ES/GE320 MEDITERRANEAN OCEANOGRAPHY
IES Abroad Barcelona

DESCRIPTION:
This course provides an overview of the main oceanographic and biological characteristics of the Mediterranean Sea, from the bathymetry, geology and chemistry of a semi-enclosed sea, to the environmental characteristics and ecological processes of different marine habitats and the current human-induced threats of climate change and invasive species. Through a broad range of topics, the course covers: (i) the particular oceanographic characteristics of the Mediterranean, with its unique chemical and hydrographic features resulting from a complex geological history and geographical position; (2) the factors affecting primary production in the Mediterranean and its consequences for fisheries and trophic chains across different ecosystems; (3) the main characteristics and ecological dynamics of the most emblematic Mediterranean ecosystems and; (4) the key challenges faced by the Mediterranean in the face of climate change, over-exploitation, pollution and invasive species.

The course features a mandatory full-day excursion to the Delta del Ebro that will take place on a Friday.

CREDITS: 3 credits

CONTACT HOURS: 45 hours

LANGUAGE OF INSTRUCTION: English

INSTRUCTOR:

PREREQUISITES: None

ADDITIONAL COST: None

METHOD OF PRESENTATION:
- **Readings:** Readings will introduce the basic concepts for each session, introducing students to the main physical, hydrological, geological and chemical processes, as well as the characteristics and dynamics of key Mediterranean ecosystems.
- **Reading Quizzes:** These are designed to evaluate students on the readings and help them focus on the key concepts from each article.
- **Lectures:** Lectures accompany the students through the core topics and concepts for each session, illustrate how these apply in the Mediterranean marine biome, and provide a platform to discuss the content from the readings. Lectures for particular ecosystems will introduce the key concept first and then focus on the differences for Mediterranean habitats and ecosystems. The course features a mixed methods approach to lectures to support the learning process, using class-discussions, videos, group activities and participation to build the scaffolding of each class.
- **Lab class:** students will be trained in mollusc anatomy, taxonomy and identification, in preparation for the survey activities during the field excursion.
- **Course related excursion:** The course includes one mandatory field element: a full-day trip to the Delta del Ebro, **which will be on a Friday.** This is designed to illustrate some of the material reviewed during the lectures and presented in the readings, to provide students with a learning methodology that is closer to academic research, and contribute to help the student to gain a deeper insight into some of the topics covered by the course.
- **Research project:** Students will carry out a research project on a selected topic through an extensive literature review, presenting their findings during an in-class presentation.

REQUIRED WORK AND FORM OF ASSESSMENT:
- Reading seminars and quizzes - 15%
- Course related excursion and lab class - 15%
- Midterm exam - 20%
- Final exam - 25%
- Research project & presentations - 25%

Reading seminars and quizzes
Students will prepare and take part in short seminar sessions and quizzes in class based on the set readings.

Course related excursion

Midterm exam and Final exam

Research project & presentation

LEARNING OUTCOMES:
By the end of the course, students will be able to:

- Recognise the major components of Mediterranean marine ecosystems
- Describe the dynamics of Mediterranean marine ecosystems
- Analyse the impact of human activities on Mediterranean marine ecosystems
- Value marine biodiversity and the need for sustainable development.

ATTENDANCE POLICY:
As a member of our class community, you are expected to be present and on time every day. Attending class has an impact on your learning and academic success. For this reason, attendance is required for all IES Barcelona classes, including course-related excursions. If a student misses more than three classes in any course without justification, 3 percentage points will be deducted from the final grade for every additional absence. Seven unjustified absences in any course will result in a failing grade. Absences will only be justified, and assessed work, including exams, tests and presentations rescheduled, in cases of documented medical or family emergencies.

CONTENT:

SESSION	Content	Assignments
Session 1	● Course introduction (objectives, contents and assessment). ● An overview of the major Mediterranean marine ecosystems and species.	
Session 2	Living in the water column: environmental constraints and adaptations	● Herring, P. (2002). The biology of the deep ocean. Oxford: Oxford University Press. (pp 1-7). ● Mann, K.N. (1991). Organisms and ecosystems, In R.S.K. Barnes and K.H. Mann (eds.). Fundamentals of aquatic ecology. London: Blackwell. (pp 8-11). ● Burd, B. J., & Thomson, R. E. (2022). A review of zooplankton and deep carbon fixation contributions to carbon cycling in the dark ocean. Journal of Marine Systems, 103800.
Session 3	Mollusc taxonomy and identification lab	

