21st Century Marine Pollutants: Noise and Plastics

SFS 3755

Syllabus
4 credits

The School for Field Studies (SFS)
Center for the Conservation of Marine Megafauna
Veli Lošinj, Lošinj Island, Croatia

This syllabus may develop or change over time based on local conditions, learning opportunities, and faculty expertise. Course content may vary from semester to semester.

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COURSE CONTENT SUBJECT TO CHANGE

Please note that this is a copy of a recent syllabus. A final syllabus will be provided to students on the first day of academic programming.

SFS programs are different from other travel or study abroad programs. Each iteration of a program is unique and often cannot be implemented exactly as planned for a variety of reasons. There are factors which, although monitored closely, are beyond our control. For example:

- Changes in access to or expiration or change in terms of permits to the highly regulated and sensitive environments in which we work;
- Changes in social/political conditions or tenuous weather situations/natural disasters may require changes to sites or plans, often with little notice;
- Some aspects of programs depend on the current faculty team as well as the goodwill and generosity of individuals, communities, and institutions which lend support.

Please be advised that these or other variables may require changes before or during the program. Part of the SFS experience is adapting to changing conditions and overcoming the obstacles that may present. In other words, this is a field program, and the field can change.

Course Overview

The Croatian National Tourist Board promotes 'Croatia – full of life', and previously, 'the Mediterranean as it once was'. How do these statements balance with the current and future state of the Croatian Adriatic Sea?

Global growth of the use of the oceans is having a significant effect. Since the mid twentieth century noise levels in the world's oceans have doubled every decade. Noise can be attributed to many different sources, perhaps the most important is commercial shipping. The commercial shipping fleet has tripled since 1950, and tonnage has increased more than ten-fold. Marine mammals and particularly cetaceans are susceptible to noise pollution.

The oceans are vulnerable not only to the users of the sea and the associated threats, but also to land based pollutants. For centuries there has been a wide awareness of the potential harm from chemical pollutants that come downstream into the marine environment, however, the ubiquitous nature of marine litter and plastics has only been recognized in the last couple of decades.

Twenty-first century marine pollutants is a 4-week interdisciplinary course with an aim to provide students with critical, applicable knowledge concerning these contemporary pollutants and provide practical skills of integrating knowledge into evidence-based marine conservation management. Participants will gain knowledge on the Mediterranean, Adriatic and Croatian contexts towards these pollutants. The study is based on the island of Lošinj Croatia. Lošinj is regionally known as the 'Island of Vitality', it's history as a health resort provides a perfect context to host this summer school.

Finally, students will deepen their knowledge of the Adriatic and Mediterranean marine ecosystems, examining the ecological connectivity of these semi-enclosed seas. Emphasis will be placed on ecosystem resilience and strategies to reduce emerging pollutant threats in the context of climate change, within one of the most vulnerable marine regions globally.

The course has two main themes:

Noise

Students will gain knowledge on bioacoustics, particularly related to cetacean vocalization and the impact of underwater noise on species wellbeing. In addition, they will engage in methodologies related to acoustic research and data collection through applied activities on the sea and in the lab. Finally, students will be introduced to complementary research methods including boat survey work, abundance estimates and distribution patterns of dolphins.

Plastics

Students will understand the impacts of plastic pollution from seabed to seashore and within the water column, utilizing equipment such as manta nets, underwater drones and snorkeling surveys. Students will be encouraged to develop critical thinking about plastics and consider the scale of the problem, by analyzing the composition of marine litter, its sources and potential choke points for mitigation and prevention measures.

Both themes will be analyzed and discussed during lectures, discussions, workshops and exercises. Students will spend time snorkeling in the clear waters of the island bays, amongst seagrass meadows. Material taught in class and learned in the field will be assessed through a variety of assignments.

