KERALA UNIVERSITY OF FISHERIES AND OCEAN STUDIES

Panangad, Kochi- 682506, Kerala

M.Sc. Marine Biology

OBE Syllabus

2024

Kerala University of Fisheries and Ocean Studies

M.Sc. in MARINE BIOLOGY

Regulations, Eligibility Scheme and Syllabus

The M.Sc. in Marine Biology program, rebranded in alignment with national standards, was originally launched in 2012 under the School of Ocean Science and Technology. Spanning four semesters, this two-year course provides students with a comprehensive understanding of marine biodiversity, its ecological interactions, and adaptations across various marine environments. Fieldwork forms a core component of the curriculum, focusing on collection methodology, identification, sampling techniques, and research design related to major marine groups, including fishes, invertebrates, reptiles, mammals, and marine algae.

Supplementing field studies, students engage in lectures, laboratory work, discussions, and readings to reinforce their knowledge and skills. An independent research project in the fourth semester allows for deeper exploration of specific interests within marine biology. This hands-on approach equips students with the practical skills necessary for effective research and assessment in the field.

Career opportunities for graduates in Marine Biology are vast and diverse, encompassing roles in education, research, and industry. Graduates can pursue positions in academic institutions, governmental and non-governmental research organizations, and the aquaculture sector. The program also offers entrepreneurial avenues in aquaculture and ornamental fish culture. Given the growing importance of marine ecosystems and the significant demand for skilled professionals, the M.Sc. in Marine Biology is highly relevant, preparing students to become effective scientists, educators, and entrepreneurs dedicated to marine biodiversity conservation and management.

1. Eligibility Criteria

B.Sc with 50% or 6.5/10.0 or 2.24/4.0 marks in any of the following subject combinations.

B.Sc in Zoology/ B.Sc in Aquaculture/B.Sc in Industrial Fish and Fisheries/BFSc/BFSc (N)/B.Sc in Microbiology/B.Sc in Zoology / Botany/Chemistry/ B.Sc in Life Science/B.Sc in Biotechnology/B.Sc in Bio – Informatics/ B.Tech Bio- Informatics

1a. Assessment and Standards of Passing

The evaluation of the students in a course shall be based on his/her performance in various examinations, term papers/assignments/ student seminars/records/case study and project reports. Assessment will be based on both internal and external evaluation

1b. No of Seats:

25

2. Process Of Admission

Candidates for admission will be selected on the basis of entrance examination conducted by Kerala University of Fisheries & Ocean Studies

3. Programme and Scheme of Examination

3.a The Structure of the Programme

Sl. No.	Particulars	Programme
1	Duration programme	4 semesters
2	Accumulated minimum Credits required for successful completion of the programme	90
3	Minimum Credits required	75%

The course offers a total of 28 core papers including practical papers, 9 elective papers, 13 open elective/MOOC courses under choice-based credit system and one dissertation work during the course. The course consists of 16 Core courses 3 Elective courses in theory, 2 open elective courses/ MOOC, 12 practical courses and one field trip/study tour. Final Semester is devoted fully for dissertation. Total credit is 90.

The Vice- Chancellor shall condone up to 10% of the shortage, if the candidate applied with necessary supporting evidence and remitting a fee of Rs. 1,000/- on the recommendation of the Director/Head of the Department of the School.
Each semester shall have a maximum of 110 working days, which includes actual class days and examination days

3b. Scheme of Evaluation

The performance of the students shall be evaluated through internal and external assessment in the case of theory papers. The ratio of internal and external assessment will be 50:50. Internal assessment will be through internal written examinations, assignments, student seminars, percentage of attendance etc., by the course teacher(s) concerned. The University shall conduct external examination and there will be double valuation in each and the average of the two will be counted as mark for the final examination. If there is a difference of more than 10% between first and second valuations, third valuation will be conducted by the passing board of Examinations and that will be final mark. The passing board will be constituted by the Honb'le Vice Chancellor from the list of external and internal examiners appointed for the valuation of answer paper of the final external examination. There will be no provisions for revaluation of answer script at any stage. However, the students can apply for recounting of the marks for which candidates have to remit a fee of Rs. 300/- per paper or any other amount as decided by the University from time to time. The passing board may decide to give moderation subject to a maximum permission for each paper and in total for a pass to secure certain percentage of pass if necessary. However, the maximum marks awarded to a student should not exceed '5' per semester.

A separate minimum of 50% of marks for internal and external examinations shall be secured by the candidates for a pass.

The evaluation of a course shall be indicated by grade points ranging from 0-10. The total combined marks of a course divided by 10 will give the grade point which has to be rounded to the first two decimal places. Average of the grade point of all the courses in respective semesters shall be the GPA for the semester.

The evaluation scheme for each semester contains two parts, an internal assessment and an external examination. All practical examinations will be internally evaluated as per the procedures.

A student has to obtain a minimum OGPA of 5/10 in the first two semesters, with a pass in each paper, in order to register for the 4^{th} semester.

4. Evaluation and Grading**

Marks %	Classification
<50 %	Failed (Grade Point <5)
50 to 59%	Second Class (Grade point of 5 and <6)
60 to 74%	First Class (Grade point of 6 and <7.5)
>75%	First class with distinction (Grade point of 7.5 and above)
** Fractions of marks will be rounded to the nearest number.	

A Schedule of the internal examinations shall be prepared by the Director/HoD as the case may be, notified to the students at the beginning of each semester. Supplementary examination for mid- term shall be conducted only with the prior approval of the Vice Chancellor on very special cases. It will be sanctioned only in exceptional cases and after very careful scrutiny. Answer scripts of internal examinations evaluated by the teacher shall be shown to the students within 15 days after to the conduct of the examination. Rank, medals, etc will be awarded for those candidates who successfully complete the course in the first attempt within the stipulated period as per regulation. The first rank will be awarded to the student who secures the highest OGPA, provided that the candidate secures grade point 7.5/10 or more.

Repetition of courses: A student who has not secured the minimum of 50% marks in a course may appear for re-examination of that course in a subsequent semester. Whenever the course is offered. If a student is absent in internal examinations, on genuine grounds supplementary examination may be sanctioned by the Vice – Chancellor as a very special case as he desires so, on the request of student.

Late arrival in examinations: Student will not be allowed to enter the examination hall after 30 minutes of commencement of the examination and to leave the examination hall within one hour after the commencement.

3a. Internal Evaluation

Two internals with 25 marks each need to be conducted preferably one internal at the middle of the semester and the other at the end of the semester, the average of the two is to be taken.

The Schematic wise for internal evaluation is given below:

Component	Weightage
Two internals (25 mark each, the average is to be taken)	25
Assignments	10
Seminar	5
Classroom performance	5
Attendance	5*
Total	**50**
*>90 (5 mark); 85-89 (4 marks); 80-84 (3 marks);75-79 (2 marks)	

3b. Practical Examination (Internal)

Component	Weightage
Practical	60
Record	20
Viva Voce	20
Total	**100**

3c. External Examination 50 marks

3d. Project /Dissertation work

The student will devote the first three semesters for course work and the final semester for dissertation/ project work related to a relevant area of specializations.

Any of the faculty from the list of Faculty (Both regular and contract faculty of KUFOS) can be the supervising guide.

The student shall prepare and submit the dissertation/project report (three copies) printed (A4 size) and hard bound to Head of the Department. The plan of the Dissertation/project report shall be as decided by the Board of Studies/Academic Council from time to time.

For the evaluation of the Dissertation/Project Report, a Board will be constituted by the Head of the Department. The Board shall consist of the Project Guide, External Examiner(s) and the Head of Department concerned.

The Dissertation/ Project report shall be subject to double valuation: One by internal faculty, that is, the Guide, and the other by an external examiner. The average of these two marks shall be marks of the Dissertation/Major Project report to be awarded to the student. Maximum marks are 100. As far as possible, the external evaluation shall be done by external member of the Board of Viva –voce after its constitution.

In unavoidable circumstance, the student can submit the project report as late submission with a late of fee of Rs.500/- However, the maximum permission time for late submission shall not exceed one month.

Distribution of weightage allotted for dissertation will be as follows:

Component	**Internal Evaluation Marks**	**External Evaluation Marks**
Thesis	80	80
Presentation & Viva-voce	20	20
Total	100	100

Final mark is the Average of internal and external evaluation (100).

3e. Dissertation - Thesis Pattern

1. Title page
2. Declaration by candidate
3. Certificate from Guide
4. Certificate from Head of the Department& Countersigned by Internal & External Examiners
5. Acknowledgement
6. Table of contents
7. List of Tables
8. List of Figures
9. Abbreviations
10. Abstract – 1 page
11. Introduction - (5-10 pages, includes introduction of the topic, scope and objectives of the study)
12. Review of Literature
13. Materials and Methods
14. Results & Discussion
15. Summary
16. References
17. Appendix, if any
18. Publications if any
19. Reference citation pattern- as that of Aquaculture Journal (Elsevier)

Maximum number of pages should be between 50-100 pages (from Introduction to References) excluding graphs & Tables.
Font – Times New Roman, Arial or Bookman Old Style
Line space – Double space for text
Font Size – 12 for text, 14 for subtitle (Bold), 16 for title (Bold)..

KUFOS

M.Sc. Marine Biology Programme

Program Specific Outcomes (PSO)

The Marine Biology program at Kerala University of Fisheries and Ocean Studies (KUFOS) aims to equip students with a comprehensive understanding of marine ecosystems, marine organisms, and conservation strategies, while fostering scientific inquiry and ethical responsibility.

1. **Basic and Advanced Knowledge**

Students will acquire a solid foundation in core and advanced marine biology concepts, including ecology, biodiversity, and oceanography, preparing them for further study and research.

2. **Marine Surveying and Laboratory Techniques**

Students will gain expertise in marine surveying methods, including habitat mapping, habitat monitoring, species identification, water sampling, and specimen collection, along with laboratory techniques such as genetic analysis and microscopy to study marine biodiversity.

3. **Marine Conservation and Management**

Students will learn about sustainable marine resource management, conservation strategies, and the role of marine protected areas in preserving biodiversity.

4. **Data Collection and Analysis**

Students will gain expertise in collecting, analyzing, and interpreting marine data using bioinformatics, GIS, and statistical tools to assess marine ecosystems and biodiversity.

5. **Applications in Marine Science**

Students will explore the practical applications of marine biology in areas such as aquaculture, biotechnology, coastal management, and fisheries science for real-world problem solving.

6. **Marine Policy and Regulatory Knowledge**

Students will understand marine regulations and policies at both national and international levels, ensuring effective conservation and sustainable resource use.

7. **Ethical and Environmental Considerations**

Students will be trained to consider ethical implications of marine research, focusing on issues such as marine pollution, climate change, and the protection of endangered species.

8. **Research and Innovation in Marine Biology**

Students will learn the research process, from hypothesis formulation to experimentation, promoting innovation in marine biology research and conservation efforts.

9. **Problem-Solving and Critical Thinking**

Students will develop critical thinking skills to address challenges in marine ecosystems, devising innovative solutions to issues like habitat degradation and species conservation.

10. **Communication and Collaboration Skills**

Students will effectively communicate marine biology concepts and collaborate in interdisciplinary teams, enabling them to contribute to diverse marine science projects.

M.Sc. Marine Biology-Course Structure, Scheme & Syllabus

(Credit semester System-2020 Admission onwards)

SEMESTER - I							
Course code	**Course Title**	**Course Sessions**	**Credit**		**Exam duration (hrs).**	**Internal (%)**	**External (%)**
		Hrs.		**Total**			
Core Courses							
MB 2101	Physical, Chemical and Geological Oceanography	3	3	19	3	50	50
MB 2102	Marine Biology	3	3		3	50	50
MB 2103	Taxonomy, Evolution and Speciation	3	3		3	50	50
MB 2104	Cell Biology & Genetics	3	3		3	50	50
MB 2105	Physiology & Biochemistry	4	4		3	50	50
MB 2106	Molecular Biology & Instrumentation	3	3		3	50	50
Elective Courses							
MB 2107	Coral Reef and Mangroves - Ecology and Management	2	2	3	3	50	50
MB 2108	Climate Change Impacts	2	2		3	50	50
MB 2109	Bioinformatics	2	2		3	50	50
Practical courses							
MB 2110	Physical, Chemical & Geological Oceanography	-4	1	4	3	100	--
MB 2111	Biochemistry & Physiology	-4	1		3	100	--
MB 2112	Cell & Molecular Biology	4	1		3	100	--
MB 2113	Marine Biology	4	1		3	100	--
***Total Credit load for I Semester:* 25**							

SEMESTER - II							
Course code	**Course Title**	**Course Sessions**	**Credit**		**Exam duration (hrs).**	**Internal (%)**	**External (%)**
		Hrs.		**Total**			
Core Courses							
MB 2201	Marine Planktonology, Algology & Benthos	4	3	15	3	50	50
MB 2202	Concepts of Ecology& Ecological Dynamics	3	3		3	50	50
MB 2203	Biodiversity – Principles, Conservation and Management	3	3		3	50	50
MB 2204	Fish Biology	3	3		3	50	50
MB 2205	Marine Microbiology	3	3		3	50	50
Elective Courses							
MB 2206	Fish Health Management	2	2	2	3	3	50
MB 2207	Fishing Techniques and their Impacts	2	2		3	50	50
MB 2208	Remote Sensing and GIS	2	2		3	50	50
Open Elective Courses / MOOC							
OST 2201	General Oceanography	3	3	3	3	50	50
OST 2202	Environment & Biodiversity*	3	3		3	50	50
OST 2203	Marine Biotechnology	3	3		3	50	50
OST 2204	Marine Drugs	3	3		3	50	50
OST 2205	Climate Change and Polar Science	3	3		3	50	50
OST 2206	IPR and GI	3	3		3	50	50
Practical courses							
MB 2209	Marine Planktonology, Algology & Benthos	4	2	6	3	100	--
MB 2210	Fish Biology	4	1		3	100	--
MB 2211	Marine Biodiversity	4	1		3	100	--
MB 2212	Marine Microbiology	4	1		3	100	--
MB 2213	**Study Tour**		1			100	--
***Total Credit load for II Semester:* 26**							