Session 4	Living in the water column: the blue Mediterranean	• Stambler, N. (2014). The Mediterranean Sea-Primary productivity. In S. Goffredo and Z. Dubinsky (eds.) The Mediterranean Sea. Its history and present challenges. Heidelberg: Springer. (113-121). • Longhurst, A. (1998). Ecological geography of the sea. Now York: Academic Press. (pp 138-142). • Di Cicco, A., Sammartino, M., Marullo, S., & Santoleri, R. (2017). Regional empirical algorithms for an improved identification of phytoplankton functional types and size classes in the Mediterranean Sea using satellite data. Frontiers in Marine Science, 4, 126.
Session 5	The rocky shores and the subtidal rocks	• Sala et al. (2012). The structure of Mediterranean rocky reef ecosystems across environmental and human gradients, and conservation implications. PLoS ONE 7: e32742. • Gili, J.M. et al (2014). Zoobenthos. In S. Goffredo and Z. Dubinsky (eds.) The Mediterranean Sea. Its history and present challenges. Heidelberg: Springer. (213-235).
Session 6	Beaches and soft bottom ecosystems	• Little, C. (2000). The biology of soft shores and estuaries. Oxford: Oxford University Press. (pp 35-56). • Peters, W. S. (2022). Underwater-sailing locomotion in intertidal gastropods: a comparison of Neotropical species. Archiv für Molluskenkunde International Journal of Malacology, 93-105.
	Course related trip: Ebro Delta (on Friday)	
Session 7	Seagrass meadows	• Pérez-Lloréns, J. et al. (2014). Authochthonous seagrasses. In S. Goffredo and Z. Dubinsky (eds.) The Mediterranean Sea. Its history and present challenges. Heidelberg: Springer. (137-158). • Milchakova, N.A. (2003). The seagrasses of the Black, Azov, Caspian and Aral seas. In E.P. Green and F.T. Short (eds.) World Atlas of seagrasses. Berkley: University of California Press. (pp 59-63).

Session 8	Estuaries and coastal marshes	● Blondel, J. and Aronson, J. (1999) Biology and wildlife of the Mediterranean region. Oxford: Oxford University Press. (pp 125-130). ● Franco, A., Elliott, M., Franzoi, P., & Torricelli, P. (2008). Life strategies of fishes in European estuaries: the functional guild approach. Marine Ecology Progress Series, 354, 219-228.
Session 9	The deep sea.	● Herring, P. (2002). The biology of the deep ocean. Oxford: Oxford University Press. (pp 239-254). ● Sogin, E. M., Kleiner, M., Borowski, C., Gruber-Vodicka, H. R., & Dubilier, N. (2021). Life in the dark: phylogenetic and physiological diversity of chemosynthetic symbioses. Annual review of microbiology, 75, 695-718.
Session 10	Bathymetry, hydrography and chemistry of a semi-enclosed sea	● Longhurst, A. (1998). Ecological geography of the sea. Now York: Academic Press. (pp 134-138). ● Skliris, N. (2014). Past, present and future patterns of the thermohaline circulation and characteristic water masses of the Mediterranean Sea. In S. Goffredo and Z. Dubinsky (eds.) The Mediterranean Sea. Its history and present challenges. Heidelberg: Springer. (29-48). ● Pinardi, N., Cessi, P., Borile, F., & Wolfe, C. L. (2019). The Mediterranean sea overturning circulation. Journal of Physical Oceanography, 49(7), 1699-1721. ● Mavropoulou, A. M., Vervatis, V., & Sofianos, S. (2022). The Mediterranean Sea overturning circulation: A hindcast simulation (1958–2015) with an eddy-resolving (1/36) model. Deep Sea Research Part I: Oceanographic Research Papers, 187, 103846.
Session 11	From Tethys to the Mediterranean, a convulsive geological history	● Garcia-Castellanos, D., Micallef, A., Estrada, F., Camerlenghi, A., Ercilla, G., Periáñez, R., & Abril, J. M. (2020). The Zanclean megaflood of the Mediterranean–Searching for independent evidence. Earth-Science Reviews, 201, 103061. ● Stow, D. (2010) Vanished ocean. Oxford: Oxford University Press. (pp 188-214 and 227-241).
Session 12	Midterm exam	