Learning Objectives

After taking this course, students will be able to:

1. Apply multiple interdisciplinary field methods to investigate marine noise and plastic pollution, including hydrophone deployment, acoustic data collection, photo-identification surveys, and plastic sampling and analysis
2. Analyze data to evaluate the ecological and behavioral impacts of marine pollutants on marine megafauna and ecosystems, including the interpretation of data to assess the impacts of noise and plastic pollution
3. Evaluate current management and regulatory frameworks addressing 21st-century marine pollution
4. Evaluate public opinion regarding marine litter and plastics based on scientific literature and your own results and propose solutions to the challenges of these pollutants

Assessment

The evaluation breakdown for the course is as follows:

Assessment Item	Value (%)
Marine Litter and Plastics Pollution Quiz	10
Plastic Presentations	20
Field Exercises: Plastics Pollution	20
Noise Pollution Quiz	15
Noise Presentations	25
Field Exercises: Noise	10
TOTAL	**100**

Marine Litter and Plastics Pollution Quiz (10%)

This quiz will assess students' comprehension of pre-course readings and introductory lectures covering the sources, impacts, and management of plastic pollution in marine ecosystems. The format will include multiple-choice and short-answer questions focusing on the global and Adriatic contexts, types of plastic pollutants, and their ecological implications.

Plastic Presentations (20%)

Students will work in small groups to investigate a major topic related to marine litter and plastic pollution. Each group will research both global and regional dimensions of their topic, referencing scientific literature and case studies from the Adriatic and Mediterranean Seas.

Field Exercises: Plastics Pollution (20%)

Field Exercises (FEX) provide hands-on experience in interdisciplinary fieldwork. Students will take part in all stages of the research process, including:

- Sampling and data collection: Deployment and recovery of manta nets and underwater drones, snorkeling surveys, and beach litter assessments
- Laboratory work: Sorting and classifying plastics by type, size, and source; preparing sediment and water column samples for microplastic analysis.
- Reporting and analysis: Each student (or team) will submit a concise field report that includes a description of methods, raw data summaries, basic statistical analysis, and a brief discussion.

Noise Pollution Quiz (15%)

This quiz will test students' understanding of marine bioacoustics and noise pollution concepts introduced in pre-course readings and lectures. Topics include sound propagation in water, major anthropogenic noise sources, effects on marine mammals, and current management frameworks. The quiz will consist of multiple-choice and short-answer questions.

Noise Presentations (25%)

Groups will prepare presentations exploring key themes related to underwater noise pollution. Each group will research both global and regional dimensions of their topic, referencing scientific literature and case studies from the Adriatic and Mediterranean Seas.

Field Exercises: Noise Pollution (10%)

Field Exercises (FEX) provide hands-on experience in interdisciplinary fieldwork. Students will take part in all stages of the research process, including:

- Field data collection: Deploying and recovering hydrophones; conducting boat-based acoustic and visual surveys for bottlenose dolphins; logging navigation and observation data into the research app; and practicing photo-identification techniques for individual recognition.
- Data processing and interpretation: Working in small teams, students will analyze acoustic recordings to identify sound sources and generate spectrograms, linking observed dolphin behavior to acoustic activity.
- Field report: Each student (or team) will submit a field report detailing their fieldwork methods, data analysis (e.g., sound level summaries, spectrogram interpretation), and key findings.

Grading Scheme

A	95.00 - 100.00%	B+	86.00 - 89.99%	C+	76.00 - 79.99%	D	60.00 - 69.99%
A-	90.00 - 94.99%	B	83.00 - 85.99%	C	73.00 - 75.99%	F	0.00 - 59.99%
		B-	80.00 - 82.99%	C-	70.00 - 72.99%		

General Reminders

Honor Code/Plagiarism – SFS places high expectations on their students and we hold students accountable for their behaviors. SFS students are held to the honor code below. SFS has a zero-tolerance policy towards student cheating, plagiarism, data falsification, and any other form of dishonest academic and/or research practice or behavior. Using the ideas or material of others without giving due credit is cheating and will not be tolerated. Any SFS student found to have engaged in or facilitated academic and/or research dishonesty will receive no credit (0%) for that activity.

> *"SFS does not tolerate cheating or plagiarism in any form. While participating in an SFS program, students are expected to refrain from cheating, plagiarism and any other behavior which would result in a student receiving credit for work which they did not accomplish on their own. Students are expected to report any instance of cheating or plagiarism by others."*

AI Usage in Assignments – SFS acknowledges the growing role of artificial intelligence (AI) tools in education and professional settings. While AI can be a valuable resource for learning and productivity, its use must align with the learning goals and integrity of each assignment. For this reason, students are encouraged to discuss the acceptable uses of AI for each assignment with the instructor. If you wish to use AI for any part of an assignment, consult with the instructor beforehand to ensure that its use adheres to the academic expectations of the course. Let's work together to navigate this evolving landscape responsibly!