SEMESTER - III							
Course code	**Course Title**	**Course Sessions**	**Credit**		**Exam duration (hrs).**	**Internal (100%)**	**External (100%)**
		Hrs.		**Total**			
Core Courses							
MB 2301	Marine Bio-prospecting & Biotechnology	3	3	15	3	50	50
MB 2302	Marine Pollution & Toxicology	3	3		3	50	50
MB 2303	Marine Fisheries & Aquaculture	3	3		3	50	50
MB 2304	Marine Resource Management and Ecosystem Modelling	4	3		3	50	50
MB 2311	Biostatistics & Research Methodology	3	3		3	50	50
Elective Courses							
MB 2305	Ocean Policy & Education	2	2	2	3	50	50
MB 2306	Integrated Coastal Zone Management	2	2		3	50	50
MB 2307	Seafood Technology	2	2		3	50	50
Open Elective Courses / MOOC							
OST 2301	Coastal Oceanography	3	3	3	3	50	50
*OST 2302	Ornamental Fishes and Aquarium Maintenance	3	3		3	50	50
OST 2303	Fundamentals of Molecular Biology	3	3		3	50	50
OST 2304	Instrumentation Techniques	3	3		3	50	50
OST 2305	Marine Geology	3	3		3	50	50
OST 2306	Food Safety and Quality Control	3	3		3	50	50
OST 2307	Marine Chemistry	3			3	50	50
Practical courses							
MB 2308	Marine Pollution & Toxicology	4	2	4	3	100	--
MB 2309	Biotechnology & Instrumentation	4	1		3	100	--
MB 2310	Marine Resource Management and Ecosystem Modelling	4	1		3	100	--
MB 2312	Biostatistics & Research Methodology	4	1		3	100	--
						Total Credit load for III Semester: **24**	

SEMESTER IV		
Course code	Course Title	Credit
MB 2401	Project	15
		Total Credit load for IV Semester: **15**

Total Credit load for M.Sc. Marine Biology	**25+26+24+15= 90**

SEMESTER – I

CORE COURSES

Course Name	**Physical, Chemical and Geological Oceanography**		
Course code	**MB 2101**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To comprehend the history and progress of oceanography**	**U/R**	**1,6**
2	**To analyse the fundamentals of oceanographic processess**	**An**	**1,4**
3	***To* analyze the complex interactions between physical, chemical, geological, and biological processes in the ocean**	**An**	**1,4,9**
4	**To integrate knowledge from various oceanographic disciplines to explain global circulation patterns, climate systems, ecosystem dynamics, and biogeochemical cycles.**	**E**	**1,3,4**
5	**To apply knowledge of oceanographic principles and processes to interpret data, evaluate marine environmental challenges**	**A**	**3,5,9**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			
Unit No	**Unit Content**	**CO No.**	
I	History of Oceanography, Major expeditions, Fundamentals of Physical Oceanography and Meteorology: Physical properties of sea water – distribution in space and time of temperature, salinity, density, pressure. T-S diagram and water masses.	**1**	
II	Global and regional circulation; major wind systems; Carioles effect; El Nino; La Nina; IOD, Ekman transport; Rossby and Kelvin waves; Findlater jet; ocean currents; waves and tides; upwelling, down welling and convective mixing; air-sea interaction. Water cycle, clouds, warm and cold core eddies and fronts. Remote forcing. Overview of monsoon. Physical environment of deep sea.	**2,3,4,5**	
III	Fundamentals of Marine Geology: The ocean floor – bathymetry. Structure and origin of ocean basins, sea floor spreading, plate tectonics, continental shelves, slopes, continental margins, submarine canyons, trenches, guyots, ocean ridges, geothermal vents. Marine sediments – types and distribution. Methods of exploring the ocean floor. Marine sediments, oozes, Beach profiling, coastal features.	**2,3,4,5**	
IV	Fundamentals of Chemical Oceanography: Elemental composition of seawater, chemical properties of seawater, distribution of dissolved gases, major and minor elements,	**2,3,4,5**	

	nutrients. Carbon, nitrogen, phosphorus and silicon cycles in marine environment, C:N:P Ratio. Oxygen Minimum Zone (OMZ) and its significance in marine ecosystem.	
V	Bio-geo-chemical interactions in Arabian Sea and Bay of Bengal - Effects of physical and chemical parameters on marine organisms - Phytoplankton, Zooplankton, Nekton and Benthos. Primary and secondary production. Role of microbes in nutrient cycling, microbial loop.	**2,3,4,5**

Text books and References

- Barnabe, G. and Barnabe-Quet, R. 2000. Ecology and Management of Coastal Waters: The Aquatic Environment. Springer – Praxis Books in Aquaculture and Fisheries, UK, 396 pp.
- Eugen Seibold, Wolfgang Berger. 2017. The Sea Floor: An Introduction to Marine Geology. Springer International Publishing.272 pp.
- Ittekkot, V. and Nair, R.R. (Eds.) 1993. Monsoon Biogeochemistry SCOPE/UNEP International Carbon unit, University of Hamburg, Hamburg, Germany: 193pp.
- John H. Steele, Steve A. Thorpe, Karl K. 2010. Turekian. Elements of Physical Oceanography: A derivative of the Encyclopedia of Ocean Sciences. Academic Press 658 pp.
- Jon Erickson, Timothy, Ph.D. Kusky. 2002. Marine Geology: Exploring the New Frontiers of the Ocean. Facts on File 333 pp.
- Kennish, M. J., 2001. Practical Handbook of Marine Science, Third Edition. CRC Press: 876 pp.
- Lalli, C. M. and Parsons, T.R., 1997. Biological Oceanography: An Introduction, 2nd Edition. The Open University, Butterworth-Heinemann, Oxford: 314 p.
- Meadows, P.S and Campbell, J.I., 1993. An Introduction to Marine Science, Blackie Academic & Professional, London: 285 p. Millero, F.J. and Sohn, M.L., 1992. Chemical Oceanography, CRC Press, Boca Raton: 531 pp.
- Millero, Frank J. 2013. Chemical Oceanography, Fourth Edition CRC Press 594 pp.
- Neumann, G. and Pierson, W.J., 1966. Principles of Physical Oceanography. Prentice-Hall Inc., New Jersey Norton W.H., 2004. The Elements of Geology. Kessinger Publishing. 272pp.
- Pond, S., and Pickard. G.L. 1983. Introductory Dynamical Oceanography. 2nd ed. Pergamon Press, Oxford: 329 pp.
- Pickard G.L., and W.J. Emery. 1990. Descriptive Physical Oceanography: An Introduction. 5th enlarged ed. Oxford: Pergamon Press.
- Riley J.P. & R. 1971. Chester. Introduction to marine chemistry. London, New York, Academic Press, 465 p
- Riley J.P. & R. 1976. Chemical Oceanography. Academic Press 425 pp.
- Robert H. Stewart. Introduction to Physical Oceanography Sears, M. and Merriman, D. (Eds.) 1980. Oceanography: the past. 812pp. Secaucus, N. J.: Springer-Verlag New York, Inc.
- Sverdrup, H.U., Johnson, M.W., and Fleming, R.H. 1942. The Oceans: their Physics, Chemistry, and General Biology: Prentice-Hall Inc: 1087 pp.

Course Name	**Marine Biology**
Course code	**MB 2102**

CO No.	**Expected Course Outcome**	**Learning Domains**	**PO. No.**
1	**To explain the types and divisions of various marine habitats**	**U/R**	**1,2**
2	**To define the major marine plants, the characteristics that distinguish them across broad taxonomic and habitat ranges**	**U/R**	**1,2**
3	**To define the major marine invertebrates the characteristics that distinguish them across broad taxonomic and habitat ranges**	**U/R**	**1,2**
4	**To define the major marine vertebrates the characteristics that distinguish them across broad taxonomic and habitat ranges**	**U/R**	**1,2**
5	**To analyze marine biodiversity and conservation challenges and promote global biodiversity conservation.**	**An**	**3,7,9**

***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**

Unit No	**Unit Content**	**CO No.**
I	Introduction to Marine Biology. Oceanographic studies in India. Ocean as a habitat, Classification of marine environment, Life in the Sea - factors affecting marine life, patterns of distribution and adaptations. Marine plants - cyanobacteria, chrysophyta,dinophyta, chlorophyta. Seaweeds - classification and distribution. Sea grasses and mangroves.	**1,2**
II	Classification and biology of marine invertebrates. Porifera - General characters, classification, and examples. Cnidarians - General characters, classification, and examples. Coral reefs - types, theories of formation and distribution. Polychaetes - General characters, classification and examples. General characters, morphology and distribution of Nemertinea, Entoprocta, Ectoprocta, Phoronida, Pogonophora, Sipunculaand Brachiopoda. Chaetognatha. Economically important forms in each taxon.	**3**
III	Crustacea - General characters, classification, comparative morphology. Crustacean appendages, larval forms, evolution, distribution with examples. Mollusca - Classification, general characters with reference to bivalves, gastropods and cephalopods.	**3**

	Echinodermata- General characters, classification and examples. Economically important forms in each taxon.	
IV	Marine vertebrates: Prochordata - Classification and comparative morphology, reproduction and early development, larval metamorphosis. Pisces - Cartilaginous and bony fishes: General characters, Classification and distribution.	**4**
V	Marine reptiles - Adaptive radiation of marine reptiles – sea snakes and turtles. Marine birds – General characters, adaptation and importance of coastal and marine birds.	**4**
VI	Marine mammals - General characteristics, classification and evolution of cetaceans and sirenians. Distribution, adaptations and importance. Endangered marine mammals. Conservation strategies.	**4,5**

Text books and References

- CMFRI. 2010. Marine Mammal Research and Conservation in India. Central Marine Fisheries Research Institute, Cochin: 20 pp.
- George Karleskint, Richard Turner, James Small. 2009. Introduction to Marine Biology. Brooks Cole 598 pp.
- Hyman, L., 1967. Invertebrate Zoology. Vols. I to IV. McGraw Hill Books Co., New York.
- John F. Morrissey and James L. Sumich. 2012. Introduction to the Biology of Marine Life. Jones & Bartlett Learning
- Levinton, J.S., 2009. Marine Biology: Function, Biodiversity, Ecology. Third Edition. Oxford University Press, Oxford, UK: 640 pp.
- Peter Castro and Michael Huber. Marine Biology. 11th Edition (2018). McGraw – Hill Education. 496pp.
- Philip V. Mladenov. 2013. Marine Biology: A Very Short Introductio. Oxford University Press, USA 144 pp.
- Reynolds, J.E. and Rommel, S.A. (Eds.). 1996. Biology of Marine Mammals. Smithsonian Institution Press, Washington, D.C. 896 pp.
- Schreiber, E.A. and Burger, J. (Eds.) 2001. Biology of the Marine Birds, CRC press: 722 pp.
- Steele, J.H., Thorpe, S.A. and Turekian, K.K. (Eds.) 2010. Marine Biology: A Derivative of the Encyclopedia of Ocean Sciences, Academic Press: 630 pp.
- https://marinebio.org/creatures/marine-biology/
- https://ocean.si.edu/category/lesson-plan-subject/marine-biology

Course name	**Taxonomy, Evolution and Speciation**		
Course code	**MB 2103**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To analyze the historical development and key features of taxonomic systems.**	**An**	**1,9**
2	To describe and apply conventional taxonomic methods **to classify and identify species**	**R,U, A**	**2,4**
3	**To describe shellfish and finfish taxonomy**	**R,U**	**1,2**
4	**To apply standardized methods for collection and preservation of samples**	**A**	**2,4**
5	**To analyse the processes, laws, and theories related to evolution**	**An**	**1,9**
6	**To examine speciation processes and phylogenetic analysis**	**U/R, An**	**1,8**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	**Unit Content**	**CO**
I	Basic principles of taxonomy and phylogeny: History of taxonomy, nomenclature. International Code of Nomenclature: salient features, principles, important rules and recommendations, Provisions for the governance of the Code. Taxonomic hierarchy.	**1**
II	Conventional taxonomic methods - morphometric measurements and meristic counts - truss morphometry. E.g. crustaceans and fishes. Taxonomic keys. Phylogenetic studies: Cladistics in taxonomy, cladogram, characters used for phylogeny reconstruction.	**2**
III	Shellfish and finfish taxonomy. Taxonomic characters of molluscs, decapods crustaceans (prawns and crabs) and fishes. Classification up to families. Collection, preservation, labelling and curation methods of major phyla: Sponges, annelids, molluscs, arthropods, echinoderms, fishes, reptiles and birds.	**3,4**
IV	Concept of Evolution. Lamarckism, Darwinism, Natural selection, NeoDarwinism and Mutation theory. Variations-nature and types. Mechanisms that decrease and increase variations (natural selection, genetic drift, mutation, recombination and gene flow). Speciation: modes of speciation – allopatric/sympatric speciation, eco-phenotypic variation, isolating mechanisms, speciation in time.	**5,6**
V	Macro and micro-evolution: definitions, mechanisms and importance. Phylogeny: introduction and concepts of phylogeny. Phylogenetic trees, cladistics and phylogenetic reconstructions, hierarchy of species, transitional forms and molecular phylogeny	**5,6**

Text books and References

- Crist, D.T. Scowcroft, G. and Harding Jr., J.M. 2009. World Ocean Census; a Global Survey of Marine Life, Firefly Books, New York: 256 pp.
- Guido di Prisco, Peter Convey (auth.), Guido di Prisco, Cinzia Verde (eds.). 2012. Adaptation and Evolution in Marine Environments, Volume 1: The Impacts of Global Change on Biodiversity. Springer-Verlag Berlin Heidelberg 236 pp.
- Hewitt, G.M., Johnston, A. and Young, J.P.W. (Eds.) 1991. Molecular Techniques in Taxonomy, Springer-Verlag: 410 pp.
- Mayr, E. and Ashlock, P.D. 1991. Principles of Systematic Zoology. McGraw-Hill, New York: 475 pp.
- Quicke, Donald L.J. 1993. Principles and Techniques of Contemporary Taxonomy, Blackie Academic & Professional, London: 331 pp.
- Schuh, R. T. and Brower, A. V. Z. 2009. Biological Systematics: Principles and Applications (2ndedn.). Cornell University Press: 311 pp.
- Venkataraman K & C. Sivaperuman. 2014. Marine Faunal Diversity in India: Taxonomy, Ecology and Conservation. Academic Press 546 pp.
- Winston, Judith E. 1999. Describing Species: Practical Taxonomic Procedure for Biologists, Columbia University Press, New York
- https://marinebio.org/creatures/marine-biology/marine-taxonomy/
- http://www.marinespecies.org/
- https://www.sciencelearn.org.nz/resources/140-classifying-marine organisms

