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D2.1 TRAINING CURRICULUM

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D 2.1. Training Curriculum

PROJECT INFORMATION

Project Acronym	EcoMarine
Project title	Building a Comprehensive Mechanism for Preserving Marine Ecosystems and Life from the negative consequences of Climate Change and the disposal of Plastic Debris
Agreement number	619158-EPP-1-2020-1-CY-EPPKA2-CBHE-JP
EU programme	Capacity Building for Higher Education (EAC/A02-2019-CBHE)
Project website	www.ecomarine-project.eu

PREPARED BY

Organization	University of Cyprus (Cyprus) University of Oviedo (Spain) Universiti Malaysia Terengganu (Malaysia) Universiti Kebangsaan Malaysia (Malaysia) Andhra University (India) University of Kerala (India) Archipelagos Institute of Marine Conservation (Greece)
Authors	Yianna Samuel (UCY) Alba Ardura (UniOvi) Eva Garcia-Vazquez (UniOvi) José Luis Acuña (UniOvi) Andres Arias (UniOvi) José M. Rico (UniOvi) Alice Masper (Archipelagos) Tim Grandjean (Archipelagos) Laura Macrina (Archipelagos) Myrsini Lymperaki (Archipelagos) Amanda Batlle (Archipelagos) Konstantis Alexopoulos (Archipelagos) Kiera McGarvey Sears (Archipelagos) Shahriman M. Ghazali (UKM) Zaidi Che Cob (UKM) Muzzneena Ahmad Mustapha (UKM) Mohammad Rozaimi Jamaludin (UKM) Ester Salimun (UKM) Fredolin Tangang (UKM) Liew Ju Neng (UKM) Mardiana Jansar (UKM) Masni Mohd. Ali (UKM) Suriyanti Su Nyun Pau (UKM) Muhammad Syafiq Musa (UKM) Kesaven Bhubalan (UMT)

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619158-EPP-I-2020-1-CY-EPPKA2-CBHE-JP

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	Yusof Shuaib Ibrahim (UMT) Lee Jen Nie (UMT) Poh Seng Chee (UMT) Shahidee Zainal Abidin (UMT) Tan Chun Hong (UMT) Ku Mohd Kalkausar Ku Yusof (UMT) Siti Nurtahirah Jaafar (UMT) Mohd Nizam Lani (UMT) Alyza Azzura Abd Rahman Azmi (UMT) Maisarah Jaafar (UMT) Tuan Nurul Sabiqah Tuan Anuar (UMT) Muhammad Hafiz Borkhanuddin (UMT) Roswati Md Amin (UMT) Wan Mohd Afiq Wan Mohd Khalik (UMT) Maizah Abdullah (UMT) Noorlin Mohamad (UMT) Janakiram Pasupuleti (Andhra University) Katru Umadevi (Andhra University) Siripurapu Geetha (Andhra University) Durgasi Chandrasekhar (Andhra University) Mavuduri Jagannath (Andhra University)
Date	30 June 2024
Version	V 3.0
Dissemination Level	Restricted to other E+ Programme participants (including EACEA, Commission services and project reviewers)

Reviewed by	George Fragos (BK-Consult, Germany)		
Date of Review			
Acceptance level	Accepted ☐	To be reviewed ☐	Rejected ☐

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TRAINING CURRICULUM

1. Introduction

The new syllabus and training material on marine ecosystem and climate change monitoring, that will be offered by the HEIs in the Partner Countries (India and Malaysia) has been designed, based on the findings and preparatory work of WP1: Preparation of Training and Monitoring. The syllabus provides hands-on training on a wide range of fields of marine ecosystem monitoring covering the fields of climate change at sea, blue carbon, plastic and microplastic debris as well as monitoring of protected marine ecosystems (coral reefs, mangroves, seagrass meadows). The final syllabus consists of three Modules:

Module 1: Monitoring of marine plastics and microplastics

Module 2: Monitoring and managing marine ecosystems.

Module 3: Monitoring climate change at sea and blue carbon.