Deadlines – Deadlines for written and oral assignments are instated to promote equity among students and to allow faculty ample time to review and return assignments before others are due. As such, deadlines are firm; extensions will only be considered under extreme circumstances. Late assignments will incur a penalty of 10% of your grade for each day you are late. After two days past the deadline, assignments will no longer be accepted. Assignments will be handed back to students after a one-week grading period. Grade corrections for any assessment item should be requested in writing at least 24 hours after assignments are returned. No corrections will be considered afterwards.

Content Statement – Every student comes to SFS with unique life experiences, which contribute to the way various information is processed. Some of the content in this course may be intellectually or emotionally challenging but has been intentionally selected to achieve certain learning goals and/or showcase the complexity of many modern issues. If you anticipate a challenge engaging with a certain topic or find that you are struggling with certain discussions, we encourage you to talk about it with faculty, friends, family, the HWM, or access available mental health resources.

Participation – Since we offer a program that is likely more intensive than you might be used to at your home institution, missing even one lecture can have a proportionally greater effect on your final grade simply because there is little room to make up for lost time. Participation in all components of the course is mandatory, it is important that you are prompt for all activities, bring the necessary equipment for field exercises and class activities, and simply get involved.

Course Content

Type: D: Discussion, **DEX**: Desk Exercise, **FEX**: Field Exercise, **FL:** Field Lecture, **L**: Lecture, **O**: Orientation

No	*Title and outline*	*Type*	*Time (hrs)*	*Required Readings*
1	**Course Introduction**	O	1.0	
2	**Plastics and Marine Megafauna Impacts** Individual and population level effects of plastics pollution on marine megafauna	L	1.0	Senko et al. (2020).
3	**Plastic Pollution in the Adriatic Sea** Status of plastic pollution in Adriatic Sea (floating, water column, sea floor, beaches)	L	1.0	Schmid et al. (2021).
4	**Debating Plastics as a Marine Threat** Controversy about plastic pollution as one of the major threats in marine environment	D	1.0	Stafford and Jones (2019). Avery-Gomm et al. (2019).

No	Title and outline	Type	Time (hrs)	Required Readings
5	**Sea Turtle Intro, Diets, and Plastic Ingestion** Sea turtle species identification with focus on differences in their diet and potential for plastic ingestion during feeding	L	1.0	Duncan et al. (2019a).
6	**Plastics Sampling** EU protocols for plastic sampling and analysis, MSFD requirements, indicators of GES etc.	L	1.0	Galgani et al. (2023).
7	**Plastics in the Water Column** Water column visual surveys and manta net deployment	FEX	3.0	
8	**Plastics on the Beach** Beach assessment for macro litter and meso-plastic (5-25mm) and sediment sampling for micro-plastics	FEX	3.0	Botterell et al. (2025).
9	**Plastics on the Sea Floor** Deployment of underwater drones and trawler sampling	FEX	3.0	
10	**Plastics on the Sea Floor** Snorkel survey review of local bays	FEX	3.0	
11	**Turtle Rescue Centre** Health status assessment and treatment of turtles that are suspected to ingest plastics	FEX	2.0	
12	**Turtle Rescue Centre** Necropsy and analysis of ingested plastics	FEX	3.0	Duncan et al. (2019b).
13	**Plastics Analysis** Analysis of collected samples from sediment, water column, and sea bed	DEX	2.0	
14	**Student Presentations on Plastics Topics**	D	2.0	
15	**Marine Animal Acoustics** Why make sound? The production and diversity of marine mammal sounds.	L	1.0	Au & Hastings, Ch 10
16	**Bottlenose Dolphin Ecology and Behavior** Spatial and social ecology, population dynamics, current knowledge in Adriatic, methodologies for study	L	1.0	Pleslic et al. (2018). Holcer et al. (2015.
17	**Hydrophone Deployment** Hands-on work on a small boat to deploy different types of passive acoustic recorders (e.g. SoundTrap and Develogic SonoVault)	FEX	3.0	
18	**Intro to Acoustics and Sound Measurement** Equipment, principles; sound propagation and measuring noise (what is a dB?)	L	2.0	Au & Hastings, Ch 2 & 4
19	**Photo ID and Acoustic Survey Methods** Megafauna photo ID & acoustic data collection during boat-based surveys	FEX	9.0	
20	**Hydrophone Recovery**	FEX	3.0	