Course name	**Cell Biology & Genetics**		
Course code	**MB 2104**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To Build a perspective on the cellular and molecular level organization of organisms**	**E**	**1,8**
2	**To compare and analyze the processes of cell cycle, cell division and molecular division**	**U, An**	**1,4**
3	**To explain the concepts of gene regulation in E coli**	**R, U**	**1**
4	**To Analyse the use of different tools and techniques of gene cloning**	**An**	**2,4,8**
5	**To comprehend the recent trends in cell biology**	**An, R/U**	**1,8**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			
Unit No	**Unit Content**	**CO**	
I	Introduction to Cell. Cell wall, composition, function. Plasma membrane, structure, function, fluid mosaic, model, membranes, lipids and protein transport across the membranes- passive, active; phagocytosis, endocytosis, role of clatherin coated vesicles. Endoplasmic Reticulum, Golgi complex exocytosis Lysosomes: phagocytosis, endocytosis. Structure of mitochondria and organization of respiratory chain; Structure of nucleus- nucleolus, nuclear membrane, transport across nuclear membrane. Organization of endomembrane system.	**1**	
II	Molecular aspects of cell division and cell cycle, regulation of cell cycle events, apoptosis, necrosis. Extracellular Matrix, collagen, proteoglycans, fibronectin, laminins, integrins, selectin, cadherins, role of tight junctions and gap junctions, role of G- proteins coupled receptors, cAMP, tyrosine kinase in cell signal transductions. Recent Trends in Cell Biology	**2,5**	
III	Evidence of DNA as genetic material- gene as a unit of mutation and recombination. Molecular nature of the gene, organization of prokaryotic and eukaryotic genomes replication of DNA- role of different enzymes and accessory proteins in prokaryotic and eukaryotic DNA replication.	**1**	
IV	DNA Replication: conservative, semi conservative, rolling circle, Cairn s model of replication. mechanism of replications: okazaki fragments, role of different enzymes and accessory proteins. Specific examples of replication single stranded phage, double stranded.	**2**	

V	Regulation of gene expression in prokaryotic and eukaryotic organisms; post-transcriptional regulation; the structure, formation and function of microRNAs; process of translation control. Cloning, gene mapping, sequencing, chromosomal mapping	**4**

Text books and References

- AVSS Sambamoorthy 2009 Genetics , Second Edition. Narosa New Delhi.
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- Cooper, G. M., & Hausman, R. E. 2009. The cell: A molecular approach. Washington DC, ASM Press.
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- George Plopper, David Sharp, Eric Sikorski, Benjamin Lewin. 2013. Lewin's Cells. Jones and Bartlett Publishers, Inc. 1080 pp.
- Jane B. Reece, Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky, Robert B. Jackson, Fiona E. Rawle, Dion G. Durnford, Chris D. Moyes, Kevin Scott, Sandra J. Walde. 2018. Campbell Biology, Second Canadian Edition Pearson 1553 pp.
- Jocelyn E. Krebs, Elliott S. Goldstein, Stephen T. Kilpatrick. Lewin's Genes X.
- Sudbury, Mass. : Jones and Bartlett, 2011. P.K. Gupta, Genetics. Rastogi publications. P.S. Verma, V.K. Agarwal. 2004. Cell Biology, Genetics, Molecular Biology, Evolution and Ecology. S. CHAND & COMPANY LTD. 1291 pp.
- Pollard T.D., W. C. Earnshaw, J. Lippincott-Schwartz, G. T. Johnson. 2016. Cell Biology. Elsevier 900 pp.

Course name	**Physiology & Biochemistry**		
Course code	**MB 2105**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To comprehend the neuro and physiological processes in animals and fishes**	**R/U**	**1,4**
2	**To analyse the growth and regulatory factors of growth in fishes and decapod crustaceans**	**An**	**1,9**
3	**To investigate the biorhythm and physiological adaptation sin fishes**	**R/U**	**1,4**
4	**To comprehend the structure of micro and macro biomolecules**	**R/U**	**1,4**
5	**To apply various biochemical methods in biochemical research for separation, quantifying and characterizing biological compounds.**	**A**	**2,5**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	**Unit Content**	**CO**
I	Introduction to Animal Physiology. Digestion and Respiration. Functional anatomy of digestive system. Digestion and absorption. Neuroendocrine regulation of gastro – intestinal movements and secretions. Breathing movements and exchange of respiratory gases at the pulmonary surface. Respiratory quotient Respiratory Pigments – chromoproteins, Transport of respiratory gases - transport of oxygen and carbon dioxide, Bohr effect and Haldane effect. Neural and hormonal control of breathing. Respiratory acidosis and alkalosis and regulation of blood pH.	**1**
II	Circulation and Excretion. Cardiac physiology: physiology of heartbeat, Rhythmicity, and diseases associated with heart. Components of blood and functional significance. Cascade of biochemical reactions (factors) involving in blood coagulation. Functional anatomy of mammalian kidney and its renal units. Physiology of urine formation. The significance of Henley's loop. Role of hormones in renal physiology. Formation of nitrogenous excretory products NH 3, Urea & Uric acid.	**1**
III	Neuro – Muscular Physiology. Structure of neuron, Fundamentals of nerve impulse- resting potential, Action potential, role of ion channels. Types of synapses- electrical and chemical, gap junctions, ligand gated channels and the Mechanism of synaptic transmission, cholinergic and	**1**

	adrenergic, Neuromuscular junction. Types of muscles: striated, non-striated and cardiac muscles. Ultra structure of striated muscle. Muscle contraction – Muscleproteins, sliding filament theory, Energetics of muscle contraction.	
IV	General outline on Feeding, Excretion, Respiration and reproduction. Growth of fishes – factors affecting growth. Moulting and growth in decapod crustaceans – regulatory factors. Environmental factors responsible for biorhythms; significance of biorhythms. Physiological adaptations in fishes.	**1,2,3**
V	Biochemical basis of life. Significance of macromolecules and micromolecules, carbohydrates, proteins, lipids and nucleic acids. Chemistry of carbohydrates and their metabolism- structure and functions of monosaccharides, oligosaccharides and polysaccharides- glycolysis, citric acid cycle, HMP pathway, gluconeogenesis, glycogen synthesis and glycogenolysis. Classification and chemistry of lipids: structure and functions of triglycerides, phospholipids, glycolipids, significance of PUFA. Metabolism of fatty acids. Classification of Proteins and their functions- structure of proteins, essential and non-essential amino acids - chemistry, catabolism, urea cycle, biosynthesis of essential amino acids. Biocatalysts-enzymes- nomenclature, classifications, kinetics and mechanism of action allosteric enzymes, isoenzymes, lysozymes, co-enzymes, cofactors catalytic RNA.	**4**
VI	Biochemical methods filtration, centrifugation, sedimentation, solvent extraction, chromatography (ion exchange, size exclusion, affinity, adsorption, hydrophobic interaction, TLC, GLC, HPLC) Spectrophotometric techniques-UV, VISIBLE, IR, NMR, MASS	**5**

Text books and References

- Davidson, V.L. and Sittman, D.B. 1994. Biochemistry, 3rd edn. Harwal Publishing, Philadelphia, PA, USA, 584 pp.
- David L. Nelson, Michael M. Cox. 2017. Lehninger Principles of Biochemistry. W. H. Freeman 3270 pp.
- Hill, R.W., Wyse, G.A. and Anderson, M. 2012. Animal Physiology, 3rd edn., Sinauer Associates, Inc., 800 pp.
- Hoar, W.S. 1975. General and Comparative Physiology, 2nd revised edn. Prentice Hall Publishers, 896 pp.
- Martin, D.W., Mayes, P.A. and Rodwell, V.W. (Eds.) 1981. Harper's Review of Biochemistry, 19th edn. Lange Medical Publishers, Los Altos, CA, 614 pp.
- Nelson, D.L. and Cox, M.M. 2013. Lehninger Principles of Biochemistry. W.H. Freeman, 1198 pp.
- R. C. Newell (Eds.). 1976. Adaptation to Environment. Essays on the Physiology of

Marine Animals. Butterworth & Co Publishers Ltd. 541 pp.

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- Scheer, B.T. 1963. Animal Physiology. Wiley, New York, 409 pp.
- Schmidt-Nielsen, K. 1997. Animal Physiology – Adaptation and Environment. Cambridge University Press, 607 pp.

- Victor W. Rodwell, David Bender, Kathleen M. Botham, Peter J. Kennelly, P. Anthony Weil. 2018. Harper's Illustrated Biochemistry. McGraw-Hill Education / Medical 2023 pp.
- Voet, D. and Voet, J.G. 2010. Biochemistry. 4th edn., John Wiley & Sons, 1520 pp.

- Watermann, T.H. (Ed.) 1960. The Physiology of Crustacea, Vol. 1. Academic Press, New York.
- Watermann, T.H. (Ed.) 1961. The Physiology of Crustacea, Vol. 2. Academic Press, New York.
- Winona B. Vernberg, F. John Vernberg (auth.). 1972. Environmental Physiology of Marine Animals. Springer-Verlag Berlin Heidelberg 350 pp.

Course name	**Molecular Biology & Instrumentation**		
Course code	**MB 2106**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To investigate the key concepts of DNA and molecualar taxonomy in eukaryotes and prokaryotes**	**R/U**	**1,2**
2	**To analyse the processes of mutation, recombination and DNA replication**	**An**	**1,9**
3	**To apply this knowledge to the processes of DNA extraction, PCR, and sequencing and analyze the methodologies for sequence alignment and phylogenetic tree construction**	**A**	**2,4,8**
4	**To evaluate the role of software tools in DNA barcoding and their application in the census of marine life**	**An**	**4,5,8**
5	**To recall the methodologies and working principles of various microscopes and biochemical techniques to analyse and purify cellular inclusions and biomolecules.**	**R/U**	**1,2**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	**Unit Content**	**CO No.**
I	Evidence of DNA as genetic material- gene as a unit of mutation and recombination. Molecular nature of the gene, organization of prokaryotic and eukaryotic genomes- replication of DNA- role of different enzymes and accessory proteins in prokaryotic and eukaryotic DNA replication.	**1,2**
II	DNA Replication: conservative, semi conservative, rolling circle, Cairn s model of replication. mechanism of replications: okazaki fragments, role of different enzymes and accessory proteins. Specific examples of replication. The origin and adaptive significance of duplications, deletions, inversions, and translocations, so chromosomes, ring chromosomes, centric fusions and fissions. Specialized chromosomes. Mutation and Mutagenesis- mechanism of mutation, spontaneous mutations, Induced mutations, reverse mutations, suppressor mutations, chemical mutagenesis by nitrous acid, hydroxylamine, alkylating agents, intercalatersphysical mutation by UV. Mechanism of DNA repairs process- Photo reactivation, excision repair, recombination repair, sos pair mechanism and their regulation- heat shock response.	**2**
III	Molecular taxonomy - phylogeny, molecular markers, species-specific markers, DNA bar-coding. Sample collection and preservation, DNA extraction, polymerase chain reaction (PCR), DNA sequencing, Sequence alignment and	**1,3,4**

	construction of phylogenetic trees. Softwares in DNA bar-coding. Census of marine life.	
IV	Methodology and working of microscopes - Phase contrast microscope - Fluorescent microscope - Electron microscopes – TEM and SEM, different fixation techniques for EM, Freeze etch and freeze fracture methods for EM - Laser scan confocal microscope - Study of Cells using microscopes (light, phase dark field, fluorescence, polarization and electron microscope). Modern trends and instrumentation in cell biology- cellular inclusions at ultra-structural level, cell divisions, cell and tissue culture.	**5**
V	Centrifugation - Ordinary, high speed centrifuge - Density gradient centrifugation – Ultracentrifugation. Electrophoresis – Principle - Gel electrophoresis – SDS PAGE, Agarose Gel Electrophoresis - High voltage electrophoresis - Immuno electrophoresis- principle and application. Chromatography - Principle - Column chromatography, Ion exchange chromatography, HPLC, Gas chromatography.	**5**

Text books and References

- Agarwal, V. K. 1999. Textbook of Cytology. S. Chand & Co. Ltd., 504 pp.
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- Bernard R. Glick, Jack J. Pasternak, Cheryl L. Patten. 2009. Molecular Biotechnology: Principles and Applications of Recombinant DNA, 4th Edition. ASM Press 1020 pp.
- Bisen, Prakash Singh, Sharma, Anjana. 2012. Introduction to Instrumentation in Life Sciences. CRC Press 377 pp.
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- Lewin, B. 2004. Genes. 9thedn., Jones and Bartlett Publishers, 892 pp. Roger L. Lundblad, F MacDonald. 2018. Handbook of Biochemistry and Molecular Biology. CRC Press 1019 pp.
- Sheller, D.E. and Bianchi 2002. Cell and Molecular Biology. Wiley. 704 pp.
- Swargiary, Ananta. 2017. Biological Tools & Techniques (A textbook for UG/PG students of Life Sciences).

- Watson, J. D., Hopkins, N.H., Roberts, J.W., Steitz, J.A. and Weiner, A.M. 1987.

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- Watson, J.D., Baker, T.A., Bell, S.P., Gann, A., Levine, M., Losick, R. 2014. Molecular Biology of the Gene. Pearson, 872 pp.
- Watson, J.D., Gilman, M., Witkowski, J. and Zoller, M. 1992. Recombinant DNA 2nd edn., Scientific American Books, New York, 626 pp.
- https://plato.stanford.edu/entries/molecular-biology/

ELECTIVE COURSES / MOOC

Course name	**Coral Reef and Mangroves - Ecology and Management**		
Course code	**MB 2107**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	To comprehend the diversity, structure and distribution of coral reefs and mangroves	**R/U**	**1,3**
2	To analyse and evaluate the ecological interactions within coral reef and mangrove ecosystems,	**An. E**	**1,3,9**
3	To evaluate the ecological services of mangroves and coral reefs	**E**	**3,5,9**
4	To investigate the organizations and measures involved in conservation of coral reefs and mangroves	**R/U**	**3,6**
5	To evaluate the effectiveness of ecological restoration principles, remote sensing techniques, and community-based conservation initiatives in promoting biodiversity and sustainability of mangroves and coral reefs	**E**	**3,4,5**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	**Unit Content**	**CO No.**
I	Coral reefs – Types, structure and distribution in world oceans. Zonation and limiting factors. Factors influencing the growth, productivity, reproduction, larval dispersal and settlement of corals. Major species of corals in India. Protected coral reefs.	**1**
II	Ecology of coral reefs: Major reef communities, species interactions, food chains and food webs, symbiotic relationships. Crypto-fauna, Ecology of reef fishes. Natural processes and succession in coral reefs, Interactions with adjacent ecosystems. Degradation and destruction of coral reefs: impact of climate change and anthropogenic interventions including destructive fishing practices.	**2**
III	Coral reef conservation measures. Activities of various organizations in coral reef conservation and management. Ecosystem services of coral reefs.	**3,4**
IV	Mangrove ecosystems. Distribution of mangroves – global, regional and local levels. Major species of mangroves. Mangrove diversity, zonation and adaptations. Faunal and floral communities in mangrove ecosystem, food chains and food webs. Ecosystem services of mangroves.	**1,2,3**
V	Conservation and management: principles of ecological restoration –habitat enhancement, afforestation; Mangrove conservation activities around the world; Use of Remote Sensing and GIS techniques for mapping mangrove	**4,5**

	distribution; Joint Mangrove Management (JMM) programme.	

