UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

COURSE SYLLABUS

Climate Change Impacts On Marine Ecology

2627-2-F7504Q036

Aims

The course is designed to equip students with a comprehensive understanding of climate change's main impacts on the marine environment from an ecological perspective. It will begin with a general introduction to climate change, focusing on its historical traits, causes, and consequences. After providing the students with information about where to gather marine climate change-related data, the course will go through climate change's main ecological and biological effects, such as aquatic organisms' calcification, species demography, abundance, distribution, and phenology. Moreover, the course will explore the environmental impacts on different ocean regions, from the poles to tropical waters, focusing on the Mediterranean Sea and tropical coral reefs. Some specific examples of the direct effects of climate change on human activities will be reported. Finally, the lessons will discuss possible solutions to study and contrast marine climate change.

D1 – Knowledge and understanding:
At the end of the course, students will have acquired a comprehensive understanding of the main drivers of climate change and their ecological consequences in marine environments. They will understand the mechanisms underlying biological and ecological responses to climate change, including effects on calcification, demography, abundance, distribution and phenology of marine organisms. Students will also gain knowledge of regional patterns of climate change impacts across polar, temperate, Mediterranean and tropical marine ecosystems, as well as current approaches for monitoring and assessing climate-related changes.

D2 – Applying knowledge and understanding:
Students will be able to interpret and critically analyse scientific information and datasets related to marine climate change impacts. They will be able to identify the ecological consequences of climate change at different levels of biological organization, compare responses among marine ecosystems, and apply appropriate scientific approaches to evaluate climate change impacts and potential mitigation or adaptation strategies.

D3 – Making judgements:
Students will develop the ability to critically evaluate scientific evidence concerning marine climate change, distinguish between different sources of information, assess uncertainties associated with ecological predictions, and formulate scientifically sound conclusions on the impacts of climate change and possible management

responses.

D4 – Communication skills:
Students will develop the ability to communicate scientific concepts related to marine climate change using appropriate terminology. They will be able to discuss ecological processes, interpret scientific findings, and present evidence-based arguments during classroom discussions and the final examination.

D5 – Learning skills:
Students will develop the skills necessary to independently update their knowledge by consulting scientific literature, international assessment reports and marine climate change databases. They will acquire the ability to critically evaluate new scientific information and continue their learning in the rapidly evolving field of marine climate change ecology.

Contents

The course introduces the fundamental principles of climate change and their ecological implications for marine ecosystems. It covers the physical drivers of climate change, methods and databases for assessing climate change impacts in the marine environment, and the main biological and ecological responses, including changes in calcification, demography, abundance, distribution, and phenology of marine organisms. Regional case studies focus on polar, temperate, Mediterranean, and tropical marine ecosystems, with particular attention to coral reefs and the Mediterranean Sea. The course also examines the impacts of climate change on marine resources and fisheries, approaches for monitoring climate-related stress from molecular biomarkers to ecological indicators, and current strategies for mitigating and adapting to climate change in marine ecosystems. Seminars delivered by invited experts complement the lectures by presenting recent advances and real-world applications in marine climate change research.

Detailed program

Lesson 1. Course introduction
Course organization, learning objectives, teaching activities, assessment methods, and overview of the main topics.

Lesson 2. Fundamentals of marine ecology
Review of key ecological concepts required for understanding marine ecosystem responses to environmental change.

Lessons 3–4. Climate change: drivers and biological consequences
Overview of the causes of climate change, major environmental changes affecting the oceans, and their biological implications across different levels of organization.

Lesson 5. Assessing marine climate change impacts
Marine climate change datasets, databases (e.g. Marine Climate Change Impact Database), and approaches for retrieving and analysing scientific information.

Lesson 6. Ecological responses across ocean regions
Comparison of ecological responses to climate change in different marine environments and climatic zones.

Lesson 7. Effects on calcifying organisms
Ocean acidification, calcification processes, and consequences for marine calcifiers.

Lesson 8. Species demography
Effects of climate change on survival, reproduction, recruitment, and population dynamics.

Lesson 9. Species abundance
Changes in population abundance and community composition under changing environmental conditions.

Lesson 10. Species distribution
Range shifts, species redistributions, biological invasions, and emerging biogeographical patterns.

Lesson 11. Species phenology
Climate-driven changes in life-cycle events and ecological mismatches.

Lesson 12. Polar marine ecosystems
Climate change impacts on Arctic and Antarctic ecosystems, including sea-ice loss and ecosystem restructuring.

Lesson 13. Temperate marine ecosystems
Ecological responses and vulnerabilities of temperate marine environments.

Lesson 14. The Mediterranean Sea
Climate change impacts in the Mediterranean Sea, including warming, marine heatwaves, biological invasions, and biodiversity changes.

Lesson 15. Tropical oceans and coral reefs
Effects of warming and ocean acidification on tropical marine ecosystems, with particular emphasis on coral bleaching and reef degradation.

Lesson 16. Climate change and marine resources
Impacts on fisheries, marine ecosystem services, and implications for sustainable resource management.

Lesson 17. Monitoring climate change impacts
Biomarkers, biological indicators, ecological monitoring, and assessment tools for climate-related stress.

Lessons 18–19. Future perspectives
Mitigation and adaptation strategies, ecosystem resilience, restoration, nature-based solutions, and future research challenges.

Seminars
Two seminars delivered by invited experts will address current research topics and emerging challenges in marine climate change ecology.

Prerequisites

A basic knowledge of marine ecology, biology, and environmental sciences is recommended. Students are expected to be familiar with fundamental ecological concepts, including species interactions, population and community ecology, and the functioning of marine ecosystems. Basic understanding of biological and ecological terminology, together with the ability to read scientific texts in English, will facilitate learning. No prior expertise in climate change science is required.

Teaching form

The course consists of 42 hours of face-to-face lectures, delivered over 21 two-hour sessions. All teaching activities are conducted in person and follow a Didactic Delivery (DE) format, combining theoretical explanations with the discussion of case studies, recent scientific literature, and examples from different marine ecosystems. Classroom interaction is encouraged through questions and guided discussions aimed at promoting critical thinking and facilitating the understanding of key concepts.

Textbook and teaching resource

Teaching materials, including lecture slides prepared by the instructor, will be made available to students through the University's e-learning platform before or after each lecture. Additional learning resources will include selected scientific articles, review papers, and technical reports from international organizations (e.g. IPCC, IPBES, IUCN), which will be recommended during the course to support and deepen specific topics.

Semester

First Semester

Assessment method

Assessment consists of an individual oral examination covering the topics presented during the lectures and the teaching materials made available throughout the course. No mid-term examinations are planned.

The oral examination is designed to assess the student's:

- knowledge and understanding of the ecological impacts of climate change on marine ecosystems;
- ability to explain the mechanisms underlying biological and ecological responses to climate change;
- capacity to critically analyse and discuss scientific concepts, case studies, and monitoring approaches presented during the course;
- ability to use appropriate scientific terminology and communicate concepts clearly and accurately.

The final grade is based on the overall quality of the oral examination. Evaluation criteria include the level of knowledge acquired, the ability to integrate concepts across different topics, critical thinking, clarity of exposition, the use of appropriate scientific language, and the capacity to formulate well-reasoned and scientifically supported arguments.

Office hours

Office hours are available **Monday to Friday, from 9:00 a.m. to 5:00 p.m., by appointment**. Students are kindly requested to arrange a meeting in advance by contacting the instructor via email. Upon request, meetings may also be held remotely via an online platform.

Sustainable Development Goals

LIFE BELOW WATER