No	Title and outline	Type	Time (hrs)	Required Readings
	Hands-on work on a small boat to recover different types of passive acoustic recorders (e.g. SoundTrap and Develogic SonoVault)			
21	**Anthropogenic Noise and Marine Impacts**	L	1.0	Erbe et al. (2018).
22	**Acoustic Methodologies** Advantages and disadvantages of different acoustic methodologies; basics of sound processing	L	1.0	Constaratas et al. (2024).
23	**Acoustic data analysis** Logging basics, spectrograms, etc.	DEX	3.0	
24	**Student Presentations on Noise Topics**	D	2.0	
25	**Debrief and Course Wrap-up**	D	1.0	
	Total		**54**	
	UMN Instructional Hours*		**64.8**	

**UMN defines* *an instructional hour as a 50-minute block. SFS syllabi are written in full 60-minute hours for programming purposes. Therefore 50 full hours = 60 UMN instructional hours (for four credit courses) and 25 full hours = 30 UMN instructional hours (for two credit courses).*

Reading List

*Readings in **Bold** are required

1. **Au, W. W. L., & Hastings, M. C. (2008).** *Principles of marine bioacoustics* (Vol. 510). Springer New York, NY.
2. Avery-Gomm, S., Walker, T. R., Mallory, M. L., and Provencher, J. F. (2019). There is nothing convenient about plastic pollution. Rejoinder to Stafford and Jones "Viewpoint – Ocean plastic pollution: A convenient but distracting truth?" Marine Policy 106, 103552. doi: 10.1016/j.marpol.2019.103552
3. Bloom, S. G., Alksne, M. N., Rice, A., Lankhorst, M., Širović, A., & Baumann-Pickering, S. (2025). Seasonal changes in physical oceanography modulate cetacean predator-prey dynamics in the San Diego Trough. *Marine Ecology Progress Series*, *762*, 111-133. https://www.int-res.com/abstracts/meps/v762/meps14864
4. **Botterell, Z. L. R., Ardren, J., Dove, E., McArthur, E., Addison, D. S., Adegbile, O. M., et al. (2025).** A global assessment of microplastic abundance and characteristics on marine turtle nesting beaches. Marine Pollution Bulletin 215, 117768. doi: 10.1016/j.marpolbul.2025.117768
5. **Constaratas, A. N., Holcer, D., Özgöbek, Ö., & Širović, A. (2024).** Acoustic occurrence of deep-diving cetaceans in the southern Adriatic Sea. *Marine Mammal Science*(e13204), 1-21. https://doi.org/https://10.1111/mms.13204
6. Darmon, G., Schulz, M., Matiddi, M., Loza, A.L., Tomás, J., Camedda, A., Chaieb, O., El Hili, H.A., Bradai, M.N., Bray, L. and Claro, F. (2022). Drivers of litter ingestion by sea turtles: Three decades of empirical data collected in Atlantic Europe and the Mediterranean. *Marine Pollution Bulletin*, *185*, p.114364.
7. **Duncan, E.M., Arrowsmith, J.A., Bain, C.E. et al. (2019a).** Diet-related selectivity of macroplastic ingestion in green turtles (*Chelonia mydas*) in the eastern Mediterranean. Sci Rep 9, 11581. https://doi.org/10.1038/s41598-019-48086-4**Duncan, E. M., Broderick, A. C.,**
8. **Fuller, W. J., Galloway, T. S., Godfrey, M. H., Hamann, M., et al. (2019b).** Microplastic ingestion ubiquitous in marine turtles. Global Change Biology 25, 744–752. doi: 10.1111/gcb.14519
9. **Erbe, C., Dunlop, R., & Dolman, S. (2018).** Effects of Noise on Marine Mammals. In H. Slabbekoorn, R. J. Dooling, A. N. Popper, & R. R. Fay (Eds.), *Effects of Anthropogenic Noise on Animals* (pp. 277-309). Springer New York. https://doi.org/10.1007/978-1-4939-8574-6_10
10. **Galgani, F., Ruiz-Orejón, L. F., Ronchi, F., et al., (2023)**. Guidance on the Monitoring of Marine Litter in European Seas An update to improve the harmonised monitoring of marine litter under the Marine Strategy Framework Directive, EUR 31539 EN, Publications Office of the European Union, Luxembourg, 2023, ISBN 978-92-68-04093-5, doi:10.2760/59137, JRC133594.
11. **Holcer, D., Fortuna, C. M., & Mackelworth, P. C. (2015).** *Adriatic sea: important areas for conservation of cetaceans, sea turtles and giant devil rays*. UNEP-MAP-RAC/SPA. http://www.rac-spa.org/sites/default/files/doc_open_seas/adriatic_sea_cetaceans_turtles_rays_abnj.pdf