Text books and References

- Bakus, G.J., 1994. Coral reef ecosystems. Oxford and IBH publishing Company, New Delhi: 232 p.
- Colin D. Woodroffe (auth.), Howard J. Teas (eds.). 1993, Biology and ecology of mangroves. Springer Netherlands 189 pp.
- Mark D. Spalding, Edmund P. Green, Corinna Ravilious. 2001. World Atlas of Coral Reefs. University of California Press 430 pp.
- McClanahan T. R., C. R. C. Sheppard, D. O. Obura. 2000. Coral Reefs of the Indian Ocean: Their Ecology and Conservation. Oxford University Press, USA 550 pp.
- Naskar, K. 2004. Manual of Indian Mangroves. Daya Publishers, New Delhi. 220 p.
- Peter, S. (Ed.) 2006. Coral reef fishes: Dynamics and diversity in a complex ecosystem, Academic Press, London.
- Pam Walker, Elaine Wood. 2005. The Coral Reef (Life in the Sea) 157 pp.
- Singh, V.P. and Odaki, K. 2004. Mangrove ecosystem: structure and function. Scientific Publishers, New Delhi: 297 p.
- Yuri I. Sorokin (auth.). 1993. Coral Reef Ecology. Springer-Verlag Berlin Heidelberg 475 pp.
- https://www.noaa.gov/education/resource-collections/marine-life/coral-reef
- ecosystems
- https://wwf.panda.org/our_work/our_focus/oceans_practice/coasts/coral_reefs/

Course name	**Climate Change Impacts**		
Course code	**MB 2108**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To analyze climate change impacts and mitigation strategies on ocean ecosystems**	**An**	**3,7,9**
2	**To evaluate climate models and their projections to develop informed responses and strategies for climate change mitigation and adaptation.**	**An, E**	**3,4,9**
3	**To analyze and develop the multifaceted impacts and mitigation strategies of climate change on ecosystems**	**E**	**3,9**
4	***To* evaluate and design engineering and ecological approaches and innovative solutions for climate change mitigation**	**R/U**	**3,5,9**
5	**To evaluate Ecosystem-based Adaptation (EbA) strategies in risk management**	**E**	**3,5**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	**Unit Content**	**CO No.**
I	Introduction to climate change - Greenhouse gases and aerosols - Carbon cycle - Fundamental principles of climate change - The oceans and climate change -Climate variability and change - Climate change and Ocean warming – ocean acidification - Threatened ecosystems: Coral reefs, polar and coastal ecosystems.	**1**
II	Introduction to Global Climate Models (GCMs) GCM projections for impact assessments - Introduction to Regional Climate Models (RCMs) - RCM projections for regional and local impact assessments - Next-generation IPCC scenarios - Differences in model predictions - Multi-model ensembles - Bias correction - Observation networks - Overview of climate change responses – Global and regional scale responses - Climate projections and uncertainty.	**2**
III	Climate Change Impacts: Ecosystems - Social, ecological and economic impacts of climate change and their interactions - Payment for ecosystem services and biodiversity -the water cycle - Flood discharge modification from climate change - Climate change impacts on food production - Extreme events - Catastrophic disasters - Climate change modifications to extreme events and challenges.	**3,4**
IV	Mitigation and Adaptation Practices and Resilience - Mitigation and adaptation options - Key constraints and measures - engineering vs. ecological and socioeconomic approaches. Fisheries – Aquaculture - Marine pollution - Marine non-renewable resource extraction - environmentally	**1,2,3**

	sound renewable energy projects - The ocean as a renewable energy source - carbon capture and storage. Ocean fertilization - - Institutional, budgetary and implementation challenges.	
V	Ecosystem-based Adaptation (EbA) - EbA strategies into risk management plans - comprehensive networks of Marine Protected Areas (MPAs) - Increasing ecosystem resilience – Restoration of fragmented or degraded ecosystems, and reestablishing critical processes - long-term adaptive Management - Adaptation measures for climate change impacts on food production - Cost-benefit analysis of adaptation measures - Reducing extreme even losses through adaptive practices - Assessing adaptation costs at national and regional scales - Adaptation options in various sectors - Adaptation strategies and re-adjustments - Local wisdom and indigenous technologies.	**4,5**

Text books and References

- Boyle, G. 2004. Renewable Energy. Oxford University Press, Oxford. 464 p. Coley, D.2008. Energy and Climate Change: Creating a Sustainable Future, Wiley and Sons, Chichester, UK, 656 p.
- Herr, D. and Galland, G.R. 2009. The Ocean and Climate Change. Tools and Guidelines for Action. IUCN, Gland, Switzerland. ISBN: 978-2-8317-1201-7, 72 p.
- Mendonca, M. 2007. Feed-in Tariffs: Accelerating the Deployment of Renewable Energy. EarthScan, London. ISBN 9781844074662,
- Mendonca, M., Jacobs, D. and Sovacool, B.2009. Powering the Green Economy. Routledge. ISBN-13: 978-1844078585, 224p.
- Mark Maslin. 2014. Climate Change: A Very Short Introduction. Oxford University Press 200 pp.
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- https://www.un.org/en/sections/issues-depth/climate-change/

Course name	**Bioinformatics**		
Course code	**MB 2109**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To comprehend bioinformatics fundamentals and apply sequencing knowledge to solve biological problems and explore future possibilities.**	**An, U/R**	**1,4,8**
2	**To comprehend the significance of biological databases and evaluate their roles in research and data analysis.**	**An, U/R**	**1,4,8**
3	**To develop skill in data retrieval, sequence analysis, and evaluating alignment methods with scoring matrices.**	**E, An, A**	**4,8**
4	**To develop skill in using BLAST tools and analyzing its results to interpret evolutionary trends.**	**E, An, A**	**4,8**
5	**To apply computational tools to analyze biological pathways**	**A**	**5,8**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	**Unit Content**	**CO No.**
I	Introduction to bioinformatics, - Concepts, brief history and its role and importance in modern biology, internet, internet, portals, servers and search engines. Central Dogma: DNA-RNA-Protein, Introduction to DNA and Protein sequencing, Human Genome Project, SNP, Future and scope of Bioinformatics	**1**
II	Biological databases, their purpose. Nucleotide sequence databases, Primary nucleotide sequence databases-EMBL, GeneBank, DDBJ; Secondary nucleotide sequence databases; Protein databases- UniProt, Protein Data Bank	**2**
III	Uploading and downloading of data, FASTA format, data retrieval from databases. Sequence Analysis-Basic concepts, Alignment of pairs of sequence:- Homologous, Analogue, Orhtologous, paralogous, Xenologous (Need for sequence alignment, Local and Global alignment, Scoring matrices- PAM and BLOSUM matrices	**3**
IV	Pairwise sequence alignments: BLAST, Multiple sequence alignments (MSA) BLAST:- Nucleotide BLAST, Protein BLAST, PSI-BLAST, Analysis of BLAST results, E Value, sensitivity and specificity of BLAST, FASTA Structure analysis tools and softwares. Construction of rooted and un-rooted phylogenetic trees, their interpretation and use in analyzing evolutionary trends, steps in phylogenetic analyses.	**4**
V	Brief overview of computational biology - computation, prediction and modulation of biological pathways, (ex. Kegg pathways) e-cell, computational analyses of genomes and proteomes.	**5**

Text books and References

- P. Narayanan, Bioinformatics: A Primer, New Age International Publishers. Harshawardhan P. Bal, Bioinformatics Principles and Applications, Tata McGraw Hill Publishing Company Ltd. S.C. Rastogi, N. Mendiratta, P. Rastogi, Bioinformatics – Concepts, Skills and Application. CBS Publishers and Distributors, New Delhi.
- Dan E. Krane and Michael L. Raymer, Fundamental Concepts of Bioinformatics, Pearson Education. Claverie & Notredame, Bioinformatics - A Beginners Guide, Wiley-Dreamtech India Pvt Ltd.

PRACTICAL COURSES

Course name	Physical, Chemical & Geological Oceanography & Marine Biology		
Course code	MB 2110		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To operate oceanographic instruments like CTD sensors and Niskin bottles to measure key water parameters.**	**A**	**2,5**
2	**To use meteorological tools such as anemometers and barometers to assess atmospheric conditions.**	**A**	**2,5**
3	**To construct and interpret T-S diagrams for water mass analysis.**	**A**	**4,5**
4	**To perform sediment analysis to determine grain size distribution.**	**A**	**2,5**
5	**To apply data logging and statistical software to analyze oceanographic and meteorological data for climate and conservation studies.**	**A**	**4,5**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			
Operation of oceanographic and meteorological equipments and softwares. Methods of measurement of meteorological parameters and estimation salinity, temperature,dissolved oxygen, turbidity, nutrients and currents. T-S diagram. Sediment analysis.			

Course name	Biochemistry & Physiology		
Course code	MB 2111		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To apply biochemical techniques for quantifying carbohydrates, proteins, and lipids.**	**A**	**2,4**
2	**To utilize various chromatography methods for biomolecule separation and analysis.**	**A**	**2,4**
3	**To employ analytical techniques for precise biochemical measurements.**	**A**	**2,4**
4	**To examine the functional morphology of respiratory organs in diverse aquatic species.**	**A**	**2,4**
5	**To analyze integument structures and their derivatives across different aquatic animal groups for understanding environmental adaptations.**	**A, An**	**2,5,9**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Estimation of carbohydrate, protein and lipid. Biochemical methods – centrifugation, precipitation, solvent extraction, chromatography (Ion exchange, size exclusion, affinity, paper, TLC, GLC, HPLC) – Demonstration of Colorimetry, fluorimetry, spectrophotometry – visible and UV.Physiological experiments - Functional morphology of respiratory organs of aquatic animals- gills of shark, mullet and mudskipper; Functional morphology of integument and its derivative in different groups (skin, scale, etc).

Course name	**Cell & Molecular Biology**		
Course code	**MB 2112**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To perform cytological techniques for cell viability assessment and mitosis observation in plant tissues.**	**A**	**2,4**
2	**To prepare karyotypes, calculate mitotic indices, and create thin tissue sections using microtomy.**	**A**	**2,4**
3	**To apply histochemical staining methods for tissue-specific analysis.**	**A**	**2,4**
4	**To utilize DNA technology techniques including isolation, purification, RFLP, PCR, and hybridization.**	**A**	**2,4,8**
5	**To monitor cell growth through protein assays, cell density measurements, and centrifugation-based protein content determination.**	**A**	**2,4**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Cytological and Histological techniques- determination of number of viable cells in a cell population. Mitosis - Onion root tip squash preparation- Preparation of Karyotypes, Determination of Mitotic index. Meiosis - squash preparation of immature anther- identification of different stages. Microtomy and histochemical techniques - Preparation of thin sections of tissues and staining with tissue specific stains. Use of protein assay to monitor cell growth - Cell growth; cell density; centrifugation; protein determination. DNA technology - Isolation, purification and manipulation of DNA; RFLP, PCR, Hybridization.

Course name	**Marine Biology**		
Course code	**MB 2113**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To identify representative species from various phyla and classes through fieldwork in diverse marine ecosystems.**	**A**	**2,4**
2	**To apply standardized techniques for collecting and preserving biological samples from coral reef, inter-tidal, and mangrove ecosystems.**	**A**	**2,4**
3	**To conduct comprehensive ecosystem case studies, documenting faunal and floral communities and their seasonal variations.**	**A**	**3,4**
4	**To maintain detailed records of field and laboratory work, emphasizing systematic data collection and analysis.**	**A**	**2,4**
5	**To analyze ecosystem dynamics through the interpretation of collected data and community inventories.**	**A, An**	**4,5,9**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			
Identification of representative examples coming under different phyla and classes dealt with in theory. Materials and methods employed in field collection and preservation of biological samples. Case studies of selected coral reef, inter-tidal and mangrove ecosystems. Inventory of associated faunal and floral communities and their seasonal variations. Documented record of the field and laboratory works.			

SEMESTER – II

CORE COURSES

Course name	**Marine Planktonology, Algology and Benthos**		
Course code	**MB 2201**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To comprehend and evaluate the ecology of plankton, marine phytoplankton, zooplankton, benthos and macroalgae**	**U/R**	**1,3**
2	**To develop skills in using sampling and preservation techniques of plankton, measuring primary production, and identification of plankton and seaweeds**	**A, An**	**2,4**
3	**To evaluate microalgal and sea weed culture**	**E, A**	**3,4,5**
4	**To evaluate the role of benthic organisms in ecosystem processes**	**E**	**3,5**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			
Unit No	**Unit Content**	**CO No.**	
I	Plankton - classification, ecology and interrelationships. Sampling and preservation techniques. Plankton nets and recorders; catching efficiency of various nets and quantitative analysis. Plankton fixatives and preservatives.	**1,2**	
II	Phytoplankton in the marine environment – classification, ecology, physiology, spatial and temporal distribution, changes in distribution patterns in different ocean ecosystems. Phytoplankton pigments, photosynthesis and primary production - rate of primary production in Arabian Sea, Bay of Bengal, latitudinal and seasonal variations in primary productivity. Methods of measuring primary production. Algal blooms. Role of phytoplankton in global carbon cycle – impacts of climate change. Micro-algal culture.	**1,2,3**	
III	Zooplankton in the marine environment – distribution and abundance in space and time, classification, major groups of zooplankton in Indian Ocean region, Arabian Sea Paradox in relation to zooplankton, micro-zooplankton, energetics and secondary production, trophic structure, swarms, indicator species, predator-prey relationship; grazing in the aquatic ecosystem, vertical migration of zooplankton, DSL, bioluminescence, identification and importance of meroplankton. Secondary productivity.	**1,2**	

IV	Benthic organisms in the marine environment – Classification and descriptions of benthic invertebrate communities, spatial and temporal distribution, major groups of benthos in Indian ocean region with special emphasis on Arabian Sea and Bay of Bengal. Species adaptations to living in cohesive and non-cohesive sediments. Faunal mediation of ecosystem processes. Benthic-pelagic coupling. Bioturbation. Bio-irrigation. Organism-sediment interactions and concepts of benthic succession.	**1,4**
V	Macro-algae of Indo-Pacific region. Major species, spatial and temporal distribution patterns. Zonation and adaptations. Seaweed culture. Economic uses.	**1,3**

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Course name	**Concepts of Ecology& Ecological Dynamics**		
Course code	**MB 2202**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To analyze species adaptations in relation to marine environmental factors.**	**U/R, An**	**1,3,9**
2	**To examine the characteristics and adaptations of coastal ecosystems.**	**A, An**	**1,3**
3	**To investigate the physical, chemical, and biological aspects of Indian estuarine systems.**	**E, A**	**3,5**
4	**To evaluate animal associations within marine environments.**	**E**	**3,5**
5	**To appreciate the importance of marine ecosystems and their conservation.**	**Ap**	**3,6**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			
Unit No	**Unit Content**	**CO**	
I	Sea as a biological environment – ecological factors – light, temperature, salinity, pressure. Adaptations to pelagic, benthic, oceanic and coastal zones.	**1**	
II	Coastal systems – mangroves, sea weeds, sea grass, salt marshes, sand dunes, coral reefs - intertidal and interstitial zones. Deep sea adaptations - Fauna of hydrothermal vents, cold seeps, whale falls and other reducing habitats.	**2**	
III	Occurrence, types and distribution of estuaries. Estuarine systems in India. Ecology and adaptations of estuarine organisms. Economic importance of estuaries. Functions of rivers and river basins in transport of materials to the estuaries and oceans, their importance in biogeochemical cycles. Modification of dissolved and particulate matter. Estuarine mixing zones. Physical, chemical and biological aspects of Cochin Estuary.	**3**	
IV	Animal associations in marine environment – endoecism, inquilinism, epizooism, mutualism, communalism, symbiosis and parasitism. Community ecology - colonization and succession, mechanisms of succession. Prey-predator relationship – density dependent and density independent factors. Population ecology - group attributes, population growth, density variations and concept of carrying capacity. Environmental factors responsible for biorhythms. Circadian, tidal and lunar rhythms in marine and estuarine animals. Significance of biorhythms, biotic and abiotic factors influencing homeostasis.	**4**	
V	Marine ecosystems – concepts, principal components. Marine trophic structure - food chains, food web, ecological pyramids, energy flow in pelagic, benthic and deep sea and	**5**	

	polar ecosystems. Anthropogenic changes in marine habitat. Species invasions. Impact of climate in Antarctic and Arctic ecosystems.	