The design of the training material syllabus has been based on a sequence of methodological steps:

1. Identification of the different programmes and the modules they will contain: The identification of these curricula was based on the analysis of the existing set of skills and competences of marine and environmental scientists in the Partner's countries; and b) the expected ones for optimum ecosystem monitoring
2. All skills and key competences will be also usable by other HEIs out of the partnership, while the related material will be developed in such a way that it can be easily upgraded in the future.
3. Designing the structure and core content of the programme modules: Once the different modules that comprise the educational programme(s) have been identified, we proceeded to the actual design of their content and of the respective teaching methodologies and resources. The five general components of the programme design will be: a) Planed learning outcomes; b) Recommended bibliography; c) Course Content or Subject Matter – What subject matter is to be included and how do these align to existing marine ecosystem monitoring d) Curriculum Experience - What instructional strategies/ resources/ activities will be employed and how will learners be assessed; e) Curriculum Evaluation – What methods and techniques will be used to assess the results of the curriculum.
4. Adaptation of the course programmes to the local needs: Following the generic design of the programme structure and the development of the module content, a second step of adapting them to the specific marine ecosystem context of India and Malaysia will take place. This 'adaptation' is necessary to ensure that the more generic structure and content, developed in collaboration by the partners and drawing on the breadth and wealth of knowledge, experience, needs and requirements across many countries, is fit-for-purpose and suited to the context and specific requirements of the partner's country. This task requires a clear set of methodological principles and guidelines for the adaptation of the curricula. It is, therefore, important to keep in

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mind the various parameters or elements of the given curriculum which require particular attention from the point of view of adaptation.

5. Designing supportive materials and resources: As a result of the whole procedure, 2 packages of supportive materials and resources were developed in order to guide and facilitate the implementation of the programmes by 2 main groups of stakeholders, namely the learners and the trainers. Part of these materials are programme specific (e.g. the trainers guide), while others will be more generic and will be used to support the delivery across all programmes.

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2. Module 1: Monitoring of marine plastics and microplastics

2.1 Introduction - Objectives

Plastic waste is a major global issue. It is the most important and abundant marine litter material. Many marine organisms ingest microplastics or find themselves entangled in bigger pieces of marine litter. This course introduces the scientific questions concerning the global increase in environmental plastic and investigate the role of particle size in microplastic uptake by organisms. The lectures will introduce the global challenges related to plastic pollution as we understand them today and discuss future research needs and knowledge gaps. Topics covered: Plastic polymer chemistry, environmental sampling and analytical methods, effects of microplastics on marine organisms, needs for risk assessment for environmental and human health. The course will also encompass a practical session, with a demonstration of analytical methods in the laboratory as well as critical reading and discussion of published literature.

2.2 Syllabus

1. **Introduction of Marine Litter pollution**
   - 1.1. Plastic litter as a global ocean concern
   - 1.2. Composition of plastic litter
   - 1.3. Types of plastic marine litter and physical descriptors
   - 1.4. Impacts of marine litter

2. **Designing Monitoring and Assessment Programmes**
   - 2.1. Indicators and targets
   - 2.2. Data requirements for monitoring
   - 2.3. Basics of survey design
   - 2.4. Identification methods

3. **Monitoring methods for shorelines**
   - 3.1. Description and relevance of the shoreline compartment
   - 3.2. Examination of existing protocols

4. **Monitoring methods for the sea surface and water column**
   - 4.1. Monitoring methods for the sea surface
   - 4.2. Monitoring methods for the water column

5. **Monitoring methods for the sea floor,**
   - 5.1. Description and relevance of plastic and microplastic on the seafloor
   - 5.2. Methods of sample collection from the seafloor
   - 5.3. Deposition trend of microplastics on the seafloor

6. **Monitoring methods for marine biota**
   - 6.1. Description and relevance of marine litter-biota interaction
   - 6.2. Selection of biota for monitoring and monitoring of biota for plastic ingestion

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6.3. Monitoring associated chemicals from ingested plastics
6.4. Occurrences, sources & effects of marine entanglement
6.5. Monitoring impacts of marine litter on habitats

7. Sample processing for microplastics
7.1. Physical characteristics
7.2. Chemical characteristics
7.3. Biological characteristics

2.3 References

1. GESAMP (2019). Guidelines or the monitoring and assessment of plastic litter and microplastics in the ocean (Kershaw P.J., Turra A. and Galgani F. editors), (IMO/FAO/UNESCO-IOC/UNIDO/WMO/IAEA/UN/UNEP/UNDP/ISA Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection). Rep. Stud. GESAMP No. 99, 130p. https://wedocs.unep.org/bitstream/handle/20.500.11822/30009/plasLit.pdf?sequence=1&isAllowed=y
2. Giuseppe Bonanno, Martina Orlando-Bonaca (eds), 2022. Plastic Pollution and Marine Conservation: Approaches to Protect Biodiversity and Marine Life, 1st Edition, Paperback ISBN: 9780128224717
3. Eriksen M, Lebreton LCM, Carson HS, Thiel M, Moore CJ, et al., Plastic Pollution in the World's Oceans. (2014)
4. Laurent C. M. Lebreton, Joost van der Zwet, Jan-Willem Damsteeg, Boyan Slat, Anthony Andrady & Julia Reisser , River plastic emissions to the world's oceans (2017)
5. https://mcc.jrc.ec.europa.eu/documents/201702074014.pdf

