ES 201 THE MEDITERRANEAN: A PLASTIC SEA
Fondazione IES Abroad Rome

DESCRIPTION:
The primary aim of this course is to provide a current and comprehensive overview on issues related to plastic pollution at a global level, focusing on plastic accumulation in the Mediterranean Sea. The course explores the many open questions concerning the accumulation, distribution and fate of plastic litter and implications for marine wildlife and humans. A historical synopsis of marine pollution research is provided to appreciate the rapid development of this research field, especially in relation to microplastics. The various primary and secondary sources on microplastics and the pathways through the environment to the ecosystem are examined. Due to the small size and variety of plastic polymers, the detection, identification, and quantification of microplastics are challenging at present; for this purpose, a critical appraisal of the main methods and procedures for the sampling of plastic litter and its composition are evaluated and applied to a specific case study. Chemical, biological, and ecological implications of plastic pollution are also analyzed to allow students to evaluate the deleterious effects on marine wildlife.

The course prepares students to read scientific literature in a critical and objective way, considering the comparability of results obtained from different studies. It provides a deep understanding of the magnitude of plastic pollution in surface waters of the Mediterranean basin as well as a comparison with plastic accumulation in open oceans. The course also covers other specific topics such as plastic aging and degradation; propagation over trophic levels of the marine food web; toxicants associated with plastic debris and how they may affect marine life and human health. The course also considers how plastics compare with other anthropogenic pollutants in terms of ecological risk and the role of society in tackling this matter, with a special focus on procedures to reduce the input of litter into oceans.

CREDITS: 3

CONTACT HOURS: 45

LANGUAGE OF PRESENTATION: English

INSTRUCTOR: Valentina Sciutteri, Ph.D.

PREREQUISITES: None

METHOD OF PRESENTATION:
Lessons include lectures (using slides and videos), class discussions, case studies and field studies.

REQUIRED WORK AND FORM OF ASSESSMENT:
- Class participation 10%
- Short essay 20%
- Presentation 10%
- Reflection paper: 15%
- Midterm exam 20%
- Final exam 25%

Course Participation
A rubric for course participation will be posted on Moodle and shared with students at the beginning of the term.

Short essay
Students will prepare a research essay on one of the topics covered in the course. The essay should be concise yet informative. The written assignment is due on week 5, session 2, by 6.00pm. Students who submit their papers after the deadline will lose 4 percentage points from the essay's grade. The paper should be a maximum of 1000 words in length (3-4 pages), Times New Roman font (12pt) and should be submitted both electronically (to the Professor's e –mail) and in paper format to the instructor in class.

Presentation
Students are requested to give a presentation to the class on their research topic (maximum of 5 minutes per student).

Reflection paper
Students will analyse and reflect on a specific topic, supporting it with their observations as well as using scientific concepts acquired during the course. The reflection paper is due on week 8, session 1, by 6.00pm. Students who submit their papers after the deadline will lose 4 percentage points from the paper's grade. The reflection paper should be a maximum of 800 words in length (2-3 pages), Times New Roman font (12pt) and should be submitted both electronically (to the Professor's e –mail) and in paper format to the instructor in class.

Midterm exam
Written test with both multiple-choice and open-ended questions.

Final exam
Written test with both multiple-choice and open-ended questions.

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

- Develop the concept of plastic as a complex and dynamic structure that changes its bioavailability
- Outline and discuss scientific concepts and methodological approaches concerning plastic sampling
- Identify the chemical, biological, and ecological factors that may affect marine ecosystems and human health
- Define the plastic pollution issue in areas with high human pressure, such as the Mediterranean Sea
- Analyze and evaluate data from scientific outputs
- Define and appreciate the specific contribution of Italian researchers to the international field of plastic characterization
- Discuss and critically evaluate the ecological risks associated with plastic pollution
- Identify the initiatives in tackling this global issue

ATTENDANCE POLICY:
Attendance is mandatory for all IES Abroad Rome classes, including field studies. If a student misses more than one class in this course, 2 percentage points will be deducted from the final grade for every additional absence. Any exams, tests, presentations, or other work missed due to student absences can only be rescheduled in cases of documented medical or family emergencies. IES Abroad Rome will only consider extreme emergency cases and will strictly adhere to this policy. Do plan your semester accordingly.