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Course name	**Biodiversity – Principles, Conservation and Management**		
Course code	**MB2203**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To comprehend the definitions and types of biodiversity**	**U/R**	**1,6**
2	**To evaluate the current status of marine biodiversity and island biodiversity in India.**	**E**	**1,3,6**
3	**To evaluate the different methods of biodiversity documentation and conservation**	**E**	**1,3,6**
4	**To analyse the different methods of measuring biodiversity**	**An**	**1,4,5**
5	**To remember the different categories of ecosystem services and their valuation**	**U/R**	**1,3**
6	**To analyse key international treaties and global efforts for managing genetic resources related to biodiversity.**	**An**	**3,6**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			
Unit No	**Unit Content**	**CO No.**	
I	Definition and types of biodiversity, Ecological, Genetic and organismal diversity; importance of biodiversity. Mega biodiversity countries, biodiversity hotspots – global and Indian. Marine biodiversity. Present status of marine biodiversity in India. Island biodiversity. Causes of biodiversity loss.	**1,2**	
II	Biodiversity documentation. Methods in documentation. Para taxonomy in biodiversity inventory. Extinct, endangered, threatened and vulnerable species – Red List. Zoological Survey of India (ZSI) and its role in marine biodiversity documentation. Impact of alien species, GMOs and exotic species on endemic biota. Threats to marine biodiversity. Census of Marine Life. Conservation methods,exsitu and in-situ conservation. Levels of conservation – alpha, beta and gamma. Protected areas, national parks, wild life sanctuaries, reserves, MPAs. Marine National parks of India. Social, ethical and policy issues in biodiversity conservation.	**3**	
III	Measuring Biodiversity - Margalef species richness, Simpson's dominance, Pielou's evenness and Shannon-Weiner diversity indices. Taxonomic and phylogenetic diversity indices. ABC plot, dominance plot, species area plot, geometric class plot. Softwares for biodiversity assessment.	**4**	
IV	Ecosystem services. Ecosystem valuation - Direct use value – food, medicine, industrial and recreational values; Indirect Use Values – environmental modulation, biological control, and ecological services. Sustainable utilization of biological resources, the importance of local and indigenous	**5**	

	knowledge. Genetic resource ownership, bio-piracy and IPR. Issues related to IPR.	
V	International treaties and global efforts for management of genetic resources relating to biodiversity. Convention on Biological Diversity (CBD). Biodiversity legislation in India. Ramsar Convention 1971, Indian Biodiversity Act 2002, National Biodiversity Authority of India. State Biodiversity Boards and Biodiversity management committees, National bureaus dealing with genetic resources – NBPGR, NBAGR, NBAIM, NBAII and NBFGR. Organizations involved in protection and conservation – CITES, IUCN, WWF for Nature, UNEP.	**6**

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Course name	**Fish Biology**		
Course code	**MB 2204**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To *comprehend the* evolutionary history and classification of fishes**	**U/R**	**1, 4**
2	**To *evaluate* the ecological adaptations of marine fishes**	**E**	**1, 5**
3	**To *evaluate* the significance of structure and physiological adaptations of fishes**	**E**	**1, 5**
4	***To evaluate* various methods for studying food and feeding habits and age determination in fishes**	**E**	**1, 4**
5	***To comprehend the reproduction strategies and behavior of fish***	**U/R**	**1, 5**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	**Unit Content**	**CO No.**
I	Evolution of fishes - fish phylogeny- ostracoderms placoderms hagfishes, Chondrichthyes osteichthyes- evolutionary trends. outline classification. Ecology – reef fishes- pelagic fishes-adaptations. Zoogeography – Marine fishes – Continental shelves, tropical, subtropical, temperate, arctic , Antarctic and polar regions. Procedure for fish sampling.	**1,2**
II	External form and structure - Fish integument – Locomotion – Alimentary system and nutrition - Accessory respiratory organs - sensory mechanisms - Acoustico-lateral line system - Osmotic/ionic regulation and acid base balance - Buoyancy regulation - Air bladder and its functions – webarian ossicles. Circulatory and nervous systems.	**3**
III	Food and feeding habits – methods – merits and demerits of methods – food habits of commercially important marine fin fishes. Length-weight relationship – estimation – gastro-somatic index. Growth- factors affecting growth – hard parts – estimation.	**4**
IV	Reproduction – spawning and maturation – gonado-somatic index- length at minimum maturity – relative condition factor – sex ratio and metamorphosis – Sexual cycle and fecundity - egg/larval development, Parental care. Spawning season of commercially important marine fin fishes.	**5**
V	Behavior– migratory, shoaling, feeding behavior, communication modalities - community structure - Fish migration - Deep sea adaptations – climate change and its impact on marine fishes.	**5**

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CO No.	Expected Course Outcome	Learning Domains	PO No.
1	**To comprehend the concept of the marine microbiology and the functioning roles of microbes in marine environment**	**U/R**	**1,3**
2	To **gain knowledge of the structure, characteristics and ecological roles and interactions of coastal, shallow, and deep-sea microorganisms**	**U/R**	**1,3**
3	**To evaluate the culture techniques and control measure of microbes.**	**E**	**1,3,6**
4	**To analyse and evaluate the water quality control**	**E, An**	**1,4,5**
5	**To acquire knowledge of microbial pollution and microbial biogegradation**	**U/R**	**1,3**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Course Name	**Marine Microbiology**		
Course code	**MB 2205**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To comprehend the concept of the marine microbiology and the functioning roles of microbes in marine environment**	**U/R**	**1,3**
2	To **gain knowledge of the structure, characteristics and ecological roles and interactions of coastal, shallow, and deep-sea microorganisms**	**U/R**	**1,3**
3	**To evaluate the culture techniques and control measure of microbes.**	**E**	**1,3,6**
4	**To analyse and evaluate the water quality control**	**E, An**	**1,4,5**
5	**To acquire knowledge of microbial pollution and microbial biogegradation**	**U/R**	**1,3**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	Unit Content	CO No.
I	Introduction to marine microbiology, marine microbial research in India. General classification and taxonomy of marine microorganisms. Distribution of microorganisms in the marine habitats. Role of microbes in nutrient cycling in the ocean. Microbes of extreme environments – hydrothermal vents, polar regions and deep sea.	**1**
II	Bacteria: Ultra structure, growth and life cycle; Culture techniques; Growth of bacteria – growth curve, continuous culture systems, chemostat, turbidostat. Control of Microorganisms- Physical chemical methods, Disinfectants, Antibiotics and mechanisms of antibiosis. Methods of sterilization; Inoculation techniques using different media;	**2,3**

	Pure culture and cultural characteristics; Current methods of identification, characterization and classification of microorganisms; Staining techniques; Microscopy. Characteristic features of eubacteria, archaeae, fungi - Molds and Yeasts, algae, protozoa and viruses- Viruses of bacteria - bacteriophages, cyanophages, baculoviruses etc.	
III	Ecology of coastal, shallow and deep-sea microorganisms; Diversity of microorganisms - Archaea, bacteria, cyanobacteria, algae, fungi, viruses and actinomycetes in the marine environment.	**2**
IV	Microbial pollution of coastal waters, faecal indicator bacteria, Pathogenic microorganisms, Prevention and control of water pollution, quality standards, International and National standards. Microbial diseases diagnosis and control.	**4,5**
V	Microbial biodegradation - natural and synthetic material in the marine environment. Microbial degradation of Pesticides and hydrocarbons. Bioremediation of xenobiotics, oil, heavy metals, pesticides and plastics.	**5**

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ELECTIVE COURSES

Course Name	**Fish Health Management**		
Course code	**MB 2206**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To recognize fundamental disease concepts,**	**U/R**	**1,3**
2	To **identify and classify viral, bacterial, fungal, and parasitic diseases affecting fish and shellfish**	**U/R**	**1,3,5**
3	**To describe the invertebrate defence system**	**E, U/R**	**1,3,4**
4	**To learn the impact of natural environmental factors and human activities on the emergence and spread of zoonotic and aquatic diseases and its control**	**E, An**	**3,5,6**
5	**To gain proficiency in the general procedures for diagnosing diseases in marine fish and shellfish**	**U/R**	**1,3,5**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	**Unit Content**	**CO No.**
I	Introduction to disease, Basic disease terminology, stress and general adaptation syndrome - Host/Pathogen/Environment relationship - Basic principles of pathology and epidemiology.	**1**
II	Introduction to viral, bacterial and fungal diseases fish and shellfish - Bacterial pathogens of finfishes and crustaceans (Furunculosis, Vibrio spp., shell disease, etc.) - Viral pathogens of finfish and crustaceans (nodavirus, VHSV, IHNV, WSSV and other shrimp viruses, etc.) - Protozoan and Myxozoan parasites of crustaceans - Protozoan and Myxozoan parasites of finfish - Metazoan Parasites Helminthes, Copepodes, etc. Diseases of bivalve molluscs - Bivalve case studies: bacterial parasites - Bivalve case studies: protozoan parasites; Non infectious diseases - Tumors and cancers of aquatic organisms.	**2**
III	Invertebrate defense system - Vertebrate immunity - Tissues of Immune system- Primary lymphoid organs, structure and functions (Thymus and Bursa of Fabricius) - Secondary lymphoid organs, structure and functions (Spleen, lymphnode and Payers patches) - Biological and physical properties of immunoglobulin - Immunization - Immediate type of hypersensitivity - Delayed type cell mediated hypersensitivity .	**3**
IV	Zoonotic diseases - Impact of natural environmental factors	**4**

	on diseases - Impact of human activities on diseases - Aquatic diseases and exotic species - Disease control and management - chemotherapeutic agents - prophylaxis-vaccinesadjuvants, immuno-stimulants and probiotics - selective breeding, genetic engineering - Use and abuse of antibiotics and chemicals in health management. Fish health and quarantine systems. Seed certification, SPF and SPR stocks - development and applications.	
V	General procedures for disease diagnosis - Examination of marine fish and shell fish for parasites – Taxonomy and identification of fish parasites - Field visit for disease monitoring – Histopathology of diseases - Sampling, preparation of media and culture of pathogenic bacteria - Techniques for bacterial classification; Enzyme linked immune-sorbent assay (ELISA) technique and its applications. Immunofluorescence technique (Direct & Indirect and Sandwich antibody labelling techniques. Immuno-diffusion techniques (Mancini and Oucheterlony immunediffusion techniques). Monoclonal antibody technology (Hybridoma technology).	**5**

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Course Name	**Fishing Techniques and their Impacts**		
Course code	**MB 2207**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To gain knowledge to classify various fishing gears**	**U/R**	**1,2**
2	**To evaluate the impact of fishery practices on marine resource environment**	**E**	**3,6**
3	**To demonstrate knowledge of the Code of Conduct for Responsible Fishing (CCRF) and its key articles,**	**E, U/R**	**3,6**
4	**To identify and describe mitigation measures to reduce the impacts of fishing on marine resources**	**E, An**	**3,5,6**
5	**To apply the principles of Ecosystem Approach to Fisheries (EAF) management**	**A**	**2,5**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	**Unit Content**	**CO No.**
I	Classification of fishing gears. Surrounding nets, trawl nets, gillnets and entangling nets, traps, hooks and lines, seine nets, dredges, lift nets, falling gears. grappling and wounding gears, stupefying devices. Fish Aggregating Devices (FADs) and Artificial Reefs (ARs). Destructive fishing practices. Ghost Fishing. By catch and discards. Fishing gear selectivity. Types of Bycatch Reduction Devices and the principles of operation. Turtle Excluder Devices - types of TEDs.	**1**
II	Impacts of bottom trawling and other fishing practices on resources and environment. Overfishing. Fishing down the marine food webs. Trophic chain and the energy flow across the ecosystem. Non-fishery impacts on resource abundance	**2**
III	Code of Conduct for Responsible Fishing (CCRF). Articles of CCRF. Elaboration of Article 8: Fishing Operations.	**3**
IV	Mitigation measures to reduce impacts of fishing on resources, biodiversity and environment. Management and technological measures.Integration of fisheries into coastal area management.	**4**
V	Ecosystem approach to fisheries (EAF) management. Excess fishing capacity. Fishing capacity management. Approaches to rebuild resources. Participatory approach to fisheries management. Marine Protected Areas (MPAs). Certification and ecolabelling of fisheries.	**5**

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- John, S. 1996. Commercial Fishing Methods - An Introduction to Vessels and Gear. Fishing News Books, ISBN 0852382170, 359 p.
- Meenakumari, B., Boopendranath, M.R., Pravin, P., Thomas, S.N., and Edwin, L. (Eds.) 2009. Handbook of Fishing Technology, Central Institute of Fisheries Technology, Cochin: 380 p.
- Sreekrishna, Y. and Shenoy, L. 2001. Fishing Gears and Craft Technology. Directorate of Information and Publications of Agriculture, Indian Council of Agricultural Research, 342 p.