2.4 Other useful references

Marine Plastic Debris and Microplastics: Global Lessons and Research to Inspire Action and Guide Policy Change, United Nations Environment Programme (2016)

K. Tsiaras, Y. Hatzonikolakis, S. Kalaroni, A. Pollani, G. Triantafyllou, Modelings the pathways and accumulation patterns of micro- and macro-plastics in the Mediterranean, Front. Mar. Sci., 04 October 2021 | https://doi.org/10.3389/fmars.2021.743117

Frontiers | Modeling the Pathways and Accumulation Patterns of Micro- and Macro-Plastics in the Mediterranean | Marine Science (frontiersin.org)

A. Gkanasos, K. Tsiaras, G. Triantaphyllidis, A. Panagopoulos, G. Pantazakos, T. Owens, C. Karametsis, A. Pollani, E. Nikoli, N. Katsafados, G. Triantafyllou, Stopping microplastic and microplastic pollution at source by installing novel technologies in river estuaries and waste water treatment plants: The CLAIM project, Front. Mar. Sci., 24 December 2021 | https://doi.org/10.3389/fmars.2021.738876

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Frontiers | Stopping Macroplastic and Microplastic Pollution at Source by Installing Novel Technologies in River Estuaries and Waste Water Treatment Plants: The CLAIM Project | Marine Science (frontiersin.org)

Training Module for Marine Microplastics Monitoring

http://www.yslmep.org/wp-content/uploads/2020/05/Training-Module-for-Marine-Microplastics-Monitoring-EN.pdf

[1] Jambeck, J. R., Geyer, R., Wilcox, C., Siegler, T. R., Perryman, M., Andrady, A., … Law, K. L. (2015). Plastic waste inputs from land into the ocean. Science, 347(6223), 768–771.

[2] Schmaltz, E., Melvin, E. C., Diana, Z., Gunady, E. F., Rittschof, D., Somarelli, J. A., … Dunphy-Daly, M. M. (2020). Plastic pollution solutions: emerging technologies to prevent and collect marine plastic pollution. Environment International, 144, 106067.

[3] Yin, K.; Wang, Y.; Zhao, H.; Wang, D.; Guo, M.; Mu, M.; Liu, Y.; Nie, X.; Li, B.; Li, J.; et al. A comparative review of microplastics and nanoplastics: Toxicity hazards on digestive, reproductive and nervous system. Sci. Total Environ. 2021, 774, 145758.

[4] Henderson, L., & Green, C. (2020). Making sense of microplastics? Public understandings of plastic pollution. Marine Pollution Bulletin, 152, 110908.

[5] Costanza R, De Groot R, Sutton P, Van Der Ploeg S, Anderson SJ, Kubiszewski I, Farber S, Turner RK. 2014 Changes in the global value of ecosystem services. Glob. Environ. Change 26, 152–158.

2.5 Useful links

Workshop: Training of Trainers on Monitoring and Assessment of Marine Plastics and Microplastics, 9-13 September 2019, Bali, Indonesia

Training of Trainers on Monitoring and Assessment of Marine Plastic Litter and Microplastics | Coordinating Body on the Seas of East Asia (COBSEA) (unep.org)

Manual - Training of Trainers on Monitoring and Assessment of Marine Plastics and Microplastics, 9-13 September 2019, Bali, Indonesia

Manual - Training of Trainers on Monitoring and Assessment of Marine Litter and Microplastics - 9-13 September 2019, Bali, Indonesia (unep.org)

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3. Module 2: Monitoring and managing marine ecosystems

3.1 Introduction - Objectives

This module will help in choosing the most appropriate marine monitoring method(s) in relation to the study objectives. The methods in this module are in line with ongoing international research and development into monitoring methods for the marine environment. The numerous ways in which these ecosystems are inter-connected and inter-dependent will also be discussed. Emphasis will be placed on indicators of stress that should be the focus of ecosystem health monitoring efforts. A broader context of managing these ecosystems will also be introduced. The class will examine management and advisory bodies of these ecosystems; how marine protected areas can be a tool for conservation and the impacts of these tools; engage stakeholders with design and implementation of management plans.