CONTENT:

Week	Content	Assignments
Session 1	**Introducing plastic pollution: an insight into the issue** **Distribution and composition**	• Galgani F., Hanke G., Maes T. (2015) *Global Distribution, Composition and Abundance of Marine Litter*. In: Bergmann M., Gutow L., Klages M. (eds) Marine Anthropogenic Litter, pp. 29-56 https://doi.org/10.1007/978-3-319-16510-3_2 (21 pages)

Session 2	**The Mediterranean Sea: A Case Study**	• Cózar A, Sanz-Martín M, Martí E, González-Gordillo JI, Ubeda B, Gálvez JÁ, et al. (2015) *Plastic Accumulation in the Mediterranean Sea*. PLoS ONE 10(4): e0121762. doi:10.1371/journal.pone.0121762 (9 pages) • Suaria, G. et al. (2016) *The Mediterranean Plastic Soup: synthetic polymers in Mediterranean surface waters.* Sci. Rep. 6, 37551; doi:10.1038/srep37551 (10 pages) • Sharma S, Sharma V and Chatterjee S (2021) *Microplastics in the Mediterranean Sea: Sources, Pollution Intensity, Sea Health, and Regulatory Policies.* Front. Mar. Sci. 8:634934. doi:10.3389/fmars.2021.634934 (20 pages)
Session 3	**Fate of Plastics Entering the Oceans** **An Emerging Pollutant: Microplastics**	• Andrady A.L. (2015) *Persistence of Plastic Litter in the Oceans*. In: Bergmann M., Gutow L., Klages M. (eds) Marine Anthropogenic Litter. Springer, pp 57-72 Cham. https://doi.org/10.1007/978-3-319-16510-3_3 (11pages) • M. Cole , P. Lindeque, C. Halsband , T. S. Galloway (2011) *Microplastics as contaminants in the marine environment: A review*. Marine Pollution Bulletin Volume 62 pp 2588–2597 doi:10.1016/j.marpolbul.2011.09.025 (20 pages) • Ogunola OS, Palanisami T (2016) *Microplastics in the Marine Environment: Current Status, Assessment Methodologies, Impacts and Solutions*. J Pollut Eff Cont 4: 161. doi:10.4172/2375-4397.1000161 (13 pages)
Session 4	**Sampling Methods and Errors**	• Dannielle S. Green, Louise Kregting, Bas Boots, David J. Blockley, Paul Brickle, Marushka da Costa, Quentin Crowley (2018) *A comparison of sampling methods for seawater microplastics and a first report of the microplastic litter in coastal waters of Ascension and Falkland Islands.* Marine Pollution Bulletin, Volume 137, pp 695-701 (6 pages)
Session 5	**Physical, Chemical, and Biological Effects of Microplastics**	• Duis and Coors (2016) *Microplastics in the aquatic and terrestrial environment: sources (with a specific focus on personal care products), fate and effects*. Environmental Sciences Europe, 28:2 DOI 10.1186/s12302-015-0069-y (36 pages)

		• J. Wang et al. (2016) *The behaviors of microplastics in the marine environment*. Marine Environmental Research, Volume 113 (2016) pp 7-17 (10 pages) http://dx.doi.org/10.1016/j.marenvres.2015.10.014
Session 6	**Ingestion of Plastics: A Critical Appraisal on a Case Study**	• Compa M et al. (2018) *Ingestion of microplastics and natural fibres in Sardina pilchardus (Walbaum, 1792) and Engraulis encrasicolus (Linnaeus, 1758) along the Spanish Mediterranean coast*. Marine Pollution Bulletin Volume 128 pp 89-96. (7 pages) doi: 10.1016/j.marpolbul.2018.01.009 • M. Steer, M. Cole, R. C. Thompson, P. K. Lindeque (2017). *Microplastic ingestion in fish larvae in the western English Channel*. Environmental Pollution, Volume 226, pp 250-259 (9 pages) http://dx.doi.org/10.1016/j.envpol.2017.03.062
Session 7	**The Role of Plastics as Vector for Pollutants**	• Rochman C.M. (2015) *The Complex Mixture, Fate and Toxicity of Chemicals Associated with Plastic Debris in the Marine Environment*. Anthropogenic Litter. pp 117-140 (23 pages) doi.org/10.1007/978-3-319-16510-3_5
Session 8	**An Experimental Approach to Study the Chemical Behavior of Plastics**	• Pittura L, Avio CG, Giuliani ME, d'Errico G, Keiter SH, Cormier B, Gorbi S and Regoli F (2018) *Microplastics as Vehicles of Environmental PAHs to Marine Organisms: Combined Chemical and Physical Hazards to the Mediterranean Mussels, Mytilus galloprovincialis*. Frontiers in Marine Science, Volume 5:103. doi: 10.3389/fmars.2018.00103 (15 pages) • F. Rendell-Bhatti et al. (2021) *Developmental toxicity of plastic leachates on the sea urchin Paracentrotus lividus.* Environmental Pollution, Volume 269, 115744, ISSN 0269-7491, https://doi.org/10.1016/j.envpol.2020.115744 (17 pages)