Course Name	**Remote Sensing and GIS**		
Course code	**MB 2208**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To recognize key concepts of remote sensing**	**U/R**	**1,4**
2	**To identify and evaluate various types of remote sensing based on the source of energy and platform**	**E**	**1,4,5**
3	To **recall and apply the basic principles and elements of visual and digital image interpretation techniques in remote sensing**	**E, A**	**1,4**
4	**To recall and apply the definitions, objectives, and principles of Geographic Information Systems (GIS)**	**E, A**	**1,4**
5	**To recall and apply the definitions and functions of the Global Positioning System (GPS)**	**A, E**	**1,4**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	**Unit Content**	**CO No.**
I	History of remote sensing: Aerial remote sensing, Satellite Remote Sensing - Aerial Photography: Principal of Remote Sensing, Characteristics of Electromagnetic Spectrum and spectral range, Sensors, Agency involved for aerial photography, Cameras used, types of aerial photography - Measurement on Aerial photographs: Scale determination, Height measurement - Elements of Photo Interpretation-preparation of Thematic maps using aerial photographs.	**1**
II	Satellite Remote Sensing: Types of Remote Sensing based on Source of Energy Platform, Types of satellite: Landsat, IRS, SPOT, IKNOS, Quickbrid, RADAR, LIDAR, SRTM, NOAA, Types of Sensors: MSS, TM, LISS, II, III, IV, PAN, AVHRR, WIFS, AWIFs, Limitations of Remote Sensing, Basic components of an ideal Remote Sensing System.	**2**
III	Satellite Image Interpretations: Visual; Basic principles of Image interpretation, Elements of Image interpretation, Digital; Supervised, Unsupervised Hybrid, Forest cover mapping Microwave Remote Sensing: Types, Platform and Utility, Radar Microwave Remote sensing, Lidar Sensing and application. Remote Sensing data Types, Cost and Source, Ocean Colour Monitoring, C-DOM, PFZ.	**3**
IV	Geographic Information System (GIS): Definitions and objectives, Principle of GIS, Basic requirement of GIS, Data sources -Data Structure – raster and vector	**4**

	– data quality – database design – preprocessing- Data base management system in GIS – Environmental GIS – Applications in Environment - Data acquisition system using GPS	
V	Global Positioning System (GPS): Definition, Types of GPS, Principle, Functions, GPS Segments, GPS signal characteristics – Limitations – Mapping concepts – coordinate systems – Applications of GIS - Methods of interpolations in GIS – Visualization in GIS. Application of remote sensing in marine biological studies - Ocean colour monitoring, PFZ, HAB monitoring.	**1, 5**

Text books and References

- Agarwal, C.S. and Garg, P.K. 2000. Text book on Remote Sensing in Natural Resources Monitoring and Management. Wheeler Publishing, New Delhi.
- Heywood, 2006. An introduction to Geographical information System, Prentice
- Hall. Lilisand, M. 2003. Remote sensing and image interpretation, John Wiley and Sons.
- Martin, S. 2004. An Introduction to Ocean remote sensing, Cambridge University Press.
- Meaden, G.J. and Aguilar-Manjarrez, J. (Eds.) 2013. Advances in Geographic Information Systems and Remote Sensing for Fisheries and Aquaculture. FAO Fisheries and Aquaculture Technical Paper No. 552. FAO, Rome, 425 p.

OPEN ELECTIVE COURSES

(*Elective offered by Marine Biology department*)

Course Name	**Environment & Biodiversity**		
Course code	**OST 2202**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To *comprehend* the definition of the environment and its components**	**U/R**	**1,6**
2	**To comprehend the fundamentals of ecology and ecological components**	**E, U/R**	**1,6**
3	To **comprehend the characteristics of marine environment**	**E, U/R**	**1,6**
4	**To evaluate the current status of marine biodiversity in India, including threats to biodiversity**	**E**	**1,2,6**
5	**To evaluate and describe the conservation strategies and principles of conservation organizations of biodiversity**	**E**	**1,2,6**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	**Unit Content**	**CO No.**
I	Environment: Definition, Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere. Major environmental factors - biotic and abiotic. Natural resources – conservation and management.	**1**
II	Fundamentals of Ecology and Ecosystem, Components and function of an ecosystem - Producers – consumers – decomposers. Food chain, Food web, Trophic level, Energy flow, ecological pyramids. Ecological succession. Concept of limiting factors, laws of limiting factors – laws of minimum and tolerance, Earth's carrying capacity. Ecosystem services.	**2**
III	Biomes and Habitats - aquatic habitats – fresh water: ponds, rivers, lakes, wetlands – their characteristics, flora and fauna; marine habitats – pelagic, benthic, intertidal, estuarine, Mangroves – their characteristics, flora and fauna.	**3**
IV	Definition and types of biodiversity, Ecological, Genetic and organismal diversity; importance of biodiversity. Values of biodiversity, Mega biodiversity countries, biodiversity hotspots – global and Indian. Marine biodiversity. Present status of marine biodiversity in India. Island biodiversity. Causes of	**4,5**

	biodiversity loss. Threats to biodiversity. Assessment of Biodiversity. Red Data Books. Biodiversity conservation - Strategies for biodiversity conservation, principles of biodiversity conservation - in-situ and ex- situ conservation strategies.	
V	Convention on Biological Diversity (CBD). Organizations involved in protection and conservation – CITES, IUCN, WWF for Nature, UNEP. Ramsar Convention 1971, Biodiversity legislation in India - Indian Biodiversity Act 2002, National Biodiversity Authority of India. State Biodiversity Boards and Biodiversity management committees, National bureaus dealing with genetic resources – NBPGR, NBAGR, NBAIM, NBAII and NBFGR. Environmental Impact Assessment (EIA), general guidelines and procedures for the preparation of environmental impact assessment. Public awareness.	**5**

Text books and References

- Guido di Prisco, Peter Convey (auth.), Guido di Prisco, Cinzia Verde (eds.).2012. Adaptation and Evolution in Marine Environments, Volume 1: The Impacts of Global Change on Biodiversity. Springer-Verlag Berlin Heidelberg 236 pp.
- Michael Jeffries. 2006. Biodiversity and Conservation (Routledge Introductions to Environment). Routledge 257 pp.
- Philippe Goulletquer, Philippe Gros, Gilles Boeuf, Jacques Weber (auth.). 2014. Biodiversity in the Marine Environment. Springer Netherlands 214 pp.

Course Name	**Environment & Biodiversity**		
Course code	**OST 2202**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To comprehend the definition of the environment and its components**	**U/R**	**1,6**
2	**To comprehend the fundamentals of ecology and ecological components**	**E, U/R**	**1,6**
3	To **comprehend the characteristics of marine environment**	**E, U/R**	**1,6**
4	**To evaluate the current status of marine biodiversity in India, including threats to biodiversity**	**E**	**1,2,6**
5	**To evaluate and describe the conservation strategies and principles of conservation organizations of biodiversity**	**E**	**1,2,6**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	**Unit Content**	**CO No.**
I	Environment: Definition, Structure and composition of atmosphere, hydrosphere, lithosphere and biosphere. Major environmental factors - biotic and abiotic. Natural resources – conservation and management.	**1**
II	Fundamentals of Ecology and Ecosystem, Components and function of an ecosystem - Producers – consumers – decomposers. Food chain, Food web, Trophic level, Energy flow, ecological pyramids. Ecological succession. Concept of limiting factors, laws of limiting factors – laws of minimum and tolerance, Earth's carrying capacity. Ecosystem services.	**2**
III	Biomes and Habitats - aquatic habitats – fresh water: ponds, rivers, lakes, wetlands – their characteristics, flora and fauna; marine habitats – pelagic, benthic, intertidal, estuarine, Mangroves – their characteristics, flora and fauna.	**3**
IV	Definition and types of biodiversity, Ecological, Genetic and organismal diversity; importance of biodiversity. Values of biodiversity, Mega biodiversity countries, biodiversity hotspots – global and Indian. Marine biodiversity. Present status of marine biodiversity in India. Island biodiversity. Causes of biodiversity loss. Threats to biodiversity. Assessment	**4,5**

	of Biodiversity. Red Data Books. Biodiversity conservation - Strategies for biodiversity conservation, principles of biodiversity conservation - in-situ and ex- situ conservation strategies.	
V	Convention on Biological Diversity (CBD). Organizations involved in protection and conservation – CITES, IUCN, WWF for Nature, UNEP. Ramsar Convention 1971, Biodiversity legislation in India - Indian Biodiversity Act 2002, National Biodiversity Authority of India. State Biodiversity Boards and Biodiversity management committees, National bureaus dealing with genetic resources – NBPGR, NBAGR, NBAIM, NBAII and NBFGR. Environmental Impact Assessment (EIA), general guidelines and procedures for the preparation of environmental impact assessment. Public awareness.	**5**

Text books and References

- Guido di Prisco, Peter Convey (auth.), Guido di Prisco, Cinzia Verde (eds.).2012. Adaptation and Evolution in Marine Environments, Volume 1: The Impacts of Global Change on Biodiversity. Springer-Verlag Berlin Heidelberg 236 pp.
- Michael Jeffries. 2006. Biodiversity and Conservation (Routledge Introductions to Environment). Routledge 257 pp.
- Philippe Goulletquer, Philippe Gros, Gilles Boeuf, Jacques Weber (auth.). 2014. Biodiversity in the Marine Environment. Springer Netherlands 214 pp.

PRACTICAL COURSES

Course Name	**Marine Planktonology, Algology and Benthos**		
Course code	**MB 2209**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To master the collection, preservation, and quantitative estimation of phytoplankton and zooplankton samples.**	**A**	**2,4**
2	**To gain proficiently identify and classify plankton species using appropriate logging and cataloguing techniques.**	**A**	**2,4**
3	**To perform sediment texture analysis for primary productivity and benthic community assessment.**	**A**	**2,4**
4	**To maintain accurate and organized laboratory and fieldwork records for analysis.**	**A**	**1,2**
5	**To use practical techniques to evaluate benthic community structure based on sediment and productivity data.**	**A**	**2,5**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			
Collection, preservation and quantitative estimation of phytoplankton and zooplankton; Identification and classification of various phytoplankton and zooplankton; Logging, cataloguing and sorting procedures. Estimation of primary productivity. Collection, preservation and quantitative estimation of benthos. Sediment texture analysis. Documented record of laboratory and field works.			

Course Name	**Fish Biology**		
Course code	**MB 2210**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To proficiently dissect finfish and shellfish for gut content analysis.**	**A**	**2,5**
2	**To accurately estimate physiological parameters like dissolved oxygen consumption, ammonia excretion, and hemoglobin content in fish blood.**	**A**	**2,5**
3	**To perform techniques to enumerate total red blood cells (RBC) in fish blood.**	**A**	**2,5**
4	**To conduct white blood cell (WBC) counting in fish blood to assess health.**	**A**	**2,5**

5	**To evaluate fish physiological responses to environmental conditions using blood analysis techniques.**	**A**	**2,5**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			
Dissection of finfish and shellfish. Gut content analysis. Estimation of dissolved oxygen consumption by fish. Estimation of ammonia excretion in fish. Estimation of haemoglobin content in fish blood. Enumeration of total RBC and WBC in fish blood.			

Course Name	**Marine Biodiversity**		
Course code	**MB 2211**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To identify and catalogue marine floral and faunal communities efficiently.**	**A**	**2,3,4**
2	**To quantify faunal changes in polluted waters to assess ecosystem health and biodiversity.**	**A**	**2,3,4**
3	**To use gel electrophoresis for analyzing genetic material in marine species.**	**A**	**4,8**
4	**To perform total DNA isolation, mitochondrial DNA separation, and RFLP analysis for genetic studies.**	**A**	**4,8**
5	**To utilize PCR techniques for genetic analysis and accurately document laboratory and fieldwork findings.**	**A**	**4,8**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			
Identification and cataloguing of marine floral and faunal communities. Quantification of faunal changes in polluted water. Gel electrophoresis; Total DNA isolation; Mitochondrial DNA isolation, separation and detection of fragments, Genomic libraries Training in RFLP analysis, PCR mechanics. Documented record of laboratory and field works.			

Course Name	**Marine Microbiology**		
Course code	**MB 2212**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To prepare various bacterial media, including nutrient broth, agar medium, and agar slants for microbial studies.**	**A**	**2,4**

2	**To apply effective sample collection methods from marine environments to estimate bacterial, fungal, and actinomycete populations.**	**A**	**2,4**
3	**To isolate pathogenic organisms from seafood, water, and sediment samples.**	**A**	**2,4,3**
4	**To identify unknown bacteria by separating mixed cultures and maintaining pure cultures.**	**A**	**2,4**
5	**To conduct biochemical characterization, including staining and cell morphology analysis, for bacterial identification.**	**A**	**2,4**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			
Preparation of bacterial media- culture- nutrient broth, agar medium, agar slants. Methods of sample collection form marine environments; estimation of bacterial, fungal and actinomycete population. Isolation of pathogenic organisms from seafood, water and sediment. Identification of unknown bacteria- separation of mixed cultures. Isolation, maintenance and preservation of pure cultures. Characterization biochemical tests-. staining of bacteria, cell morphology.			

Course Name	**Study Tour**
Course code	**MB 2213**
Study tour to various marine ecosystems to study marine biodiversity and to collect specimens. Visits to Oceanography and Fisheries Institutes. Submission of tour report.	