3.1.1 Learning Outcomes of the course

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

- Outline concepts and issues related to managing coastal and marine ecosystem and demonstrate the types and relevance of different monitoring methods in different scenarios.
- Conduct assessment and monitoring of coastal and marine habitats and species and prepare field reports.
- Be open to acquiring more knowledge on coastal and marine ecosystem relevant issues.
- Describe how long-term environmental monitoring programs are designed and conducted.
- Describe how monitoring results are used by the society and in research.
- Present the results for an environmental authority and the propose appropriate decisions and actions for a sustainable environment.

3.2 Syllabus

1. **Introduction**
   - 1.1. Definitions
   - 1.2. Design of marine monitoring programs
   - 1.3. Opportunities in marine monitoring
   - 1.4. Challenges in marine monitoring

2. **Monitoring and managing marine ecosystems**
   - 2.1. Aims and benefits of monitoring
   - 2.2. Designing monitoring programs
   - 2.3. Optimising monitoring methods
   - 2.4. Sampling natural systems

3. **Types of data collected**

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3.1. Marine data in perspective
3.2. Marine biological data
3.3. Marine physico-chemical data
3.4. Marine spatio-temporal data

4. Data Analysis
4.1. Use of Geographic Information Management systems
4.2. Statistics for spatial data
4.3. Monitoring biological oceanography from remote sensing
4.4. Ecosystem Modelling

5. Ecosystem Management
5.1. Management and Advisory Bodies
5.2. General Management Plans: Sea ranching & plantation
5.3. Restoration and Rehabilitation
5.4. Environmental Impact Assessment

6. Planning a successful study
6.1. Inheriting and adapting an existing study

7. Other considerations
7.1. Preventing the spread of marine pests
7.2. Health and safety
7.3. Data collection and storage

8. Key marine ecosystems
8.1. Benthic marine ecosystems
8.2. Pelagic marine ecosystems
8.3. Threats to marine ecosystems and management strategies

3.3 References

1. Md. Nazrul Islam, Sven Erik Jorgensen (eds), 2018. Environmental Management of Marine Ecosystems Copyright Year 2018, 1st Edition, ISBN 9780367571948, Published June 30, 2020 by CRC Press, 384 Pages 26 Color & 67 B/W Illustrations
2. C. R. Murthy, P. C. Sinha, Y. R. Rao, 2008. Modelling and Monitoring of Coastal Marine Processes, ISBN: 978-90-481-7844-5, Springer.

3.4 Other useful references

Noble-James, T., Jesus, A. & McBreen, F. 2018. Monitoring guidance for marine benthic habitats (Revised 2018). JNCC Report No. 598. JNCC, Peterborough.

Hill, D.; Fasham, M.; Tucker, G.; Shrewry, M.; Shaw, P. 2005: Handbook of biodiversity methods: survey, evaluation and monitoring. Cambridge University Press, Cambridge.

Kingsford, M.; Battershill, C. 1998: Studying temperate marine environments: A handbook for ecologists. Canterbury University Press, Christchurch.

Quinn, G.P.; Keough, M.J. 2002: Experimental design and data analysis for biologists. Cambridge University Press, Cambridge.

Schmitt, R.; Osenberg, C. 1996: Detecting ecological impacts: concepts and applications in coastal habitats. Academic Press, San Diego.

3.5 Useful links

Shane Geange, Debbie Freeman, Vincent Zintzen and Kath Blakemore, Introduction to Marine Monitoring, V1.0 (2016).

https://www.doc.govt.nz/globalassets/documents/science-and-technical/inventory-monitoring/im-toolbox-marine-introduction-to-marine-monitoring.pdf

Tropical Marine Ecosystems - Monitoring and Management SFS 3530 Syllabus , Summer I The School for Field Studies (SFS) The Center for Marine Resource Studies South Caicos, Turks and Caicos Islands (2018)

https://fieldstudies.org/wp-content/uploads/2018/12/TCI-Syllabus-SFS-3530-Tropical-Marine-Ecosystems-Monitoring-and-Management.pdf

Hindo-German Biodiversity Programme

https://www.indo-germanbiodiversity.com/detail-training-material-english-14.html

It also contains e-learning platforms. The course is interesting, complete and contains useful modules but its emphasis is on management and not on monitoring. It doesn't include useful Bibliography.