Session 9	**Interactions Between Microorganisms and Marine Plastics: The Influence of Biofilms**	• J. P. Harrison et al. (2011) *Interactions Between Microorganisms and Marine Microplastics: A Call for Research*. Marine Technology Society Journal, Volume 45, Number2, pp 12-20 (8 pages) DOI: 10.4031/MTSJ.45.2.2 • Kiessling T., Gutow L., Thiel M. (2015) *Marine Litter as Habitat and Dispersal Vector.* In: Bergmann M., Gutow L., Klages M. (eds) Marine Anthropogenic Litter, pp 141-181 (40 pages) https://doi.org/10.1007/978-3-319-16510-3_6
Session 10	**Class presentations** **Deadline for short essay submission**	
Session 11	**Knowledge Gaps and Research Priorities** **Midterm review**	• Jahnke et al. (2017) *Reducing Uncertainty and Confronting Ignorance about the Possible Impacts of Weathering Plastic in the Marine Environment.* Environmental Science & Technology Letters, Volume 4, Issue 3, pp 85–90 (5 pages) DOI: 10.1021/acs.estlett.7b00008 • Galloway, T., Cole, M. & Lewis, C. *Interactions of microplastic debris throughout the marine ecosystem.* Nature Ecology & Evolution, Volume 1, 0116 https://doi.org/10.1038/s41559-017-0116 (8 pages)
Session 12	**Midterm exam**	
Session 13	**General Plastic Flow**	• Alfonso Xavier Recalde Salas (2019) *Plastic flow in worldwide context MHSE11 -circular economy.* pp 3-16, pp 20-28 (8 pages) DOI: 10.13140/RG.2.2.29715.22567 • M. Ericksen et al. (2018) *Microplastic: What Are the Solutions?* Freshwater Microplastics, pp 273-298 (25 pages) DOI: 10.1007/978-3-319-61615-5_13
Session 14	**How to Recycle Plastic Materials**	• M. E. Grigore (2017) *Methods of recycling, properties and applications of recycled thermoplastic polymers.* Recycling, Volume 2, Issue 4, 24; doi:10.3390/recycling2040024

		(9 pages)
Session 15	**Reduce, Re-use, Recycle: Creating Awareness on Plastic Waste Management** **Deadline for reflection paper submission**	• WWF Report 2019: A Guide for Policy Makers in Italy https://wwfeu.awsassets.panda.org/downloads/06062019_wwf_italy_guidebook.pdf (25 pages)
Session 16	**Course-related trip:** **REMAPLAST s.r.l., plastic recycling plant in Rome**	• M. E. Grigore (2017) *Methods of recycling, properties and applications of recycled thermoplastic polymers.* Recycling, Volume 2, Issue 4, 24; doi:10.3390/recycling2040024 (11 pages)
Session 17	**Legislation and Regulation of Marine Plastic Debris**	• Chen CL. (2015) *Regulation and Management of Marine Litter*. pp 395-428 (33 pages) https://doi.org/10.1007/978-3-319-16510-3_15 • F. Thevenon Iet al. (2014) *Plastic Debris in the Ocean*. International Union for Conservation of Nature. pp 35-38 (3 pages) DOI: 10.2305/IUCN.CH.2014.03.en
Session 18	**An Appraisal of Single-use Plastic: Directive on Their Reduction**	• *Moving away from single-use. Guide for national decision makers to implement the single-use plastics directive.* https://www.actu-environnement.com/media/pdf/news-37813-rapport-mise-en-oeuvre-directive-sup.pdf (56 pages)
Session 19	**How to Reduce Plastic Pollution: An Overview of Possible Solutions**	• M. Ericksen et al. (2018) *Microplastic: What Are the Solutions?* Freshwater Microplastics, pp 273-298 https://doi.org/10.1007/978-3-319-61615-5_13 (25 pages)
Session 20	**Project description: #Pescaplastica, whose aim is to develop a virtuous model for the management and use of marine waste, fully implementing the concept of circular economy.**	• https://www.ismed.cnr.it/en/pescaplastica
Session 21	**How to Do a Quantitative Analysis of Plastic Debris on Beaches**	• H.B. Jayasiri, C.S. Purushothaman, A. Vennila (2013) *Quantitative analysis of plastic debris on recreational beaches in Mumbai, India.* Marine Pollution Bulletin, Volume 77, Issues 1–2, Pages 107-112 (5 pages)