SEMESTER III

CORE COURSES

Course Name	Marine Bio-prospecting & Biotechnology		
Course Code	MB 2301:		
CO No.	Expected Course Outcome	Learning Domains	PO No.
1	To analyze the scope of biotechnology in environmental management and aquaculture	An	5,3
2	To analyse the methods for isolation and separation of marine natural products	An	5,4
3	To evaluate marine microorganisms	E	2,3
4	To utilize biotechnology techniques and design and implement various high-throughput screening (HTS) assays to analyze biological samples effectively	E, An, A	5,4
5	To analyse and purify the recombinant proteins	An	5,4
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

Unit No	Unit Content	CO No.
I	Introduction - Scope of biotechnology in environmental management, aquaculture, bioactive compounds, Bioremediation, biosensors, biofouling, treatment of waste water, bioactive marine natural products – significance –anti-tumor – tumor promoting – anti-inflammatory – analgesic – anti-viral agents – antibiotic – cytotoxic – antimicrobial compounds.	1
II	Collection of marine organisms - Isolation and separation of marine natural products from marine flora and fauna - Diversity of bioactive metabolites in different groups of marine organisms. Marine microorganisms as a source of biomedical resources – dinoflagellates as a source of bioactive molecules – chemistry and pharmacology of marine toxins – saxitoxin – brevitoxin – ciguatoxin – tetradotoxin - Nitrogen and non-nitrogen containing marine bioactive compounds – polyketides – prostanoids – polyethers – macrolides – terpenes. Commercial development of marine natural products – chitosan - algal products – SCPs - β carotene - vitamins	2,3
III	Biotechnology techniques - Assay plates; Spectrophotometers; Microplate readers; Fluorescence assisted cell sorting (FACS); Fluorescence Microscopy; Atomic Force Microscopy (AFM); Chromatography – basic considerations, FPLC, HPLC, HPTLC; Mass spectrometry; Microarrays; Gene chips; Protein arrays; Protein chips; Automated and robotic Systems.	4
IV	Types of HTS assays: In vitro biochemical and cell based assays; Isotopic detection techniques; Non-isotopic detection	4

	techniques; Enzyme linked immunosorbent assay; Radio immunoassay; Scintillation proximity assays; Chromogenic assays; Fluorescence assays; Fluorescence polarization; Homogenous time resolved fluorescence assays; Fluorescence correlation spectroscopy; Fluorescence life time assays; Fluorescence resonance energy transfer (FRET), Electro-chemiluminescence.	
V	Recombinant proteins of commercial importance: enzymes, hormones, bio active compounds, therapeutic proteins. Principles, purification and methodological considerations in industrially relevant enzymes, Bench top and primary bioassay screens - Biological and toxicological aspects of marine natural product drug discovery, Clinical evaluation of MNPs in drug discovery.	**5**

Text books and References

- Fingerman, M., Nagabhushanam, R. and Thompson, M.F. 1997. Recent Advances in Marine Biotechnology. Vols. I-III. Oxford & IBH.
- Glick, B.R. and Pasternak, J.J. 1999. Molecular Biotechnology: Principles and Applications of Recombinant DNA Technology. ASM Press.
- Nagabhushanam, R., Diwan, A.D., Zahurnec, B.J. and Sarojini, R. 2004. Biotechnology of Aquatic Animals. Science Publ.
- Pandian, T.J., Strüssmann, C.A. and Marian, M.P. 2005. Fish Genetics and Aquaculture Biotechnology. Science Publ.
- Primrose, S.B. 1989. Modern Biotechnology. Blackwell. Singh, B. 2006. Marine Biotechnology and Aquculture Development. Daya Publ. House.

Course Name	Marine Pollution & Toxicology		
Course Code	MB 2302		
CO No.	Expected Course Outcome	Learning Domains	PO No.
1	To analyze marine pollution sources, impacts, and management strategies, emphasizing GESAMP's role in addressing key pollutants and their ecological effects.	An	7,9
2	To evaluate oil, and other pollutants' impacts on marine ecosystems	E	7,9
3	To utilize environmental monitoring techniques and analytical instruments to assess and interpret marine pollutant levels	E	4,9
4	To assess pollution's ecological impacts on marine ecosystems.	E, An	7,9
5	To examine Environmental Impact Assessment (EIA) processes	An	6,7
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

Unit No	Unit Content	CO No.
I	Marine pollution definition– role of GESAMP – major pollutants – sources – transport path – dynamics - Sewage: domestic, industrial, agricultural and aquaculture discharges, their composition and fate in the marine environment, toxicity and treatment methods, detergents – composition. Eutrophication – ecological significance – sewage disposal system. Marine debris – plastics – impactsof the marine environment	1
II	Oil pollution: Sources and fate of oil, composition and toxicity of oil, biological effects. Heavy metal pollution. Pesticide pollution – classification – sources – distribution - fate and ecological impacts with special reference to marine fishes, birds and mammals. Sources, characteristics and strategies for disposal of thermal and radioactive pollutants and biohazardous materials. Waste dumping, mining and dredging operations and their impacts. Aquatic noise.	2
III	Environmental monitoring methods – critical pollutants – objectives – status – limitations and biological indicators – bioaccumulation – biotransformation –mussel watch – water quality assessment - Methods for analysing pesticides, heavy metals, hydrocarbon, data analysis and interpretation. Use of analytical instruments – AAS, ICP and GLC.	3
IV	Ecological impacts of pollution on marine organisms. Biological magnification, changes in species distribution, changes in oxygen levels, climate change, effects on corals,	4

	invasion of non-native species through ballast water, aquaculture and accidental introduction, community changes, impact of pollution on habitat and reproduction.	
V	Environmental Impact Assessment – Scope and definition of EIA – Historical development of EIA (Global and Indian Scenario) –Legislations, Laws and Acts relevant to environmental protection in India. Elements of EIA process - screening – scoping – terms of reference – process of public hearing – Environmental clearance process in India. Impact Assessment methodologies. Public participation.	**5**

Text books and References

- Chakrabarty, A.M. 1982. Biodegradation and Detoxification of Environmental Pollutants, CRC Press.ISBN: 9780849355240, 147 p. Colwell, R.R. 1983. Biotechnology in Marine Sciences. Science, Vol. 222: 19-24
- Gupta, P.K. 1990. An Introduction to Biotechnology. Rastogi Publications, Meerut, India.
- Hayes, M.J. and Laws Jr., E.R. 2013. Handbook of Pesticide Toxicology, Volume 3: Classes of Pesticides focuses on the properties, toxicity, classes, and reactions of pesticides. 3rd revised edn., Academic Press, 949 p.
- Johnston, R. (Ed.). 1976 Marine Pollution, Academic Press.
- Kinne, O. 1984. Marine Ecology, Vol. V. Ocean Management 3&4, John Wiley & Sons.
- Klaassen, C.D. (Ed.) 2008. Casarett and Doull's Toxicology: The Basic Science of Poisons. 7th edn. McGraw-Hill, New York. ISBN 978-0-07-147051-3, 1309 p.
- Kumar, A. 2008. Aquatic Environment and Toxicology. Daya Publishing House. ISBN-13: 9788170353126.
- Landis, W., Sofield, R., Yu, M.H., Landis, W.G., Sofield, R.M., Yu, M.H. 2010. Introduction to Environmental Toxicology: Molecular Substructures to Ecological Landscapes, 4th edn., CRC Press, ISBN 9781439804100, 542 p.
- Landis, W.G. and Yu, M.G. 2004. Introduction to Environmental Toxicology. Lewis Publishers, A CRC Press Company.
- Newman, M.C. and M.A. Unger. 2003. Fundamentals of Ecotoxicology, 2nd edn. CRC/Lewis Press, Boca Raton, FL.
- Newman, M.C. and W. Clements. 2008. Ecotoxicology. A Comprehensive Treatment. Taylor and Francis / CRC Press, Boca Raton, FL.
- Ram Chandra (Ed.) 2015. Advances in Biodegradation and Bioremediation of Industrial Waste. CRC Press. ISBN: 978-1498700542, 479 p.

Course Name	Marine Fisheries & Aquaculture		
Course Code	MB 2303		
CO No.	Expected Course Outcome	Learning Domains	PO No.
1	To analyse Indian fishery and marine resource status	An	3,6
2	To evaluate aquaculture, brackishculture and mariculture principles and practices	E	5,6
3	*To* Develop resource management strategies	E	3,6
4	To apply aquaculture techniques	A	5,6
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

Unit No	Unit Content	CO No.
I	Fishery resources of India – Present status of the following resources - Elasmobranches, Oil sardines, Indian mackerel, Bombay duck, Tunas, Seer fishes, Pomfrets, Carangids, Silver bellies, Flat fishes, Ribbonfishes, Perch, Sciaenids and Polynemids, Eels and Catfishes. Marine ornamental fishes.	1
II	Present status of the following resources - Shrimps, Lobsters, Crabs, Pearl oysters and Edible Oyster, Mussels, Clams, Gastropods, Squids, Cuttlefish and Octopus. Export of marine products. Impacts of climate change on fisheries.	1
III	Aquaculture –Definition. Objectives, history and scope. Present global and national scenario. General principles of Aquaculture. Criteria for selection of species for aquaculture. Important brackish water and marine species for aquaculture in India.	1,2
IV	Brackish water farming practices of India – Prawn filtration system and Bhasabada fisheries. Culture of milk fish, mullets, pearl spot, Asian sea bass, shrimps, crabs, lobsters. Brackish water molluscan species for aquaculture-mussels and clamspresent status and prospects. Induced breeding in finfishes and shellfishes. Hatchery techniques of shrimp seed production. Live feed culture techniques.	1,2,4
V	Coastal and open sea marine culture. Present status and future prospectus of mariculture in India. Cage culture and Pen culture. Culture of pearl oyster, edible oyster, grouper and cobia. Seaweed culture. Legal aspects of coastal aquaculture – CRZ Act and Coastal Aquaculture Authority.	1,2,3

Text books and References

- Allen, R. and Steene, R.C. 1987. Reef Fishes of Indian Ocean by Gerald TFH Publication, USA.

- Bal D.V and Virabhadra Rao,K. 1990, Marine Fisheries of India, Tata McGraw Hill, 472 p.
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- Hall, S. J and B. Mainprize, Towards ecosystem-based fisheries management, Blackwell Publishing Ltd. Fish and Fisheries, 5 (2004) 1-20. Michael, R.R. 1997. Fisheries Conservation and Management. Prentice Hall.
- Pascoe, S. 2005. Bycatch Management and the Economics of Discarding. Daya Publ. House.
- Pauly, D. 1983. Some Simple Methods for The Assessment of Tropical Fish Stocks. FAO Fish. Tech. Pap. 234, 52 p.
- Pauly, D. 1999. Ecosystem consideration and the limitations of Ecosimmodels in fisheries management: insights from the Bering Sea. In: Keller, S. (Ed.) Ecosystem
- Approaches for Fisheries Management, University of Alaska Sea grant, Fairbanks,

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- Thorpe, J.E., Lannan J.E. and Nash, C.E. (Eds.) 1995. Conservation of Fish and Shellfish Resource - Managing Diversity. Academic Press Ltd, London.ISBN 0-12-690685-8.

Course Name	Marine Resource Management & Ecosystem Modelling		
Course Code	MB 2304:		
CO No.	Expected Course Outcome	Learning Domains	PO No.
1	**To assess** fish stock types and challenges **in evaluating Indian marine fish populations for sustainability.**	An, E	3,5,6
2	**To** analyse growth, mortality, and selection parameters **to optimize fishing practices and enhance sustainability.**	E, An	3,5,6
3	**To implement** fish stock assessment models **to predict sustainable yields, while evaluating key metrics and exploitation rates for effective fishery management.**	A	3,5,6
4	**To apply** sampling techniques **to analyze fishing effort and evaluate fishery management concepts and marine regulations (UNCLOS III) for sustainable marine fisheries.**	A, E	3,5,6
5	**To develop** ecosystem models **using simulation tools to apply ecosystem-based fisheries management principles and predict ecosystem dynamics.**	A	3,5,6
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	Unit Content	CO No.
I	Fishery resources – stock concept – stock definition – unit stock – mixed stock – characteristics; problems in assessing the marine resources in tropical waters –Indian marine fishes.	1
II	Growth parameters; mortality parameters and selection parameters. Length frequency distribution – Pauly's integrated method – resolution of modes – growth estimation. Growth equation - methods, estimation; growth characteristics – uses. Mortality parameters –total instantaneous mortality, fishing mortality, natural mortality, methods, estimation. Fishing gear selectivity - selection parameters – gill net selectivity – trawl selectivity – methods – estimation – uses.	2
III	Fish stock assessment models – surplus production models – VPA analysis, cohort analysis; prediction models – Beverton – Holt yield per recruit model – yield curves, Thompson - Bell model; FMSY, MEY, FMEY; Eumetric fishing, exploitation rate and ratio; estimation of potential yield.	3
IV	Sampling techniques – types of sampling – sampling the fish units; fishing effort, standardization of fishing effort, catchability coefficient. Fishery management concepts, marine regulation acts relating to marine fisheries exploitation included in the final UNCLOS III treaty.	4
V	Ecosystem modelling, ecosystem-based fisheries management – principles; ECOPATH and ECOSIM models – estimation; simulation models –predator-prey model – NPZD model – software packages used in fish stock assessment and in	5

	ecosystem modelling.	

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Course Name	Biostatistics & Research Methodology		
Course Code	MB 2311		
CO No.	Expected Course Outcome	Learning Domains	PO No.
1	**To calculate and interpret central tendency and dispersion measures to evaluate variability and data distribution characteristics in real-world datasets.**	An, E	1,3,5
2	**To conduct and interpret ANOVA to model variable relationships and assess correlation coefficients**	E, An	1,3,5
3	**To design and execute sample surveys by selecting suitable data collection methods**	A	2,3,5
4	**To formulate a clear research problem and develop a robust research design**	A, E	2,4,5
5	**To create** a well-structured scientific manuscript **using reference management software like Mendeley or Endnote.**	A	2,4,5
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	Unit Content	CO No.
I	Measures of central tendency – Mean, median, mode. Measures of dispersion – range, mean deviation, standard deviation, skewness, kurtosis.	1
II	Measures of Relationship – Basic principle of ANOVA, One way ANOVA, Analysis of variance table, Two-way ANOVA, Co-variance, Pearson's coefficient of correlation, rank correlation, Spearman's rank correlation. Regression – Linear and multiple linear regression analysis.	2
III	Design of sample surveys - Data collection - experiments and surveys, collection of primary and secondary data, selection of appropriate method for data collection, data preparation.	3
IV	Research Methodology - Meaning, objective, types and significance of research; research approaches; selecting the research problem, techniques involved in defining problem; research design, features of good design, important concepts relating to research design.	4
V	Interpretation and Scientific writing – Meaning and techniques of interpretation. Structure, Composition, Citation and Bibliography in scientific manuscripts. Impact factor, Citation index; Research abstracts, Research article, Format of scientific manuscripts and Thesis. Presentation – Types of presentation, Basic strategies for effective oral presentation. Reference management and publishing softwares - Mendeley, Endnote, LaTeX. Finding information on the World Wide Web. Environmental and biological databases. Useful websites for biological research. E journals.	5

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ELECTIVE COURSES / MOOC

Course Name	Ocean Policy & Education		
Course Code	MB 2305:		
CO No.	Expected Course Outcome	Learning Domains	PO No.
1	To analyze the ocean as a common heritage and the significance of the Exclusive Economic Zone (EEZ).	An, E	1,3,5
2	To assess the geopolitical implications of seabed exploration and India's ocean policies regarding resource management and environmental challenges.	E, An	1,3,5
3	To demonstrate data collection and analysis related to ocean functioning and develop strategies using Blue Biotechnology and Blue Economy concepts	A	2,3,5
4	To enhance ocean literacy and stewardship while addressing workforce skill gaps.	A, E	2,4,5
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			
Unit No	Unit Content	CO No.	
I	Historical evolution of ideas on ocean as a common heritage of mankind. Evolving the law of the sea – Geneva conventions – UNCLOS series – Exclusive Economic Zone (EEZ) – its significance –Regional Sea programmes of UN – Global significance – Antarctic Treaty and importance.	1	
II	Geo-political aspects of seabed exploration, mining. Seabed treaty. Role of national and international agencies and organizations in ocean management. Ocean policy (India) – overview of the existing policies in India. Indian Fisheries Act, 1987; Deep Sea Fishing Policy, 1991; Marine Fisheries Regulation Acts; Indian Ports Act, 1908; Major Port Trust Act, 1963; Merchant Shipping Act, 1958; Coast Guard Act, 1978; Maritime Act; National Environment Tribunal Act, 1995 – Conventions to which India is a signatory: Basel convention 1992; Ocean policy statement; convention on migratory species; MARPOL 73/78; Code of Conduct for Responsible Fisheries.	2	
III	Understanding the ocean's influence – the essential principles of ocean sciences; fundamental concepts about the functioning of the ocean; responsible decisions regarding ocean resources. Sustainability concept – Blue Biotechnology; Blue Economy.	3	
IV	Ocean stewardship – importance of education and public awareness; ocean science literacy; integrated themes. Building a collaborative ocean education network – participants in ocean education; coordinating ocean education. Futuristic national and international perspectives in ocean education. Future ocean	4	

	workforce – identifying gaps; capacity building initiatives required for bridging the gaps.	