Marine inventory and monitoring

https://www.doc.govt.nz/our-work/biodiversity-inventory-and-monitoring/marine/

Marine Ecosystems Dynamics, Stockholm University

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https://www.su.se/english/search-courses-and-programmes/bl7056-1.430278?open-collapse-boxes=course-reporthttps://www.um.edu.mt/courses/studyunit/BIO5003,course-detail,course-time-table,course-material

https://sisu.it.su.se/pdf_creator/37751/52448/en

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4. Module 3: Monitoring climate change at sea and blue carbon

4.1 Introduction - Objectives

Climate change is a difficult, contentious, and important issue. It is defining environmental issue of the 21st century. This course aims to address the whole complexity of climate change as an issue, by bringing together the science, impacts, economics, abatement technologies, and policy solutions into one course. The main objectives of this module are the following:

1) How does climate work? How is the sea related to climate regulation? What has been changed in the last decades – Historical data showing changes. Climate modelling.
2) Climate change and life in the sea → How climate change affects marine life (including fisheries and vulnerable habitats).
3) What can we do about climate change? Sustainable adaptation and Management measures for coping with climate change. International and European directives and decisions regarding climate change.
4) What is the coastal blue carbon?
5) What methods are used to estimate blue carbon?
6) Which is the role of blue carbon in climate change mitigation?

4.2 Syllabus

1. Introduction

1.1. Oceans of the world and main physio-chemical characteristics
1.2. Ocean circulation and regulation of global climate
1.3. Marine carbon biogeochemistry
1.4. Global atmospheric circulation

2. Climate change and key issues in the marine environment

2.1. Climate change historical data
2.2. Primary productivity
2.3. Climate change impacts on marine invertebrates
2.4. The effects of ocean acidification on marine habitat
2.5. Cycling of water and nutrients
2.6. Disturbance from alien and alien invasive species
2.7. Bioindicators for investigation of the effect of climate change on aquatic ecosystems
2.8. The tropicalization phenomenon

3. Projections of future climate change

3.1. Introduction to climate modelling
3.2. Scenarios for future climate change
3.3. Intercomparisons of climate change model results
3.4. Sea level rise and projections
3.5. IPCC key findings

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3.6. Regional climate downscaling – dynamic approach
3.7. Statistical downscaling and bias correction
3.8. Observed and future climate change in the ocean

4. Blue carbon and climate change
4.1. Fluxes pf carbon dioxide in blue carbon ecosystems
4.2. Global blue carbon stocks
4.3. Measuring blue carbon stocks
4.4. Future Challenges: filling knowledge gaps

5. International and European agreements on climate change and blue carbon
5.1. Aims, Implementation, Gaps
5.2. Protocols, Agreements, Reports

6. Blue carbon ecosystems
6.1. Types of carbon
6.2. Blue carbon ecosystems
6.3. Soil and biomass carbon

4.3 References

1. Marine Ecosystems and Global Change. Barange M., Field J. G., Roger P. Harris, Eileen E. Hofmann, R. Ian Perry, and Werner F., Oxford Scholarship Online: May 2010.
2. Marine Biology (11th Edition), Castro P. and Huber M., Publication Date). McGraw-Hill Education (Publisher), 2018.
3. COASTAL BLUE CARBON, methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrass meadows. Howard, J.; Hoyt, S.; Isensee, K.; Telszewski, M.; Pidgeon, E.; (eds), 2014, International Union for Conservation of Nature (IUCN)
4. DHI July 2016 - Marine Climate Change Guidelines

4.4 Other useful references

Jennifer Frankel-Reed, Barbara Fröde-Thierfelder, Ilona Porsché, Alfred Eberhardt, Mark Svendsen, Integrating climate change adaptation into development planning A practice-oriented training based on an OECD Policy Guidance. Training Manual. Adapted for Marine and coastal environments. Eschborn, 2016

Hilmi N, Chami R, Sutherland MD, Hall-Spencer JM, Lebleu L, Benitez MB and Levin LA (2021) The Role of Blue Carbon in Climate Change Mitigation and Carbon Stock Conservation. Front. Clim. 3:710546. doi: 10.3389/fclim.2021.710546

Howard, J., Hoyt, S., Isensee, K., Pidgeon, E., Telszewski, M. (eds.) (2014). Coastal Blue Carbon: Methods for assessing carbon stocks and emissions factors in mangroves, tidal salt marshes, and seagrass meadows. Conservation International, Intergovernmental Oceanographic Commission of UNESCO, International Union for Conservation of Nature. Arlington, Virginia, USA.

4.5 Useful links

https://oceanservice.noaa.gov/facts/carbon-cycle.html

https://earthobservatory.nasa.gov/features/CarbonCycle

https://www.whoi.edu/press-room/news-release/the-oceans-biological-pump-captures-more-carbon-than-expected/

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