Session 13	Mediterranean Marine Biodiversity	● Coll, M., et al. (2010). The biodiversity of the Mediterranean Sea: estimates, patterns and threats. PLos One **5**, e11842. ● Walls, R. H., & Dulvy, N. K. (2021). Tracking the rising extinction risk of sharks and rays in the Northeast Atlantic Ocean and Mediterranean Sea. Scientific Reports, 11(1), 1-15.
Session 14	Pollution	● Cózar, A., Sanz-Martín, M., Martí, E., González-Gordillo, J.I., Ubeda, B., Gálvez, .JÁ., Irigoien, X., Duarte, C.M (2015) Plastic accumulation in the Mediterranean Sea. PLoS ONE 10(4): e0121762. ● Ludwig, W., et al. (2009). River discharges of water and nutrients to the Mediterranean and Black Sea: major drivers for ecosystem changes during past and future decades? Progress in Oceanography 80: 199-217. ● De Sales-Ribeiro, C., Brito-Casillas, Y., Fernandez, A., & Caballero, M. J. (2020). An end to the controversy over the microscopic detection and effects of pristine microplastics in fish organs. Scientific Reports, 10(1), 12434.
Session 15	Climate change	● Lejeusne, C., Chevaldonne, P., Pergent-Martini, C.,Boudouresque, C.F., Pérez, T. (2009). Climate change effects on a miniature ocean: the highly diverse, highly impacted Mediterranean Sea. *TREE* 1204: 1-11.
Session 16	Overfishing. Film viewing. “Empty oceans, empty nets”	
Session 17	Overfishing I.	● FAO (2022). The state of world Fisheries and Aquaculture 2022 (SOFIA). ● Cánovas-Molina, A., García-Charton, J. A., & García-Frapolli, E. (2021). Assessing the contribution to overfishing of small-and large-scale fisheries in two marine regions as determined by the weight of evidence approach. Ocean & Coastal Management, 213, 105911.
Session 18	Artisanal Fisheries and Recreational Fisheries. Fisheries case study: Bluefin Tuna Fisheries	

Session 19	Marine Protected Areas	• Bazairi, H., El Asmi, S., Limam, A., Espinosa, F., Warr, S., Muirhead-Davies, N., ... & Fa, D. (2023). Marine area-based conservation in the context of global change: Advances, challenges, and opportunities, with a focus on the Mediterranean. Coastal Habitat Conservation, 17-40. • Guidetti, P. and Sala, E. (2007). Community-wide effects of marine reserves in the Mediterranean sea. *Marine Ecology Progress Series* **335**: 43-56.
Session 20	Research project workshop	
Session 21	Research project presentations I	
Session 22	Research project presentations II	
Session 23	Invasive species	• Jaubert, et al. (2003). Re-evaluation of the extent of *Caulerpa taxifolia* development in the northern Mediterranean using airborne spectrographic sensing. Marine Ecology Progress Series 263: 75-82. • Por, F.D. (2009). Tethys returns to the Mediterranean: success and limits of tropical re-colonization. BioRisk 3: 5-19.
Session 24	Tourism and the management of the coastline.	• Mejjad, N., Rossi, A., & Pavel, A. B. (2022). The coastal tourism industry in the Mediterranean: A critical review of the socio-economic and environmental pressures & impacts. Tourism Management Perspectives, 44, 101007. • Plan Bleu (2022). State of Play of Tourism in the Mediterranean: A Roadmap for a Greener, Inclusive & Resilient Tourism in the Mediterranean. UNEP/MAP Interreg Mediterranean Sustainable Tourism Community project. (Chapters 1, 2 & 4).

Final exam

COURSE-RELATED TRIP:

- Ebro Delta (on Friday)

REQUIRED READINGS:

- Bazairi, H., El Asmi, S., Limam, A., Espinosa, F., Warr, S., Muirhead-Davies, N., ... & Fa, D. (2023). Marine area-based conservation in the context of global change: Advances, challenges, and opportunities, with a focus on the Mediterranean. Coastal Habitat Conservation, 17-40.

- Blondel, J. and Aroson, J. (1999) Biology and wildlife of the Mediterranean region. Oxford: Oxford University Press. (pp 125-130).

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- Herring, P. (2002). The biology of the deep ocean. Oxford: Oxford University Press. (pp 239-254).
- Jaubert, J.M., Chisholm, J.R.M., Minghelli-Roman, A., Marchioretti, M., Morrow, J.H., Ripley, H.T. (2003). Re-evaluation of the extent of Caulerpa taxifolia development in the northern Mediterranean using airborne spectrographic sensing. Marine Ecology Progress Series 263: 75-82
- Lejeusne, C., Chevaldonne, P., Pergent-Martini, C.,Boudouresque, C.F., Pérez, T. 2009. Climate change effects on a miniature ocean: the highly diverse, highly impacted Mediterranean Sea. *TREE* 1204: 1-11.
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