		https://doi.org/10.1016/j.marpolbul.2013.10.024.
Session 22	**Course-related trip:** **A PLASTIC FREE BEACH DAY in Fiumicino**	
Session 23	**Discovery of Biopolymers and Their Biodegradable Applications**	• Lambert S. (2015) *Biopolymers and Their Application as Biodegradable Plastics.* In: Kalia V. (eds) Microbial Factories. Springer, New Delhi. pp 1-9 https://doi.org/10.1007/978-81-322-2595-9_1 (9 pages) • Di Bartolo, Alberto, Giulia Infurna, and Nadka T. Dintcheva 2021. "*A Review of Bioplastics and Their Adoption in the Circular Economy*" Polymers Volume 13, No. 8: 1229. https://doi.org/10.3390/polym13081229 (23 pages)
Session 24	**Screening of Videos on Boplastics and Discussion** **Final review**	• https://www.youtube.com/watch?v=-_eGOyAiNIQ
	Final exam	

COURSE-RELATED TRIPS:

- REMAPLAST s.r.l.: students will visit this plastic recycling plant and learn about the plastic recycling process.
- PLASTIC FREE BEACH DAY (Fiumicino): students will participate in a beach clean-up daytrip to Fiumicino.

REQUIRED READINGS:

- A. Jahnke et al. (2017) *Reducing Uncertainty and Confronting Ignorance about the Possible Impacts of Weathering Plastic in the Marine Environment.* Environ. Sci. Technol. Lett., 4, 3, 85–90 DOI: 10.1021/acs.estlett.7b00008
- Alfonso Xavier Recalde Salas (2019) *Plastic flow in worldwide context -circular economy.* pp 3-16, pp 20-28 DOI: 10.13140/RG.2.2.29715.22567
- Andrady A.L. (2015) *Persistence of Plastic Litter in the Oceans*. In: Bergmann M., Gutow L., Klages M. (eds) Marine Anthropogenic Litter. Springer, pp 57-72 Cham. https://doi.org/10.1007/978-3-319-16510-3_3
- Chen CL. (2015) *Regulation and Management of Marine Litter*. In: Bergmann M., Gutow L., Klages M. (eds) Marine Anthropogenic Litter. Springer, Cham. pp 395-428 https://doi.org/10.1007/978-3-319-16510-3_15
- Compa M et al. (2018) *Ingestion of microplastics and natural fibres in Sardina pilchardus (Walbaum, 1792) and Engraulis encrasicolus (Linnaeus, 1758) along the Spanish Mediterranean coast*. Mar Pollut Bull. 2018 Mar; 128:89-96. doi: 10.1016/j.marpolbul.2018.01.009

