysed according to a method used by Ifremer to process the samples referring for the MSFD.

1. Extraction
2. Clean-up by adsorption chromatography
3. GC-M analysis of hydrocarbons, and of PAHs by Single Ion Monitoring.

Learning objectives (Bloom's taxonomy education levels and numbers indicated in italics):

At the end of the class, participants will be able to:

1. Remember: Recall emblematic compounds that exceed NQE levels in certain areas, both in sediments and biota.

2. Understand: Explain how the chemical properties of compounds influence the phases in which they predominantly occur, and why pollutants must be monitored in these phases. Understand how the MSFD functions, including how it iterates GES (Good Environmental Status) assessments and environmental actions.

3. Apply: Interpret key elements of the annexes of the MSFD to identify whether a given compound can be considered for monitoring under the MSFD. After having understood the rationale of the various analytical steps required for PAH, analysis, practice laboratory work to carry out trace analysis.

4. Analyse: Discuss the spatial variability of contaminant concentrations.

3. Apply: List the environmental phases and organisms surveyed for the assessment of D8 and D9 in France, explain the different thresholds used for reporting pollutants in French coastal waters, and justify the normalizations applied to concentrations.

5. Evaluate and 6 Create: Comment on compounds exceeding NQE (Natural Quality Elements) in French coastal waters, and discuss whether they occur in dissolved form or in sediments.

Dynamic of microbial pathogens in coastal areas and european monitoring of bacteriological water quality (J. BAUDART)

Lecture (3H)

This class covers addresses seawater quality focusing on microbial pollution. It explains the occurrence and dynamics of microbial pathogens in marine coastal areas and the sources of faecal pollution. It includes European regulations for monitoring microbial quality in coastal bathing sites and shellfish harvesting areas.

1. Dynamic in marine coastal areas of microbial pathogens coming from continental sources
   - 1.1. The main water-borne and food-borne diseases in Europa
   - 1.2. The different sources of faecal pollutions and their temporal dynamics
   - 1.3. Investigation of faecal bacteria survival in marine environment under solar radiations and osmotic stress
2. An overview of the European regulations to monitor the microbial quality of coastal bathing sites and shellfish harvesting areas
   - 2.1. Pathogen detection in environment: the drawbacks
   - 2.2. What are the faecal indicator organisms (FIB)?
   - 2.3. Standard methods to detect FIB
   - 2.4. How is the monitoring of the bacteriological quality of bathing water in Europe?
   - 2.5. How is monitored the microbiological quality of shellfish harvesting areas in Europe?

Practical work - From samples to bacteriological analysis for water quality assessment (19H)

Two laboratory works practice pathogen detection, faecal indicator organisms, and standard monitoring methods, for point and non-point sources of pollution. The methods are applied to samples collected from the Banyuls-sur-mer Bay.

1. Water quality of seawater from Banyuls Bay: point-source microbial quality
   - 1.1. Water sampling in Banyuls-sur-mer Bay
   - 1.2. Application of standardized method to enumerate the FIB in water
   - 1.3. Data analysis
2. Microbial quality of coastal sites, in relation to non-point sources of pollution: shellfish and marine sediments
   - 2.1. Shellfish and marine sediment sampling in Banyuls-sur-mer Bay
   - 2.2. Application of standardized method to enumerate the FIB in shellfish tissues.
   - 2.3. Data analysis
3. Comparison of FIB contamination in two environmental matrices (water and shellfish)
   - 3.1. Discussion about the main sources of contamination identified in the Bay of Banyuls sur mer
4. Field trips
   - 4.1. Visit of the wastewater treatment plant of Banyuls-sur-mer (process of depuration) and discussion with the stakeholders of the communauté des communes.
   - 4.2. Visit of the Leucate lagoon (dedicated to oyster production) and discussion with the stakeholders about the bacteriological contamination and management of sanitary risks.

Learning objectives (Bloom's taxonomy education levels and numbers indicated in italics):

At the end of the class, participant will be able to:

2. *Understand:* Explain the dynamics of microbial pathogens in coastal areas. Describe the survival mechanisms of fecal bacteria under solar radiation and osmotic stress
3. *Apply:* Carry out FBI measurement following a standard method, derive FBI numbers, and interpet them in the light of environmental norms. Implement European regulations for monitoring the microbiological quality of coastal waters, including the monitoring processes for bathing waters and shellfish harvesting areas.
4. *Analyse:* Analyse the impact of point and non-point sources of pollution on bacteriological quality, including evaluating the relationship between different environmental matrices (water, shellfish, sediment).
5. *Evaluate:* Critically reflect on the challenges of pathogen detection in the environment, the limitations of standard methods, and how regulations address these issues.

6. *Create:* Discuss the role of wastewater treatment and coastal management strategies in reducing bacteriological contamination, drawing on insights from visits to the wastewater treatment plant and oyster production lagoon.

Coastal circulation and dispersal modelling (K. GUIZIEN)

This course introduces coastal hydrodynamics, its mathematical modelling, and the numerical tools used to simulate coastal hydrodynamics and dispersal applications. Students will practice parameterizing a Lagrangian dispersal run and analysing its output.

Learning objectives (Bloom's taxonomy education levels and numbers indicated in italics):

1. *Remember:* Define key terms in coastal hydrodynamics and dispersal modelling.
2. *Understand:* Explain the fundamental principles of coastal hydrodynamics and the applications of Lagrangian dispersal models.
3. *Apply:* Apply numerical tools to simulate coastal hydrodynamics and dispersal in real-world scenarios.
4. *Analyse:* Analyse the output of Lagrangian dispersal simulations, identifying patterns and trends in the data.
5. *Evaluate:* Evaluate the criteria for selecting oceanographic products for ecological applications.
6. *Create:* Synthesize the output of Lagrangian dispersal simulations into coherent results that can be used in ecological studies.

Skills acquired:

- Mastery of vocabulary for interacting with physical oceanography modelers.
- Ability to select appropriate oceanographic products for ecological applications.
- Proficiency in providing parameters necessary to run dispersal simulations.
- Expertise in synthesizing Lagrangian dispersal outputs into actionable insights.

Specific Requirements: Basic knowledge of oceanography and mathematics.

Group assignment

Students will be required to evaluate a published environmental impact assessment (EIA). They will assess the value of the document based on criteria explained in Audrey Pruski's class. Students must identify the environmental impacts discussed in the document, the initial evaluation of the environmental status, and the scientific survey proposed in the project. They will select relevant published evidences regarding potential impacts caused by similar projects and create a synthesis of these impacts.

Additionally, students will propose a feasible survey to monitor the most significant impacts of the project. They will also provide a constructive critique of the survey proposed in the EIA, comparing it with the survey they have developed.

They will present their work in an oral presentation followed by a discussion. This assignment will draw on the knowledge and skills acquired in the various classes.

Learning objectives (Bloom's taxonomy education levels and numbers indicated in italics):

4. *Analyse:* Students will read a real EIA, which is typically a lengthy document, and identify the most pertinent sections
5. *Evaluate:* They will critique the scientific approach presented in the EIA, using an in-depth synthesis, and propose an alternative survey strategy. (5. Evaluating and 6. Creating)
6. *Create:* Students will collaborate in pairs to gather information, share insights, meet deadlines, and create a joint presentation.

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.