Text books and References

- Borgeses, E.M. and Ginsberg, N. (Eds.) 1978. Ocean Yearbooks – I – XX. The University of Chicago Press, Chicago.
- Chan Kim W., Renée Mauborgne. 2005. Blue Ocean Strategy: How to Create Uncontested Market Space and Make Competition Irrelevant. Harvard Business Press 257 pp.
- Fabbri P. 1990. Ocean Management in Global Change: Proceedings of the Conference on Ocean Management in Global Change, Genoa, 22-26 June 1992. Spon Press. 656 pp.
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- Robert, K. and Alder, J. 2005.Coastal Planning and Management. 2nd edn.CRC Press, ISBN-13: 978-0415317733,400 p.
- Roonwal, G.S. (Ed.) 1986. The Indian Ocean: Exploitable Mineral and Petroleum Resources. 1st edn. Springer, ISBN-13: 978-3642955037, 214 p.
- https://oceanservice.noaa.gov/education/literacy.html
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Course Name	Integrated Coastal Zone Management		
Course Code	MB 2306		
CO No.	Expected Course Outcome	Learning Domains	PO No.
1	To identify coastal natural resources	An, E	1,3,5
2	To discuss ecological issues of non-sustainable development and biodiversity threats and examine multiple coastal zone uses and their impacts on ecosystems.	E, An	1,3,6
3	To Analyze Integrated Coastal Zone Management and develop pollution control skills.	A	1,3,5
4	To evaluate rules governing coastal tourism facilities for sustainability and analyze pollution impacts on coastal resources from tourism activities.	E	1,3,6
5	To develop practical skills in coastal biological community collection and identification while analyzing anthropogenic impacts on soil and water characteristics in coastal areas.	A	1,3,5
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

Unit No	Unit Content	CO No.
I	Coastal resources- coastal natural resources system – flora and fauna, trophic relationship, nutrient production, cycle and transport.	1
II	Developmental activities and biodiversity laws- ecological issues, non-sustainable development; threats to biodiversity, habitat destruction, depletion of fisheries; eco-friendly fishing; impact of global environmental changes. Multiple uses of the coastal zone, urban settlement, industrial development, waste disposal, shore protection works, ports and marine transportation. Land transportation infrastructure, water control and supply projects, sea fisheries, aquaculture, coastal forest industries, coastal agriculture, industries.	2
III	Integrated Coastal Zone Management (ICZM) - need and benefits, principles, goals and objectives of the ICZM programme; scope, extent of jurisdiction, boundaries of the coastal zone, policies and planning for coastal resource management; management mechanisms- pollution control, socio-economic impacts and its assessment. Disaster management for coastal environment.	3
IV	Coastal tourism: Beach resorts, restaurants and parks within the coastal zone as per existing rules and regulations. Impact of pollution on coastal resources.	4
V	Observations of soil and water characteristics and damages of coastal areas having anthropomorphic impacts; Collection, preservation and identification of coastal biological	5

	communities; Survey of different coastal zones; Visit to the marine protected areas.	

Text books and References

- Brahtz, J.F.P. 1972. Coastal Zone Management. UN Department of International Economic & Social Affairs, New York.
- Cairns, J. Jr. 1994.Implementing Integrated Environmental Management. Virginia Tech. University.
- Clark, J.R. 1992.Integrated Management of Coastal Zones. FAO Fisheries Tech. Paper No. 327, FAO, Rome.
- David, S.and Jeremy P. 2001. Inshore Fisheries Management. Methods and Technologies in Fish Biology and Fisheries. Vol. II.
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- Priestley, G.K., Edwards, J.A. and Coccossis, H. Wallingford (Eds.), 1996. Sustainable Tourism? European Experiences. CAB International, Oxford.

Course Name	Seafood Technology		
Course Code	MB 2307		
CO No.	Expected Course Outcome	Learning Domains	PO No.
1	To understand water and ice structure during freezing, interpret freezing curves for fish, and apply knowledge of crystallization and supercooling in seafood preservation.	U/R	2,3,5
2	To comprehend the methods of freezing fishery products and select various freezers for optimal preservation.	U/R	2,3,5
3	To comprehend heat transfer mechanisms in thermal processing and learn microbial heat resistance concepts for safe processing of fishery products.	U/R	2,3,5
4	To recognize the canning process for fish and shellfish and value-added canned products and additives.	U/R	2,5
5	To comprehend hurdle technology principles and irradiation techniques	U/R	2,5
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			

Unit No	Unit Content	CO No.
I	Freezing Technology in Seafood Plants- Freezing: Structure of water and ice, Influence of solutes on the structure of water and ice, freezing curve for fish. Determination of freezing points from time- temperature plots, calculation of freezing time, Crystallization, super cooling, crystal growth, eutectic point, location of ice crystals in tissue, physical changes during freezing.	1
II	Technological aspects of freezing. Different freezing methods, freezing of fishery products and the steps involved. Slow freezing vs Quick freezing, Double freezing. Post freezing treatment. selection of a freezing method, product processing, packaging and different types of freezers - Airblast freezers, Contact plate freezers, Spray and Immersion freezers, other types of freezers, Freezing time and freezer operating temperatures.	2
III	Thermal Processing of Fishery products - Principles of thermal processing. Mechanism of heat transfer: conduction, convection, radiation and dielectric and microwave heating, heat resistance of bacteria and spores, decimal reduction time, thermal death time, "Z" and "F" values, 12D concept, heat penetration, cold point, can size, shape, contents etc. on heat penetration, determination of process time. F0 value, cook value, D value, integrated F value and their inter-relationship. Heating equipment.	3

IV	Canning process, steps involved, process flow, additives, HTST processing and aseptic canning, principles and process details, canning machinery and equipment, canning process for fish/ shellfish, value added and ready to use canned products.	**4**
V	Hurdle technology: Combination with heat, heat and hydrostatic pressure, heat and low pH, heat and NaCI and nitrite, combination with ionising radiation, irradiation and hydrostatic pressure, irradiation and NaCI, irradiation and other adjuncts, heat and irradiation, irradiation and low temperature, low pH and specific acids, low aw and adjuncts like Nisin to reduce severity of heat processing. Irradiation: Radiation sources, units, dose levels, radappertization, radicidation, radurization, effects of irradiation on protein, lipids, vitamins, bacteriological aspects, physical properties, shelf life and irradiated fish products.	**5**

Text books and References

- Hall, G.M. Fish Processing Technology.
- Cleland C Andrew, Food Refrigeration Processes.
- Clucas, I.J., Fish Handling, Preservation and Processing in the Tropics.
- Balachandran, K.K. Fish Canning Principles and Practices.
- Gopakumar K. Text Book of Fish Processing Technology.

OPEN ELECTIVE COURSES

(*Elective offered by Marine Biology department*)

Course Name	**Ornamental Fishes & Aquarium Maintenance**		
Course Code	**OST 2302**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To identify key freshwater and marine ornamental fish species in India and the sector's export potential and livelihood opportunity**	**E**	**1,3**
2	**To design and set up freshwater and marine aquariums, while identifying aquarium plants and their ecological roles in maintaining water quality and overall health.**	**U/R**	**2,4**
3	**To gain knowledge in monitoring and maintenance of essential water quality parameters for healthy aquariums**	**U/R**	**2,4**
4	**To analyse the nutritional requirements, diseases and its control measures of aquarium fishes**	**An**	**1,4**
5	**To acquire knowledge of breeding techniques, transportation and quarantine methods for aquarium fish species**	**U/R**	**1,2**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			

Unit No	**Unit Content**	**CO No.**
I	Ornamental Fishes of India- Feshwater and marine. Status of Indian ornamental fish sector- Export potential. Ornamental fish as livelihood sector employment identification of potential ornamental fishes. Benefits of keeping aquarium fishes.	**1**
II	Construction of home aquarium- accessories, design and setting up of freshwater and marine aquarium. Principles of a balanced aquarium. Aquarium plants and their role.	**2**
III	Water quality maintenance in aquarium- range of water quality parameters. Filters in aquarium- types and principles.	**3**
IV	Nutritional requirements for aquarium fishes, types of aquarium fish food – artificial and live feed. Common diseases of aquarium fishes and their control.	**4**
V	Breeding techniques for major aquarium fishes- Feshwater and marine. Maintenance of broodstock. Nursery management. Conditioning, packaging and transport of aquarium fishes. Quarantine methods.	**5**

Text books and References

- Anshuman D. Dholakia (2016). Ornamenntal Fish culture and aquarium management.
- Mary Bailey & Gina Sandford (2015). Ultimate encyclopedia of Aquarium Fish & Fish care.

PRACTICAL COURSES

Course Name	Marine Pollution & Toxicology		
Course Code	MB 2308		
CO No.	Expected Course Outcome	Learning Domains	PO No.
1	To conduct a case study of a polluted marine ecosystem by analyzing key environmental parameters.	A	1,2,3
2	To evaluate the toxicity of heavy metals, pesticides, PCBs, and oil on selected marine organisms using bioassay techniques.	A	2,3,5
3	To analyze heavy metal concentrations in aquatic ecosystems using advanced methods.	A	1,2
4	To operate instruments like Gas Chromatography for pollution analysis and toxicity testing.	A	2,4
5	TO develop skills in instrumentation, data collection, and report submission for pollution studies.	A	1,2,3, 4
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			
A case study of a polluted area in marine ecosystem. Analysis of various environmental parameters. Toxicity evaluation of heavy metals on selected organisms by bioassay techniques - Toxicity assessment of pesticides, PCBs and oil on selected organisms; Analysis of heavy metals from aquatic ecosystems; Toxicity testing methods. Demonstration of Gas Chromatography and other instruments. Training on instrumentation for pollution studies and submission of reports.			

Course Name	Biotechnology & Instrumentation		
Course Code	MB 2309:		
CO No.	Expected Course Outcome	Learning Domains	PO No.
1	To extract and quantify DNA from marine organisms and perform Polymerase Chain Reaction (PCR) procedures.	A	2,3,5
2	To conduct electrophoresis for DNA analysis and implement antibacterial, antifungal, and antiviral assays using marine-derived compounds.	A	2,3
3	To extract bioactive compounds from marine organisms and operate HPLC and GC-MS for compound analysis and identification.	A	2,5
4	To perform immunoassays for protein detection and conduct FTIR and FDF-PAGE analyses.	A	2,5

5	**To develop proficiency in sample preparation, result interpretation, and maintaining laboratory records while adhering to safety protocols in marine biotechnology research.**	**A**	**1,3,5**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			
Extraction and quantification of DNA, PCR, Electrophoresis. Antibacterial, antifungal, antiviral and anti-cancer assay. Extraction of bioactive compounds from marine organisms - HPLC, GC-MS, Immunoassay, FTIR, FDF-PAGE.			

Course Name	**Marine Resource Management and Ecosystem Modelling**		
Course Code	**MB 2310**		
CO No.	**Expected Course Outcome**	**Learning Domains**	**PO No.**
1	**To use Pauly's integrated method and growth equations to estimate fish stock growth parameters.**	**A**	**1,2,4**
2	**To estimate mortality parameters (Z, M, F, f, Q) using various assessment methods.**	**A**	**1,2**
3	**To analyze surplus production models, draw yield curves, and interpret isopleth diagrams.**	**A**	**1,2**
4	**To use fisheries software packages (ELEFAN, FiSAT, EwE6) and implement basic NPZD models.**	**A**	**2,3**
5	**To construct and interpret food web models for effective fisheries management and assessment.**	**A**	**1,2,3**
***Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)**			
Pauly's integrated method assessing the growth of the fish stock. Growth equations– estimation of growth parameters; estimation of mortality parameters Z, M, F, f and Q – methods. Surplus production models and analytical models – drawing yield curves – isopleths diagrams. Software packages – ELEFAN, FiSAT – EwE6. Implementation of basic NPZD model – construction of food web model.			

Course Name	Biostatistics & Research Methodology		
Course Code	MB 2312:		
CO No.	Expected Course Outcome	Learning Domains	PO No.
1	To use basic statistical software for data entry and perform calculations like mean and standard deviation.	A	4
2	To create various types of graphs (bar diagrams, pie charts, histograms, box plots) and apply statistical functions.	A	4
3	To operate statistical software packages (SPSS, SYSTAT, PRIMER) for data analysis.	A	4
4	To develop research proposal writing and oral presentation skills for effective communication.	A	10
5	To document field and laboratory work accurately for comprehensive research records.	A	8
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			
Introduction to statistical softwares. - Data entry, calculation of mean, standard deviation; graphs – bar diagram, pie diagram, histogram, box plots, aggregate functions, formula and functions. Data analysis using softwares – (SPSS, SYSTAT and PRIMER, etc.). Preparation of a research proposal and its oral presentation. Documented record of the field and laboratory works.			

SEMESTER IV

Course Name	Project		
Course Code	MB 2401		
CO No.	Expected Course Outcome	Learning Domains	PSO No.
1	Students will develop a comprehensive understanding of marine ecosystems, including their structure and function.	U/A/E	1
2	Mastery of advanced concepts in marine biodiversity, conservation, and management practices.	U/A	1
3	Ability to apply theoretical knowledge to real-world marine biology issues through practical fieldwork and research.	U/A	1,10,12
4	Students will design and implement research projects, including hypothesis formulation and method selection.	U/A	2,3,8
5	Capacity to identify conservation challenges in marine environments, formulate research questions, and employ appropriate methodologies for investigation.	U/AP	1,5,8
*Remember (R), Understand (U), Apply (A), Analyse (An), Evaluate (E), Create (C)			