- Cózar A, Sanz-Martín M, Martí E, González-Gordillo JI, Ubeda B, Gálvez JÁ, et al. (2015) *Plastic Accumulation in the Mediterranean Sea*. PLoS ONE 10(4): e0121762. doi:10.1371/ journal.pone.0121762
- Dannielle S. Green, Louise Kregting, Bas Boots, David J. Blockley, Paul Brickle, Marushka da Costa, Quentin Crowley (2018) *A comparison of sampling methods for seawater microplastics and a first report of the microplastic litter in coastal waters of Ascension and Falkland Islands.*Marine Pollution Bulletin, Volume 137, pp 695-701, ISSN 0025-326X, https://doi.org/10.1016/j.marpolbul.2018.11.004
- Di Bartolo, Alberto, Giulia Infurna, and Nadka T. Dintcheva (2021). "*A Review of Bioplastics and Their Adoption in the Circular Economy"* Polymers 13, no. 8: 1229. https://doi.org/10.3390/polym13081229
- Duis and Coors (2016) *Microplastics in the aquatic and terrestrial environment: sources (with a specific focus on personal care products), fate and effects*. Environ Sci Eur, 28:2 DOI 10.1186/s12302-015-0069-y
- Eriksen M., Thiel M., Prindiville M., Kiessling T. (2018) *Microplastic: What Are the Solutions?.* In: Wagner M., Lambert S. (eds) Freshwater Microplastics. The Handbook of Environmental Chemistry, vol 58. Springer, Cham. https://doi.org/10.1007/978-3-319-61615-5_13
- F. Rendell-Bhatti et al. (2021) *Developmental toxicity of plastic leachates on the sea urchin Paracentrotus lividus.* Environmental Pollution, Volume 269, 115744, ISSN 0269-7491, https://doi.org/10.1016/j.envpol.2020.115744
- F. Thevenon et al. (2014) *Plastic Debris in the Ocean*. International Union for Conservation of Nature. pp 35-38 DOI: 10.2305/IUCN.CH.2014.03.en
- Galgani F., Hanke G., Maes T. (2015) *Global Distribution, Composition and Abundance of Marine Litter*. In: Bergmann M., Gutow L., Klages M. (eds) Marine Anthropogenic Litter. Springer, Cham. pp. 29-56 https://doi.org/10.1007/978-3-319-16510-3_2
- Galloway, T., Cole, M. & Lewis, C. *Interactions of microplastic debris throughout the marine ecosystem.* Nat Ecol Evol 1, 0116 (2017). https://doi.org/10.1038/s41559-017-0116
- H.B. Jayasiri, C.S. Purushothaman, A. Vennila (2013) *Quantitative analysis of plastic debris on recreational beaches in Mumbai, India*. Marine Pollution Bulletin, Volume 77, Issues 1–2, Pages 107-112, ISSN 0025-326X, https://doi.org/10.1016/j.marpolbul.2013.10.024
- J. P. Harrison et al. (2011) *Interactions Between Microorganisms and Marine Microplastics: A Call for Research.* Marine Technology Society Journal 45(2):12-20 DOI: 10.4031/MTSJ.45.2.2
- J. Wang et al. (2016) *The behaviors of microplastics in the marine environment*. Marine Environmental Research 113 (2016) 7-17 http://dx.doi.org/10.1016/j.marenvres.2015.10.014
- Kiessling T., Gutow L., Thiel M. (2015) *Marine Litter as Habitat and Dispersal Vector.* In: Bergmann M., Gutow L., Klages M. (eds) Marine Anthropogenic Litter. Springer, Cham. https://doi.org/10.1007/978-3-319-16510-3_6
- Lambert S. (2015) *Biopolymers and Their Application as Biodegradable Plastics*. In: Kalia V. (eds) Microbial Factories. Springer, New Delhi. https://doi.org/10.1007/978-81-322-2595-9_1
- M. Cole , P. Lindeque, C. Halsband , T. S. Galloway (2011) Microplastics as contaminants in the marine environment: A review. Marine Pollution Bulletin 62 2588–2597 doi:10.1016/j.marpolbul.2011.09.025
- M. E. Grigore (2017) *Methods of recycling, properties and applications of recycled thermoplastic polymers.* Recycling, 2, 24; doi:10.3390/recycling2040024
- M. Ericksen et al. (2018) *Microplastic: What Are the Solutions?* In book: Freshwater Microplastics DOI: 10.1007/978-3-319-61615-5_13
- Moving away from single-use. Guide for national decision makers to implement the single-use plastics directive. https://www.actu-environnement.com/media/pdf/news-37813-rapport-mise-en-oeuvre-directive-sup.pdf
- M. Steer, M. Cole, R. C. Thompson, P. K. Lindeque (2017). *Microplastic ingestion in fish larvae in the western English Channel*. Environmental Pollution 226 (2017) 250-259 http://dx.doi.org/10.1016/j.envpol.2017.03.062Ogunola OS, Palanisami T (2016) *Microplastics in the Marine Environment: Current Status, Assessment Methodologies, Impacts and Solutions*. J Pollut Eff Cont 4: 161. doi:10.4172/2375-4397.1000161
- Pittura L, Avio CG, Giuliani ME, d'Errico G, Keiter SH, Cormier B, Gorbi S and Regoli F (2018) *Microplastics as Vehicles of Environmental PAHs to Marine Organisms: Combined Chemical and Physical Hazards to the Mediterranean Mussels, Mytilus galloprovincialis*. Front. Mar. Sci. 5:103. doi: 10.3389/fmars.2018.00103

- Rochman C.M. (2015) *The Complex Mixture, Fate and Toxicity of Chemicals Associated with Plastic Debris in the Marine Environment*. In: Bergmann M., Gutow L., Klages M. (eds) Marine Anthropogenic Litter. Springer, Cham. https://doi.org/10.1007/978-3-319-16510-3_5
- Sharma S, Sharma V and Chatterjee S (2021) *Microplastics in the Mediterranean Sea: Sources, Pollution Intensity, Sea Health, and Regulatory Policies.* Front. Mar. Sci. 8:634934. doi:10.3389/fmars.2021.634934
- Suaria, G. et al. (2016) *The Mediterranean Plastic Soup: synthetic polymers in Mediterranean surface waters.* Sci. Rep. 6, 37551; doi:10.1038/srep37551
- WWF Report 2019: A Guide for Policy Makers in Italy https://wwfeu.awsassets.panda.org/downloads/06062019_wwf_italy_guidebook.pdf