12. Pasanisi, E., Galasso, G., Panti, C. *et al.* (2023). Monitoring the composition, sources and spatial distribution of seafloor litter in the Adriatic Sea (Mediterranean Sea) through Fishing for Litter initiatives. *Environ Sci Pollut Res* 30, 90858–90874.

13. Pasquini, G., Ronchi, F., Strafella, P., Scarcella, G. and Fortibuoni, T. (2016). Seabed litter composition, distribution and sources in the Northern and Central Adriatic Sea (Mediterranean). *Waste management*, *58*, pp.41-51.

14. Pieretti, N., Martire, M. L., Farina, A., & Danovaro, R. (2017). Marine soundscape as an additional biodiversity monitoring tool: a case study from the Adriatic Sea (Mediterranean Sea). *Ecological Indicators*, *83*, 13-20.

15. **Pleslić, G., Rako-Gospić, N., Miočić-Stošić, J., Blazinić Vučur, T., Radulović, M., Mackelworth, P., Frleta-Valić, M., & Holcer, D. (2019).** Social structure and spatial distribution of bottlenose dolphins (*Tursiops truncatus*) along the Croatian Adriatic coast. *Aquatic Conservation: Marine and Freshwater Ecosystems*, *29*(12), 2116-2132. https://doi.org/https://10.1002/aqc.3213

16. **Rako, N., Fortuna, C. M., Holcer, D., Mackelworth, P., Nimak-Wood, M., Pleslić, G., Sebastianutto, L., Vilibić, I., Wiemann, A., & Picciulin, M. (2013).** Leisure boating noise as a trigger for the displacement of the bottlenose dolphins of the Cres–Lošinj archipelago (northern Adriatic Sea, Croatia). *Marine Pollution Bulletin*, *68*(1–2), 77-84. https://doi.org/10.1016/j.marpolbul.2012.12.019

17. **Schmid, C., Cozzarini, L. and Zambello, E. (2021).** A critical review on marine litter in the Adriatic Sea: Focus on plastic pollution. Environmental Pollution, 273, p.116430.

18. **Senko, J., Nelms, S., Reavis, J., Witherington, B., Godley, B., and Wallace, B. (2020).** Understanding individual and population-level effects of plastic pollution on marine megafauna. Endang. Species. Res. 43, 234–252. doi: 10.3354/esr01064

19. **Stafford, R., and Jones, P. J. S. (2019).** Viewpoint – Ocean plastic pollution: A convenient but distracting truth? Marine Policy 103, 187–191. doi: 10.1016/j.marpol.2019.02.003

20. Urian, K., Gorgone, A., Read, A., Balmer, B., Wells, R. S., Berggren, P., Durban, J., Eguchi, T., Rayment, W., & Hammond, P. S. (2015). Recommendations for photo-identification methods used in capture-recapture models with cetaceans. *Marine Mammal Science*, *31*(1), 298-321. https://doi.org/10.1111/mms.12141

21. Weilgart, L. S. (2007). The impacts of anthropogenic ocean noise on cetaceans and implications for management. *Canadian Journal of Zoology-Revue Canadienne De Zoologie*, *85*(11), 1091-1116. https://doi.org/10.1139/z07-101

22. Zeri, C., Adamopoulou, A., Varezić, D.B., Fortibuoni, T., Viršek, M.K., Kržan, A., Mandic, M., Mazziotti, C., Palatinus, A., Peterlin, M. and Prvan, M. (2018). Floating plastics in Adriatic waters (Mediterranean Sea): From the macro-to the micro-scale. *Marine Pollution Bulletin*, *136*, pp.341-350.